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Factors associated with polybrominated diphenyl ether levels in a cohort of pregnant African American women in metropolitan Atlanta

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ABSTRACT

Factors associated with polybrominated diphenyl ether levels in a cohort of pregnant African American women in metropolitan Atlanta

By Janet Lui-Tankersley

Background: Polybrominated diphenyl ethers (PBDEs) are endocrine disrupting compounds that have been linked with adverse health outcomes. Research has shown that African Americans have disproportionately higher levels of PBDEs, as compared to Caucasians. Known routes of exposure include dust inhalation, dietary ingestion, and hand-to-mouth behaviors. However, elucidation of why higher levels exist in African Americans has yet to determined. In this study, the aim was to evaluate dietary and home environment variables as potential predictors of elevated PBDE levels in a cohort of pregnant African American women.

Methods: Blood samples and dietary data were collected from 153 women at an initial prenatal visit between 8 and 14 weeks' gestation. Samples were processed to assess levels of PBDE congeners and lipid weights. A subset of 42 patients consented to a household survey at 20-24 weeks' gestation as a supplemental study. Pearson correlations and multivariate linear regression analyses, using both a stepwise and backwards approach, were performed to determine the best fit models at an alpha of 0.05.

Results: Serum concentrations of PBDE -47, -99, and -100 were measured above the limit of detection in over 70% of participants. The best fit model of dietary predictors for PBDE-47 included intake of high omega-3 fish and insurance status ($R^2 = 0.07$). The sub-analysis with home environment variables indicated the age of the couch, shaking out a rug, and marijuana use as the best model ($R^2 = 0.15$), but when included with dietary data, only the age of the couch explained the variance in PBDE-47 levels ($R^2 = 0.24$). In the models evaluating for the summed PBDE value, the age of the couch was also significantly associated with increasing levels ($R^2 = 0.28$).

Conclusion: In this cohort, increasing PBDE exposure may be more attributable to factors within the home environment rather than diet. Regression models indicated that age of the couch accounts for a significant portion of the variance in PBDE-47 and summed PBDE levels. However, larger studies with objective measures of dust inhalation or hand-to-mouth behaviors are needed.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
BMI	Body mass index
CHAMACOS	Center for the Health Assessment of Mothers and Children of Salinas
FFQ	Food frequency questionnaire
GED	General education diploma
HPHB	Healthy Pregnancy, Healthy Baby
LOD	Limit of detection
MoBa	Norwegian Mother and Child Cohort
NHANES	National Health and Nutrition Examination Survey
PBDE	Polybrominated diphenyl ether
POP	Persistent organic pollutant
PUFA	Polyunsaturated fatty acid
SAS	Statistical Analysis Software
SES	Socioeconomic status
SD	Standard deviation
T4	Total thyroxine
TSH	Thyroid stimulating hormone

BACKGROUND / LITERATURE REVIEW

Polybrominated diphenyl ethers (PBDEs) are commonly used as flame retardants in common household products, including textiles, upholstery, furniture, and electronics (1). These compounds are known to cross the placenta, potentially affecting the development of the child, both in utero and later in childhood (2, 3). Both animal and human studies have shown associations between increasing PBDE exposure and various adverse health outcomes, such as endocrine disruption, infant birth outcomes (birth weight, Apgar scores, etc.), and cognitive or behavioral development of the child. The interactions among PBDE congeners and endocrine hormones, particularly thyroid hormones, have been investigated, given the similar chemical structure between PBDEs and total thyroxine (T4) as well as results from animal models and studies in non-pregnant humans (2). Several animal model studies investigating the relationship between PBDEs and thyroid hormone in mice or rats have found associations between exposure to PBDEs and decreased thyroid hormone and/or increased thyroid stimulating hormone (TSH) (2). Limited, smaller studies on non-pregnant humans from the early 1980s have presented various findings on associations between PBDE exposure and thyroid function. A study looking at 35 workers occupationally exposed to PBDEs found clinically relevant hypothyroidism associated with exposure, but other studies of occupationally exposed workers failed to find significant correlations between PBDE exposure and thyroid disruption (2, 4, 5).

Chevrier et al. used data collected from women enrolled in the Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS) birth cohort study in California between 1999-2000 to assess the relationship between PBDEs and thyroid hormones in pregnant women (6). Despite this cohort having PBDE levels lower than those reported in pregnant women from the National Health and Nutrition Examination Survey (NHANES), they found a statistically significant inverse relationship between PBDEs and thyroid stimulating hormone (TSH). The data from CHAMACOS did not support a significant relationship between PBDEs and T4, but there was an increased odds of subclinical hypothyroidism in women who were in the highest quartile of summed serum PBDE levels and congeners PBDE-100 and -153. Researchers from the Healthy Pregnancy, Healthy Baby (HPHB) study at Duke University also sought to examine the relationship between PBDEs and thyroid hormone levels in pregnant women (7). The PBDE levels reported in this cohort were similar to those in NHANES; however, they reported different findings from the CHAMACOS group. The data failed to demonstrate a significant relationship between PBDEs and TSH levels but did show an association between T4 and summed serum PBDE levels, congeners PBDE-44, -99, and -100. Given the inconclusive results of these studies in the presence of an established physiologic relationship and negative feedback mechanism involving TSH and T4, additional studies of the association of PBDEs, maternal thyroid hormones, and infant outcomes are warranted.

Additionally, several studies have examined the relationship between PBDE exposure and infant birth outcomes, e.g. birth weight and head circumference, but have somewhat differing results (3, 8-10). Each demonstrated an inverse relationship between increasing PBDE exposure in utero, though not all had statistical significance. Wu et al. recruited 167 pregnant women from provinces in China known as e-waste areas, where electronic or electrical devices are sent to be recycled, and they found a significant association between increasing levels of PBDEs in umbilical cord blood and adverse birth outcomes, like low birth weight (8). They failed to comment on the magnitude of differences in the birth weight with respect to PBDE levels, noting only that they used <2500 grams as the cutoff for low birth weight. Of note, the average levels of PBDEs in their population were lower than those reported in US samples. However, they did not control for potential confounding factors, such as gestational age at birth or maternal weight gain. Harley et al. analyzed the CHAMACOS cohort data from 236 women to assess the relationship between PBDEs and birth weight, and they too found an inverse relationship between increasing PBDE levels and infant birth weight (9). In their study, every 10-fold increase in PBDE-47 level in the mother was associated with a reduction of 115 grams in the infant birth weight. However, unlike Wu and colleagues, when they adjusted for potential confounders, e.g. maternal weight gain, that association became statistically not significant. A group in Sweden also looked at PBDE levels measured in breast milk from 364 women and found that the association between increasing PBDEs and low birth weight was significant only if stratified by gender (3). In an effort to address the differences amongst these studies, Zhao et al. performed a random-effects model analysis for data from 7 studies around the world and conducted a corresponding animal study (11). Their results showed a significant inverse relationship between PBDE exposure and birth weight in both the random-effects model and the animal study.

PBDEs do not degrade in the body easily or quickly due to their lipophilic nature (2). Routes of PBDE exposure can include inhalation of dust particles as well as ingestion from dietary sources or from hand-to-mouth behaviors. Some evidence suggests that, in the U.S., inhalation or ingestion of dust may play a more important role than diet in

PBDE exposure, given strict regulations over flammability that require the treatment or use of PBDEs in the manufacturing and finishing of many household products (2). Moreover, the amount of maternal PBDE exposure may be associated with sociodemographic environments within the U.S. An analysis of NHANES data from 2003-2004 showed that pregnant women are exposed to numerous chemicals that included but were not limited to PBDEs (12). Additionally, research has shown that compared to Caucasians, African Americans have higher serum PBDE levels (13-15).

In general, there have been limited studies investigating predictors of PBDE levels in pregnant women, and the underlying factors associated with elevated levels of PBDE levels among African Americans in comparison to other populations have not yet been elucidated. Caspersen et al. conducted an analysis to ascertain predictors of several different persistent organic pollutants (POPs), including PBDEs (16). They utilized data from the Norwegian Mother and Child Cohort Study (MoBa), which included pregnant women and children recruited from 1999-2008. Variables for exploration included demographics, diet, and lifestyle variables. Pertaining to PBDEs, they found that increasing maternal age was associated with higher PBDE-28 levels and that lower pre-pregnancy BMI correlated with lower PBDE-153 levels. No significant associations between PBDE levels and diet or other lifestyle variables were commented on. While this study does contribute to the body of literature on predictors of PBDEs in pregnant women, it focused more on other POP types, particularly polychlorinated biphenyls. Additionally, the regulations on POPs in Europe are vastly different from the U.S., and the study population consisted of Norwegian women. Therefore, the findings from this study are likely not directly translatable to African-American women living in the U.S.

Herbstman et al. investigated determinants of fetal exposure to PBDEs in 297 deliveries at Johns Hopkins Hospital between November 2004 to March 2005 (15). They collected data via medical record abstraction and umbilical cord blood analysis and found significant predictors of higher concentrations in cord blood in certain PBDE congeners. For PBDE-47, younger maternal age, less weight gain, higher maternal educational attainment, and maternal obesity prior to pregnancy were significant predictors of higher cord blood levels. Smoking during pregnancy was associated with increased levels of PBDE-100 and -153. This cohort consisted of mainly African American mothers (70%), however the investigators did not conduct sub-analyses to delineate if there were racial differences in these associations. Furthermore, the study was limited to data available in the medical record, which did not include dietary or home environment data.

Castorina et al. explored predictors of PBDE levels among pregnant women enrolled CHAMACOS birth cohort (17). They collected data on dietary and household information, and they also included the additional step of a home visit to record and confirm information regarding the furniture, housekeeping, and housing characteristics. Total PBDE levels and levels of PBDE-47, -99, -100, and -153 were significantly associated with having 3 or more stuffed furniture pieces in the home. They did not find any significant associations between PBDEs and dietary intake, which they concluded to be an argument for non-dietary exposures as the main contributor to PBDE levels. A major strength of this study is the inclusion of the home visit to assess furniture and housing conditions. However, the participants were mostly of Hispanic descent and also foreign born, which makes it inappropriate to generalize to the U.S. or other racial groups.

Horton et al. conducted a study in New York City between 2009-2010 to examine the relationships between demographics and lifestyle factors and various PBDE congeners in healthy pregnant women (18). They found that maternal education and having 10 or more household electronics were significantly associated with increasing levels of PBDE-47, -99, -100, and -153. In contrast to the CHAMACOS study, the investigators found a significant association between PBDEs and dietary intake. Increased levels of PBDE-153 were associated with high solid dairy intake as well as increased PBDE-47, -100, and -153 with any processed meat. This discrepancy between the two studies may be a result of the use of different dietary variables, e.g. the CHAMACOS study includes meat as an investigated variable but not specifically processed meat (17). Similar to the CHAMACOS study, the majority of these participants were of Hispanic descent, so the findings may not be generalizable to other populations.

The HPHB study at Duke University recruited a cohort of 140 women in their 34th to 38th week of pregnancy, for which over 80% self-identified as non-Hispanic black women. Buttke et al. investigated associations between self-reported behaviors, e.g. hand-to-mouth behaviors like nail biting, and serum PBDE levels (19). They found statistically significant associations between PBDE serum concentrations and both hand-to-mouth behaviors and owning large electronics but no association with self-reported dietary habits. As noted by the authors, they were able to attribute hand-to-mouth behaviors to <30% of PBDE levels, which left the majority of the elevated PBDE levels unexplained. Additionally, this study did not examine or comment on variables such as smoking status, marijuana use, maternal education level, or maternal body mass index (BMI).

The objective of this study is to correlate various maternal prenatal exposures and/or health behaviors with PBDE levels measured at 8-14 weeks gestation in a cohort of African American pregnant women. Identifying significant predictors of elevated PBDE levels in African American women may suggest potential areas of public health intervention or education.

METHODS

Research Context and Participants

This was an analysis of data available from a set of women who took part in the Emory University African American Microbiome in Pregnancy Cohort Study (20). In that cohort study, pregnant women who self-identify as African American (for purposes of the study defined as U.S.-born women of African American or Black race) were recruited from prenatal care clinics of Grady Memorial Hospital and Emory University Hospital Midtown. Women who presented to either hospital's prenatal clinic for a first prenatal visit between 8 and 14 weeks' gestation, as determined by standard criteria based upon last menstrual period and/or first trimester ultrasound, and self-identified as African American, were offered enrollment in the study. Other inclusion criteria were that women must be between 18 and 40 years of age, expecting a singleton pregnancy, able to comprehend written and spoken English, and have no chronic medical condition or take any prescribed chronic medications (verified by prenatal record). For women enrolled in the main cohort study, data collection – including collection of biological samples, clinical and questionnaire data – occurred at a prenatal care visit occurring between 8 and 14 weeks' gestation and again at a prenatal care visit occurring between 24 and 30 weeks' gestation. After the study had been enrolling women for more than two years, a supplemental grant allowed for women who enrolled in the main cohort study the option of enrolling in an optional environmental study that involved having the research coordinator come to their home between 20 and 24 weeks' gestation to complete a survey about the home environment.

The women included in this analysis included those with available blood samples for PBDE assay along with completed dietary and health surveys, which was a total of 153 participants.

Data Collection

Data collection relevant to the analyses for this study include the following questionnaire and biological items:

Socio-demographic Survey was completed at the 8-14 week prenatal care visit using self-report and prenatal administrative record review to gather information on age, years of education, marital status, and insurance status.

Health Survey was completed by self-report at the 8-14 week prenatal care visit to ascertain substance use (tobacco, alcohol, drugs) within the last month.

Modified Block-Bodnar Semi-quantitative Food Frequency Questionnaire (FFQ) was completed at the 8-14 week prenatal care visit to ascertain dietary and supplement intake over the previous three months of: vitamin D, folate, polyunsaturated fatty acids (PUFAs), essential trace elements, and probiotics (21). Data were collected using NutritionQuest online FFQ, linked to Data-on-Demand, which provides nutrient analysis of the entered data.

Household and Personal Product Use Survey was completed at the 20-24 week optional home visit encounter to ascertain the personal care products and pesticides that were used in the home in the last 48 hours along with the age of the home and furniture in the home. Of note, this optional home visit encounter for the completion of this survey was a supplemental study, introduced more than two years after the cohort was initiated, so was completed by a smaller subset of the cohort for whom other survey and blood data were available.

Blood samples were obtained via antecubital venous blood draw into from a certified phlebotomist and serum for PBDE assays were obtained and stored at -80 degrees Celsius until analysis for PBDE concentrations. Serum aliquots were processed to assess levels of PBDE congeners -47, -85, -99, -100, -153, -154, and lipid weights. Briefly, serum samples were fortified with isotopically labeled analogues of the target chemicals, homogenized and deproteinated. Supernatant was extracted twice with hexane: dichloromethane and passed through activated silica gel column to remove residual biogenic material. Sample extracts were concentrated and analyzed using gas chromatography-tandem mass spectrometry with isotope dilution calibration. Patient serum samples were extracted according to a modified Bligh and Dyer lipid extraction protocol (22).

Data from the health survey and FFQ and laboratory data were entered into REDCap software. Additional information on study protocol has previously been described in the literature (20).

Data Analysis

The hypothesis of this study was that increasing PBDE levels in this cohort of African-American women would be associated with higher intake of fat or animal protein, lower socioeconomic status (SES) as indicated by having Medicaid prenatal insurance, and older couches or activities that increase the likelihood of dust inhalation, e.g. broom use or shaking out rugs, or hand-to-mouth behaviors (proxied in this analysis by tobacco and marijuana use). The potential predictors evaluated in this study included dietary intake of solid fat, oil fat, total dairy, total meat/fish/poultry, high omega-3 fish, lunch meat, organ meat, age of sofa, broom use, shaking out rugs, insurance type, tobacco use, and marijuana use.

Study analysis

All analyses were performed using Statistical Analysis Software (SAS) version 9.4. Serum PBDE levels below the limit of detection (LOD) were assigned a value of the LOD divided by the sample volume divided by the square root of 2 (23). For a subset of the samples where lipid weights were available, serum PBDE levels were adjusted for lipid weight by dividing the PBDE concentration in pg/mL by the lipid weight in g/mL and then dividing by 1000 to calculate ng/g lipid. The concentrations of the individual congeners were converted to molar units and then summed together to create a summed PBDE variable. Serum PBDE levels were then log transformed to approximate a normal distribution. Nutrient data, e.g. intake of oil fat in grams or high omega 3 fish in ounces, obtained from the FFQs were divided into quartiles.

Pearson correlations were evaluated between PBDE congeners and the variables of interest from the dietary and home environment data. Chi-squares were calculated to compare the subset of participants with home environment data versus the whole cohort. Multivariable linear regressions models were constructed with the PBDE congeners as the dependent variable, both unadjusted and adjusted for lipids, and the dietary data as potential predictors. Sub-analyses were performed with the home environment variables as potential predictors in regression models. The covariates included in the regression models were selected using both a stepwise and backwards regression. An alpha of 0.05 was used to assess statistical significance in all analyses.

RESULTS

The sociodemographic characteristics of the study cohort are presented in Table 1. The mean age of the women in this cohort was 24.9 years of age, and the majority of participants were single or not married (83%). A minority of the participants indicated tobacco (8.5%) or marijuana use (22.9%). Most of the participants obtained at least a high school or GED level of education (82.4%). Medicaid was the predominant form of insurance with 116 participants or 75.8% having prenatal Medicaid health insurance.

Serum concentrations of PBDE -47, -99, and -100 were measured above the LOD in over 70% of study participants (Table 2). Table 3 describes the distribution of dietary and home environment factors among the study participants. The mean intake of high omega-3 fish was 0.16 ounces with a standard deviation (SD) of 0.20. The average servings of dairy in this study cohort was 1.38 with a SD of 1.01. In the subset of study participants who provided data on the home environment, a majority indicated that the age of her couch was <5 years old (61.9%), and the number that participated in shaking out a rug during cleaning was almost evenly divided (47.6% indicating no and 52.4% indicating yes for that activity). Table 4 shows a comparison between all participants and those that provided home environment data. The calculated chi-squares were statistically significant when comparing the two groups on the basis of tobacco use and highest level of educational obtainment (p = 0.02 and 0.05 respectively).

Table 5 indicates the dietary and home environment predictors that were statistically significant in the multivariate linear regressions at an alpha of 0.05 for each individual congener as well as the summed PBDE value. The best fit model of dietary predictors for PBDE-47 included intake of high omega-3 fish and insurance status (R^2 =

0.07), in which Medicaid was associated with higher levels of PBDE-47. The sub-analysis with home environment variables indicated the age of the couch, shaking out the rug, and marijuana use as the best model (R^2 = 0.15), but when included with the dietary data, only the older age of the couch explained the variance in PBDE-47 levels (R^2 = 0.24). In the models evaluating for the summed PBDE value, the older age of the couch was also significantly associated with increasing levels (R^2 = 0.28).

DISCUSSION

Prior studies, including the CHAMACOS study and the HPHB study, have examined PBDE levels and their associations with dietary, environmental, and behavioral data in pregnant women (17-19). This study is one of the few examining predictors of increasing PBDE exposure in non-Hispanic African-American women, who have been shown to have disproportionately higher levels of PBDEs as compared to non-Hispanic Caucasian women (13-15, 24). Elucidating the factors contributing to increasing PBDE levels is important for potential public health interventions, as PBDE exposure has been associated with adverse health outcomes (2-5).

In this study cohort, three of the six PBDE congeners were detectable above the LOD in over 50% of samples (PBDE-47, -99, and -100), of which PBDE-47 was detectable in 100% of the samples. Given that the majority of the levels for congeners -85, -153, and -154 had to be imputed, the results associated with those congeners should be interpreted with caution. In this study, PBDE-47 accounts for the majority of the summed PBDE value.

There have been varying conclusions in the literature regarding the importance of dietary intake in influencing PBDE burden in pregnant women. Three studies have found no association between self-reported dietary intake and PBDE levels (16, 17, 19). The study conducted by Horton et al., on the other hand, found increased levels of PBDE-153 with high solid dairy intake and increased levels of PBDE-47, -100, and -153 with intake of processed meat (18). As previously discussed, this discrepancy may be a result of the use of different dietary variables, e.g. meat in general versus processed meat. Similar to the Horton study, this study showed that intake of dairy may contribute to increasing

PBDE-153 levels ($R^2 = 0.09$), however given the small R^2 and the low detection rate of this congener in this cohort, this result is mildly suggestive of an association rather than definitive. With PBDE-47, the dietary model including higher intake of omega-3 rich fish was statistically significant, but the association was not significant after adjusting for lipid weights. These results support the conclusions of prior studies that dietary ingestion is likely not a vital component of elevated PBDE levels in pregnant women.

The data in this study do support the findings of prior studies that non-dietary exposures may contribute more to PBDE burden than dietary intake (17-19). Commercial use of PBDEs as flame retardants in the U.S. has only recently been completely phased out (at the close of 2013), which suggests that having older furniture, upholstery, or textiles may be potential sources of personal exposure to PBDEs (1). An analysis of the cord PBDE levels collected from women enrolled in the Columbia Center for Children's Environmental Health Mothers and Newborns birth cohort between 1998 and 2006 found that higher cord PBDE levels were associated with vacuuming but lower levels with damp mopping, which may trap dust rather than stirring it up into the air to be readily inhaled (24). This suggests that cleaning activities that move dust in the air may play a role in increasing PBDE levels. When including both dietary and home environment variables in the regression analysis, having a couch older than 5 years old was associated with increasing levels of PBDE-47 and the summed PBDEs (R^2 of 0.24 and 0.28, respectively). In the sub-analysis considering only home environment data, the activity of shaking out a rug and the age of the couch were included in the best fit model for PBDE-47, though these results are only suggestive of the importance of home environment, given the R^2 of 0.15 in this model.

A recent study conducted by Darrow et al. correlated serum PBDE levels in young children with PBDE levels measured from house dust and hand wipes during a home visit and found an association between increasing PBDE levels and lower SES as measured by median household income in the residential zip code (25). Horton et al. also examined the relationship between PBDE levels and SES as indicated by self-reported annual household income (18, 24). They reported an association between increasing PBDE-47 levels and lower SES but increasing PBDE-153 levels with higher SES. Cowell et al. found an association between lower maternal education level, which can be a proxy of lower SES, and rising PBDE levels (24). In this study, having Medicaid insurance predicted higher levels of PBDE-47 but private insurance predicted higher levels of congeners -100 and -154. However, the R^2 were 0.09 or less, and in the analysis considering all potential predictors which include both dietary and home environment data, the effect of insurance on PBDE levels was not found to be statistically significant. The differences in association between various congeners and SES may be due to the difference in commercial use. The penta-BDE mixture previously used in furniture consists mainly of congeners -47, -99, -100, and -153 whereas the compound more frequently used for electronics was the octa-BDE, which is mostly congeners -153 and -183 (26).

There are several limitations to this study. Lipid weights were available for 58 of the study participants, so lipid adjustments to the PBDE levels (expressed as ng/g lipid) were not complete for the entire cohort, as is standard in the field. PBDEs are lipophilic and are stored in fat in the body (2). Adjusting for lipids allows for a better estimate of the PBDEs in the serum and consequently the level in serum that is available to cross the placenta and potentially affect fetal development (23). Similar to prior studies, the nutrient data was calculated from an FFQ based on the participants' recall of the prior three months of food and supplement intake, which is not an objective measure.

Additionally, the sub-analyses of home environment relied on an optional home survey completed by a limited number of participants. The chi-square analyses indicated that the characteristics of those who did and those who did not complete the home survey were not statistically significant except when looking at tobacco use and maternal education level. Those who completed the home survey had a higher percentage of tobacco use and had higher levels of educational obtainment. The self-reported home data also do not provide an objective measure of dust exposure and thereby potential PBDE exposure via inhalation or hand-to-mouth behaviors.

FUTURE DIRECTIONS

The findings of this study support the work of prior studies that implicate the home environment, or dust in the home environment, as an important source of the PBDE burden in pregnant women, whether through inhalation or hand-to-mouth behaviors (17-19, 24). Continued exploration of the home environment or diet needs to incorporate objective measures that do not rely on participant recall and reporting and involve larger scale study cohorts. The study conducted by Darrow et al. found a positive correlation between the PBDE level measured in the serum and the PBDE level measured in hand wipes (25). This finding supports the association between hand-to-mouth behaviors and increased PBDE levels found in the HPHB study and suggests a potential public health intervention. Public health campaigns targeted towards frequent handwashing and avoidance of hand-to-mouth behaviors may be effective in reducing total PBDE burden.

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TABLES

Table 1. Demographic characteristics of the study participants

	All participants (N = 153)		**Participants with home environment data** (N = 42)	
	Mean	**SD**	**Mean**	**SD**
Age	24.94	4.65	26.17	4.6
	N	**%**	N	%
Marital status				
Single	127	83	33	79
Married	26	17	9	21
Tobacco use				
No	140	92	34	81
Yes	13	8	8	19
Marijuana use				
No	118	77	34	81
Yes	35	23	8	19
Highest education obtained				
Less than high school	1	1	1	2
Some high school	26	17	4	10
High school or GED	50	33	19	45
Some college/technical	49	32	7	17
College	15	10	7	17
Some graduate	12	8	4	10
Insurance				
Medicaid	116	76	32	76
Private	37	24	10	24
BMI at first prenatal visit				
<18.5	7	5	2	5
18.5-24.9	61	40	14	33
25-29.9	28	18	10	24
≥30	57	37	16	38

Table 2. PBDE levels (in pg/mL) measured in the serum

Congener	N	% > LOD[a]	Geometric mean	Min	Median	Max
PBDE-47	153	100	84.82	17.70	83.38	1382.08
PBDE-85	153	3	0.04	<LOD	<LOD	172.53
PBDE-99	153	78	4.47	<LOD	19.39	341.98
PBDE-100	153	73	1.87	<LOD	15.38	289.20
PBDE-153	153	27	0.30	<LOD	<LOD	301.35
PBDE-154	153	10	0.13	<LOD	<LOD	373.64
Summed PBDE[b]	153		287.30	36.70	285.12	3562.29

[a]LOD = limit of detection

[b]The summed PBDE was calculated from the total of each congener in molar units.

Table 3. Dietary and home environment characteristics of the study participants

Dietary intake (N = 153)	**Mean**	**SD**
Oil fat, in g	19.47	12.01
Solid fat, in g	47.70	26.38
Total dairy, in servings	1.38	1.01
Total meat/fish/poultry, in oz	1.63	1.50
High omega-3 fish, in oz	0.16	0.20
Lunch meat, in oz	0.78	0.87
Organ meat, in oz	0.03	0.13
Home environment (N = 42)	**N**	**%**
Age of couch		
<5 years old	26	62
>5 years old	16	38
Shakes out a rug		
No	20	48
Yes	22	52
Uses broom		
No	5	12
Yes	37	88

Table 4. Comparison of the study cohort with and without home environment data

	All participants (N = 153) %	**Participants with home environment data** (N = 42) %	**Chi-square**	**p value**
Marital status			0.5808	0.446
Single	83	79		
Married	17	21		
Tobacco use			5.1564	0.0232
No	92	81		
Yes	8	19		
Marijuana use			0.4469	0.5038
No	77	81		
Yes	23	19		
Highest education obtained			11.1499	0.0485
Less than high school	1	2		
Some high school	17	10		
High school or GED	33	45		
Some college/technical	32	17		
College	10	17		
Some graduate	8	10		
Insurance			0.0009	0.9767
Medicaid	76	76		
Private	24	24		
BMI at first prenatal visit			1.2366	0.7442
<18.5	5	5		
18.5-24.9	40	33		
25-29.9	18	24		
≥30	37	38		

Table 5. Results of multivariate linear regressions using dietary and home environment data

	Dietary predictor analysis[a] (N = 153)	**Lipid adjusted dietary predictor analysis**[a] (N = 58)	**Home environment predictor analysis**[b] (N = 42)	**All predictors**[c] (N = 22)
PBDE-47	Medicaid Insurance, intake of high omega-3 fish $R^2 = 0.07$		Older age of couch, shakes out rug, marijuana use $R^2 = 0.15$	Older age of couch $R^2 = 0.24$
PBDE-85	Tobacco exposure $R^2 = 0.06$			
PBDE-99				Intake of solid fat, intake of total dairy $R^2 = 0.07$
PBDE-100		Private Insurance $R^2 = 0.08$	Marijuana use $R^2 = 0.10$	
PBDE-153		Intake of total dairy $R^2 = 0.09$		
PBDE-154	Private Insurance $R^2 = 0.05$	Private Insurance $R^2 = 0.09$		Intake of lunch meat $R^2 = 0.18$
Summed PBDE				Older age of couch $R^2 = 0.28$

Models were evaluated for statistical significance at an alpha of <0.05.
[a]Variables considered in this analysis included oil fat, solid fat, total dairy, total meat/fish/poultry, high omega-3 fish, lunch meat, tobacco, marijuana, and insurance
[b]Variables considered in this analysis included age of couch, rug shaking, broom use, tobacco, marijuana, and insurance
[c]Variables considered in this analysis included all variables from the dietary and home environment analyses

APPENDIX

Table A1. Results summary of all multivariate linear regression models

	Dietary predictor analysis[a] (N = 154)		Lipid adjusted dietary predictor analysis[a] (N = 101)		Home environment predictor analysis[b] (N = 45)		All predictors[c] (N = 45)	
	Stepwise approach	Backwards approach	Stepwise approach	Backwards approach	Stepwise approach	Backwards approach	Stepwise approach	Backwards approach
PBDE-47	Medicaid Insurance, intake of high omega-3 fish $R^2 = 0.07$	Medicaid Insurance, intake of high omega-3 fish	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	Older age of couch, shakes out rug, marijuana use $R^2 = 0.15$	Older age of couch $R^2 = 0.24$	Older age of couch
PBDE-85	Tobacco exposure $R^2 = 0.06$	Tobacco exposure	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance
PBDE-99	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	Intake of solid fat, intake of total dairy $R^2 = 0.07$
PBDE-100	No variable met statistical significance	No variable met statistical significance	Private Insurance	Private Insurance	Marijuana use	Marijuana use	No variable met statistical significance	No variable met statistical significance

			$R^2 = 0.08$		$R^2 = 0.10$			
PBDE-153	No variable met statistical significance	No variable met statistical significance	Intake of total dairy $R^2 = 0.09$	Intake of total dairy	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance	No variable met statistical significance
PBDE-154	Private Insurance $R^2 = 0.05$	Private Insurance	Private Insurance $R^2 = 0.09$	Private Insurance	No variable met statistical significance	No variable met statistical significance	Intake of lunch meat $R^2 = 0.18$	Intake of solid fat, intake of high omega-3 fish, intake of meat/fish/poultry, shakes out rug
Summed PBDE	No variable met statistical significance	No variable met statistical significance			No variable met statistical significance	No variable met statistical significance	Older age of couch $R^2 = 0.28$	Older age of couch

Models were evaluated for statistical significance at an alpha of <0.05.
[a]Variables considered in this analysis included oil fat, solid fat, total dairy, total meat/fish/poultry, high omega-3 fish, lunch meat, tobacco, marijuana, and insurance
[b]Variables considered in this analysis included age of couch, rug shaking, broom use, tobacco, marijuana, and insurance
[c]Variables considered in this analysis included all variables from the dietary and home environment analyses