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Associations between serum levels of Polybrominated Diphenyl Ether (PBDE) flame retardants and environmental and behavioral factors in pregnant women

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Abstract

Background—Polybrominated diphenyl ethers (PBDE) are flame retardants that were previously used in upholstery, fabrics, and household appliances. PBDEs have been linked to adverse health outcomes, including neurotoxicity, thyroid hormone dysregulation, endocrine disruption, and poor semen quality. Because PBDEs pass into placental circulation, maternal exposures can approximate fetal exposures.

Objectives—Our objectives were to determine if diet and specific human behaviors were significantly associated with PBDE exposures in a cohort of pregnant women.

Methods—Women between the 34th and 38th week of pregnancy were given a questionnaire about behavioral, environmental, and dietary factors and asked to provide blood samples. Serum PBDE levels were measured using GS-MS and lipid adjusted. An adjusted ordinary least squares regression model was run to identify potential associations between behaviors and serum PBDE levels.

Results—Serum concentrations of BDEs 47, 99, 100, and 153 were found above the limit of detection in at least 50% of study participants and used in our models. Associations with serum PBDEs were observed with self-reported hand-to-mouth behaviors, including biting nails and licking fingers. Serum BDE levels of 47, 99, 153, and total PBDEs were also significantly higher in those individuals owning a large screen TV compared to those who did not. Serum PBDE levels were comparable to levels reported in the general population.

Conclusions—Hand-to-mouth behaviors may influence serum PBDE concentrations in adults. Household electronics such as large-screen TV's appear to serve as a significant source of PBDEs

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in pregnant women. Together, hand-to-mouth behaviors and TV ownership may serve as a route of exposure to PBDEs in adults.

Introduction

Polybrominated diphenyl ethers (PBDEs) are a class of synthetic flame retardant chemicals found in increasing levels in the environment and human tissues (Harrad and Hunter 2006; Sjodin et al. 2008b; Zhang et al. 2011). PBDEs have been widely used in electronics, foam upholstery and furniture, and other household materials since 1965. Until very recently, PBDEs were found in over 90% of electronic appliances and may constitute up to 30% of the weight of some textiles and furniture (Alaee et al. 2003).

PBDEs are stable, lipophilic compounds that bioaccumulate and biomagnify in the environment and food chain (Darnerud et al. 2001). PBDEs are sold as commercial mixtures according to their bromine content, and include Penta-, Octa- and Deca-BDEs (WHO 1994). These compounds are found in marine and freshwater sediments, and biomagnify in both freshwater and marine food webs (Christensen and Platz 2001; Klosterhaus et al. 2011; Lacorte et al. 2003; Law 2003; Lim and Lastoskie 2011). The ubiquitous and persistent nature of PBDEs led to concerns about their safety and effects on wildlife and human health. PBDEs have now been associated with adverse neurodevelopment outcomes and neurotoxicity, thyroid hormone dysregulation, decreased semen quality in males, and *in vitro* endocrine disruption ((Abdelouahab et al. 2011; Chen et al. 2011; Chevrier et al. 2010; He et al. 2008; He et al. 2011; He et al. 2009; Herbstman et al. 2010; Stapleton et al. 2011; Verner et al. 2011)). In the last decade, PBDEs have received international attention as a persistent organic pollutant linked to adverse health effects, and thus have been subject to environmental regulations (UNEP 2009). The penta- and octa-BDEs mixtures were banned from production in the European Union in 2004 and the sole North American manufacturer voluntarily ceased production that year prior to the formal ban in ten US states (Tullo 2003). Deca-BDE was banned in Sweden in 2007, the states of Maine and Washington in 2008, and in Canada in 2009 (BSEF 2009).

Although considerable data document the presence of PBDEs in the environment and human and animal tissues, less is known about PBDE exposure sources in humans. Diet has been hypothesized to be one of the largest source of PBDEs, similar to other POPs such as PCBs and dioxins (Bocio et al. 2003; Domingo 2004; Harrad et al. 2004; Kiviranta et al. 2004). However, measured levels of PBDE in food sources cannot alone account for levels measured in human serum and breastmilk, nor can dietary sources explain the 3 to 10 fold higher levels in the US population compared to Canada or Europe, as PBDE levels in food items are very similar between the US and Canada/Europe (Frederiksen et al. 2009). More recent studies suggest that house dust is a significant source of exposure to PBDEs as significant associations between PBDEs in dust and serum have been observed (Johnson et al., 2010; Wu et al. 2007). Furthermore, Stapleton et al. (2008) measured PBDEs on hand wipe samples, suggesting hand to mouth contacts may also be a source of exposure for this class of contaminants. To further understand the source of PBDE exposure, we evaluated potential hand to mouth behavior, dietary sources, and indoor sources of exposure to PBDEs in a cohort of pregnant women to determine common exposure pathways and sources.

Because the developing fetus is particularly susceptible to adverse health effects of PBDE exposures and PBDEs distribute freely into placental circulation, we were particularly interested in understanding PBDE exposures in pregnant women and how their serum PBDE levels compared with those of the general public (Gomara et al. 2007).

Materials and Methods

Participant Recruitment

The Duke University Institutional Review Board approved a research protocol for recruiting pregnant women into this study. Participants in this study were recruited from within an ongoing parent study assessing the effect of social, environmental, and host factors on pregnancy outcomes (the Healthy Pregnancy, Healthy Baby Study). A subset of enrolled patients, (greater than 34 weeks pregnant) were approached during their prenatal appointments at the Durham County Health Department's Prenatal Clinic which is held at the Lincoln Community Health Center in Durham, NC and asked if they wished to participate. Consenting individuals filled out a short questionnaire about lifestyle characteristics including diet, electronics, video games, and electronic usage, and a blood sample was collected during their visit. We asked participants to self-define large-screen TV. Blood samples were collected in 10 mL tubes and centrifuged at 3500 RMP for 5 minutes to isolate the serum. The 10 mL tubes (approximately 4–5 grams of serum) were then stored at −20°C until analysis for PBDEs. The Duke University laboratory analyzed these samples for a suite of 27 PBDEs. Results presented here are from samples collected between September 2008 and June 2010.

Sample Analysis

All solvents used for the analysis were HPLC-grade or better. The recovery of FBDE-69 was assessed by addition of 13C labeled 2,2′,3,4,5,5′-hexachlorinated diphenyl ether (Cambridge Isotope Laboratories, Andover, MA). Serum samples analyzed at Duke University were extracted using a previously published method (Johnson et al. 2010; Stapleton et al. 2011). Extracts were analyzed for PBDEs using a gas chromatograph (GC, Agilent 5890) coupled to a mass spectrometer (Agilent 5975) operated in electron capture negative ionization (GC/ECNI-MS) mode. SRM 1958 (Fortified Human Serum; NIST, Gaithersburg, MD) was used for quality assurance and bovine serum and deionized water as blanks. Minor laboratory contamination with BDE-47 and BDE-99 was observed and all samples were blank subtracted using the average blank measurement for these congeners. Minimum detection limits (MDL) were calculated at 3 times the standard deviation of the blanks divided by the sample mass extracted. The MDLs for the remaining congeners were determined by calculating the mass equivalent to three times the background signal and dividing by the sample size.

Statistical Analysis

Statistical analysis was done using SAS 9.2 software (SAS Institute Inc.; Cary, NC). Serum PBDE concentrations below the limit of detection were assigned a value of one-half the minimum detection limit for analysis of congeners detected in more than half of the samples. We log-transformed the serum PBDE concentrations to approximate a normal distribution for use in an ordinary least squares regression model. Based on a literature search, we adjusted our model for mother's country of birth (USA or other country), because PBDEs production and regulations vary between countries, race (Non-Hispanic Black or other) as Non-Hispanic Blacks have higher PBDE levels compared to other races (CDC 2009), educational status (high school graduate versus non-high school graduate), employment status (yes/no), and smoking status (ever versus never smoker), as smoking is associated with higher breastmilk PBDE levels (Lind et al. 2003). For hand-to-mouth behaviors, responses were categorized as no, sometimes, or yes. An alpha of 0.05 was used for statistical significance in all comparisons. Individual serum BDE measurements were not significantly correlated; thus, we analyzed BDE measurements as single compounds as well as summed as total PBDEs.

Results

Study participants

Between September 2008 and June 2010, 140 pregnant women from Durham County, NC enrolled in this study. Women were between the 34th and 38th week of pregnancy at the time of survey and blood collection. Demographic information on study participants is shown in Table 1. The mean age of participants was 22.6 years of age, with a range of 18 to 39. The majority of participants (72.5%) had completed a high school education or less, and 85.9% identified themselves as non-Hispanic black by race or ethnicity. The majority of participants (65.0%) were unemployed at the time of the survey. Over ninety-three percent of participants were not married at the time of survey, 13.6% were current smokers, and 40.7% were nulliparious. Of the 140 study participants, 15 individuals, or 10.7%, were born outside the United States. Table 2 describes the number and percent of the study population who participated in various behaviors and environmental factors. The mean number of TV's in the home was 0.9, with a range of 0 to 18, and the mean number of computers in the home was 2.7, with a range of 0 to 7. The mean number of hours spent on the computer per day was 2.4.

PBDE measurements

Serum concentrations of BDE congeners 47, 99, 100, and 153 were found above the limit of detection in over 50% of study participants (Table 3). Each of these congeners was summed as the variable total PBDE. Geometric mean levels ranged from 4.25 ng/g (95% confidence interval (CI): 3.56–5.08) for 2,2′,4,4′,6-pentabromodiphenyl ether (BDE 100) to 16.8 ng/g (95% CI: 13.89–20.27) for 2,2′,4,4′-tetrabromodiphenyl ether (BDE 47). Total PBDE levels ranged from 3.59 to 694 ng/g lipid. BDE 47 was the most abundant congener, contributing approximately 50% of the total PBDE burden (Stapleton et al. 2011).

Associations between behavior, environmental factors and serum PBDE levels

We analyzed congeners found above the limit of detection, namely BDEs 47, 99, 100, and 153, separately and as a total PBDE, in an ordinary least squares (OLS) regression model using various behavioral and environmental factors as predictors. These analyses were conducted as exploratory data analysis to inform final model construction. Adjusted models included mother's country of birth, race, education, employment status, and smoking status.

Variables that increased model fit were selected for inclusion in multivariate models and included the hand-to-mouth behaviors of licking fingers and biting nails as well as large-screen television ownership (Table 4). No significant associations between dietary consumption habits or other environmental factors and serum PBDE levels were seen.

Based on our exploratory data analysis, we included self-reported hand to mouth behaviors of biting nails and licking fingers, as well as owning a large-screen TV as predictors of serum PBDE concentrations in a multivariate linear regression model. In general, the magnitude and strength of associations were increased when both hand-to-mouth behaviors (nail-biting alone and nail-biting and finger-licking combined) and having a large-screen tv in home were combined in the model (Table 5). There was a significant association between combined hand-to-mouth behaviors of nail-biting and finger-licking, the presence of a large screen TV in the home and serum levels of all BDE congeners and total PBDE levels (BDE 47 $p=0.006$; BDE 99 $p=0.003$; BDE 100 $p=0.002$; BDE 153 $p=<0.0001$; total PBDE $p=0.006$). In separate models evaluating each risk factor, those with a large-screen television in the home have on average 1.6 times higher total PBDE serum levels than those without a large-screen television in the home. Individuals reporting licking fingers had 1.2 times the total PBDE serum levels than individuals who did not lick their fingers, while individuals reporting biting their nails had 1.3 times the levels of total serum PBDEs.

Discussion

The serum levels and distributions of PBDE congeners in this cohort were similar to levels reported among the United States population in the 2003–2004 National Health and Nutrition Examination Survey (NHANES) (Sjodin et al. 2008a). In the NHANES study, PBDE congener levels were higher in younger, and non-Hispanic black populations compared to older populations and other ethnicities. Our study population was predominantly non-Hispanic black, pregnant young adult females, and levels of PBDEs within our study population were consistent with levels in a similar ethnicity and age group in a non-pregnant sampling of the general US population (Sjodin et al. 2008). This is particularly interesting given the apparent lower socio-economic status of our study population, with a high unemployment rate and relatively low educational level.

A previous study measured PBDEs on samples of hand wipe collected from adults (Stapleton et al., 2008), suggesting that hand to mouth activities may be a source of exposure to PBDEs. We therefore hypothesized that adults with frequent hand-to-mouth behaviors were more likely to ingest PBDE containing dust particles. Furthermore, levels of PBDEs in house dust would be influenced by the electronics present in the home, specifically, electronics that may have higher PBDE applications, such as large televisions. Previous studies have observed significant relationships between PBDEs in house dust and bromine present in television sets (Allen et al., 2008). We tested this hypothesis and found significant associations between self-reported hand-to-mouth behaviors, the presence of large screen televisions in the home, and the serum levels of various PBDE congeners. We also report an effect of hand-to-mouth behaviors of nail-biting and finger-licking and the presence of a large-screen television in the home in a multivariate model that includes standard covariates for serum PBDE models.

Based on this study, we are unable to determine if the ingestion of PBDE-contaminated house dust during hand-to-mouth behaviors or an unknown factor that promotes PBDE exposure. However, because house dust is known to contain high levels of PBDEs (Allen et a. 2006; Stapleton et al. 2005), one can plausibly assume that hands contaminated with house dust through contact with household surfaces act as a vehicle for house dust consumption, similar to what is hypothesized to occur in young children, who are known to have a high propensity for hand-to-mouth behaviors (USEPA 1997).

Inhalational exposure to PBDEs has also been hypothesized to contribute to total body burden of PBDEs, with inhalation of both volatilized PBDEs in indoor and outdoor air as well as house dust as routes of exposure (Allen et al. 2007; Stapleton et al. 2005; Zhang et al. 2011). However, inhalation routes were not sufficient to explain a significant amount of PBDE body burdens(Allen et al. 2007). Indoor air has higher levels of PBDEs than outdoor air, and indoor air concentrations are positively correlated with dust concentrations of PBDEs (Hazrati and Harrad 2006; Harrad et al. 2006). Indeed, indoor air particulate PBDE concentrations are over 10 to 200 times lower than house dust concentrations (Allen et al. 2008a; Stapleton et al. 2008; Webster et al. 2008). Therefore, consumption of contaminated house dust particles through hand-to-mouth behaviors could be a more important exposure pathway for PBDEs (Johnson et al. 2010). In our study, hand-to-mouth behaviors explained less than 30% of the serum BDE levels; therefore, other exposure pathways, such as inhalation or additional passive ingestion of housedust, likely contribute to the remaining, unexplained PBDE burden.

Alternately, handwashing behaviors may modify the relationship between hand-to-mouth behaviors and serum PBDE levels. Watkins et al. showed that handwashing behavior significantly affects the amount of PBDEs found on hands (Watkins et al. 2011). This may in turn influence the amount of PBDEs ingested during hand to mouth behaviors. Our study did not include handwashing behaviors in the questionnaire; however, it is plausible that those with greater handwashing behavior have lower PBDE concentrations in the face of frequent hand-to-mouth behaviors. Including handwashing behavior as a modifider of the relationship between hand-to-mouth behaviors and serum PBDE concentrations may improve our ability to explain PBDE exposure routes.

The association between large-screen televisions and non-Deca-BDE serum PBDE levels is unexpected. Televisions have typically been associated with the use of Deca-BDE (i.e. BDE-209) in high impact polystyrene found in TV casings, rather than the lower-brominated PBDEs measured here (Allen et al. 2008b; Choi et al. 2009). However, it is possible that Penta-BDE applications may be found in internal components of the TVs. This has not been evaluated to our knowledge. It is also possible that the large-screen TV is a proxy for ownership of other electronic devices or generally a higher number of electronic devices. Our study population reported a wide range in number of TVs owned, which may result in several types of TVs in the home with varied construction or design. Importantly, the applications of different PBDE commercial mixtures likely differs by TV design, with PBDE levels much lower in newer LCD TVs than compared to cathode ray TVs (Imm et al. 2009). Given the relatively high unemployment rate and relatively low educational level of our study population, we hypothesize that some of the TVs owned in the multiple TV households are cathode ray TVs.

This study is subject to certain limitations. Because our study cohort consisted of women in the third trimester of pregnancy, it is possible that self-reported consumption and behavioral habits may have changed during pregnancy and may not reflect typical diets or behaviors. Our dietary questionnaire was limited to frequency and type of foods consumed, but did not collect detailed information on quantity or source of food. Furthermore, we are unable to assess the validity or accuracy of self-reported and recalled hand-to-mouth behaviors. Given the long half-lives of PBDEs in the body (Thuresson et al. 2006), serum PBDE levels may be the result of early- or pre-pregnancy behaviors not reflected in self-reported responses. We are unaware of how behaviors may change during pregnancy that might influence exposures, but hypothesize that diet would be among the greatest behavior affected. Other pregnancy-modified activities, such as time spent outdoors, introduction of new electronic appliances to the household, etc, have not been evaluated but might increase exposures to PBDEs during pregnancy. In addition, hand to mouth behaviors data are difficult to collect and complex to analyze. Unfortunately, we do not have information on household dust levels of PBDEs by study participant; therefore, we cannot confirm that it is the ingestion of contaminated dust during hand-to-mouth behaviors. It is possible that direct contact with treated products (e.g. furniture and electronics) could lead to sorption of PBDEs to the hand surface and thus lead to exposure. Previous studies have found significant associations between PBDE residues as measured on hand wipes with serum PBDE levels (Watkins et al. 2011). We also do not account for the multiple comparisons made across all the models presented in Tables 4 and 5. Other sources of PBDEs, such as textiles, were not evaluated and may be an important source of PBDEs in the home. Because this is the first study documenting a relationship between hand-to-mouth behaviors in adults and serum PBDE levels, this finding requires replication to evaluate residual confounding in this relationship.

Finally, although we attempted to measure BDE 209, low-level background contamination in the sample blanks resulted in all values being below the limit of detection, as reported elsewhere (Stapleton et al. 2011). BDE-209 is one of the greatest contributors to indoor air PBDEs, and thus likely an air contaminant of office and laboratory environments (Harrad and Abdallah 2008). Although levels of this congener are typically low in most non-fish food items and population serum and also in our serum as the levels in blanks were at or below those reported in the general population, we cannot evaluate differences in BDE 209 congener levels in our study. BDE-209 is poorly absorbed and has a shorter half-life (two weeks) than other PBDEs, which may account for the lack of detectable BDE-209 in our study (Thurresson et al. 2006; Huwe et al. 2008). Therefore we cannot determine whether BDE-209 was not detected because it was not absorbed by our study population or if the study population had been exposed but the congener had degraded by the time of serum collection and/or assay.

In conclusion, we report here a significant association between serum PBDE levels in pregnant women with self-reported hand-to-mouth behaviors and presence of large TVs, computers and video game electronics in the household. This is the first study to our knowledge to document a relationship between hand-to-mouth behaviors in adults and serum PBDE levels. Further study is needed to examine the relationship between PBDEs in dust and presence of PBDEs on the hand surfaces, which may act as a primary vehicle for PBDE exposure. This may have implications for public health recommendations, and suggests that increased frequency of handwashing and/or decreased hand-to-mouth behaviors could be promoted by public health officials to decrease exposures to PBDEs.

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Table 1

Demographics of study participants

	Mean (Range)
Age	22.6 (18–39)
	Frequency (Percent)
Education	
Some high school	32 (23.2)
High school	68 (49.3)
Some college	30 (21.7)
Associates degree	2 (1.5)
Bachelors degree	6 (4.4)
Missing	2 (1.5)
Race/ethnicity	
White	12 (8.9)
Black	116 (85.9)
Hispanic	7 (5.2)
Other	2 (1.5)
Missing	5 (3.6)
Country of Birth	
USA	125 (89.3)
Other country	15 (10.7)
Employment	
Employed	49 (35.0)
Unemployed	91 (65.0)
Marital Status	
Married	8 (5.7)
Single	132 (94.3)
Tobacco use	
Current	19 (13.6)
Ever	67 (48.2)
Parity	
First pregnancy	57 (40.7)

Table 2

Behavioral, environmental, and dietary characteristics of the study population.

	Yes	Sometimes	No	Unknown/Missing
	N (%)	N(%)	N (%)	N (%)
Hand-to-mouth behaviors				
Lick fingers	52 (37.1)	40 (28.6)	48 (34.3)	
Bite nails	40 (28.8)	27 (19.4)	72 (51.8)	
Chew hair	0 (0)	1 (0.7)	139 (99.3)	
Bite pencil	4 (2.9)	3 (2.1)	133 (95.0)	
Any Behavior	113 (80.7)	0 (0)	27 (19.3)	
Electronics				
Large-screen TV in home	34 (24.3)		106 (72.1)	5 (3.6)
Video game system in home	59 (42.1)		79 (56.4)	2 (1.4)
Dietary habits (times consumed per week)	**0**	**1–2**	**3–4**	**>4**
Beef	5 (3.6)	70 (50.0)	52 (37.1)	13 (9.3)
Chicken	2 (1.4)	47 (33.6)	69 (49.3)	22 (15.7)
Pork	29 (20.7)	86 (61.4)	20 (14.3)	5 (3.6)
Fish	62 (44.3)	67 (47.9)	7 (5.0)	4 (2.9)
Dairy (servings per day)	0 (0.0)	56 (40.3)	68 (48.9)	15 (10.8)
Milk Type (skim, 1%, 2%, whole)	0 (0.0)	8 (5.7)	63 (45.0)	66 (47.1)
Fast Food	9 (6.5)	76 (54.7)	42 (30.2)	12 (8.6)

Table 3

PBDE and metabolite concentrations (ng/g lipid) measured in serum from pregnant women (N=140).

Variable	MDL[1]	Detection Frequency (%)	Geometric Mean (95% CI)	Min	Max	Percentiles			
						25th	50th	75th	95th
BDE 28	1.2–3.0	38.6	N/A[2]	<1.2	16.89	---	---	2.57	5.31
BDE 47	2.0–4.5	95.0	16.8 (13.89 – 20.27)	<2.0	297.45	9.13	18.88	33.32	112.49
BDE 66	1.2	2.1	N/A	<1.2	3.93	---	---	---	---
BDE 99	2.0–4.5	65.0	4.85 (3.86 – 6.10)	<2.0	249.08	1.00	5.50	12.67	49.48
BDE 100	1.2	89.3	4.25 (3.56 – 5.08)	<1.2	107.45	2.26	4.65	7.38	27.08
BDE 85, 155	1.2	17.1	N/A	<1.2	10.49	---	---	---	4.06
BDE 153	1.2	96.4	6.03 (5.19 – 7.01)	<1.2	67.55	3.82	5.74	9.96	32.10
BDE 154	1.2	49.3	N/A	<1.2	52.89	---	---	2.42	7.21
Σ PBDEs[3]	N/A	N/A	N/A	3.59	693.95	20.63	36.87	65.46	210.49

[1] Minimum detection limit

[2] Not applicable (N/A): geometric means cannot be calculated for compounds found at under 50% detection frequency.

[3] ΣPBDEs variable includes BDEs found above the limit of detection in at least 50% of study participants, including BDE 47, BDE 99, BDE 100, and BDE 153. PBDE values below the detection limit were included as ½ the MDL for each respective compound.

Table 4

Results of adjusted ordinary least squares regression model[1] between lipid-adjusted serum PBDE levels and various behavioral, dietary, and environmental factors in pregnant women.

	BDE 47		BDE 99		BDE 100		153		Total PBDE	
	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P
Hand-to-mouth behaviors										
Lick fingers	0.16	0.33	0.22	**0.05**	0.15	0.09	0.12	0.70	0.12	0.70
Bite nails	0.18	0.07	0.19	**0.01**	0.18	**0.02**	0.15	**0.02**	0.15	**0.02**
Chew hair	0.15	0.52	0.22	**0.02**	0.14	0.10	0.11	0.57	0.11	0.57
Bite pencil	0.15	0.87	0.18	0.67	0.14	0.17	0.11	0.79	0.11	0.79
Any hand-to-mouth behavior	0.14	0.91	0.18	0.42	0.13	0.13	0.12	0.47	0.12	0.47
Electronics										
Large-screen TV in home	0.20	**0.005**	0.17	**0.03**	0.13	0.20	0.25	**0.0007**	0.21	**0.007**
Video game system in home	0.15	0.27	0.17	0.81	0.14	0.08	0.12	0.24	0.12	0.24
Number of TVs in home	0.15	0.83	0.18	0.61	0.13	0.15	0.11	0.85	0.11	0.85
Number of computers in home	0.15	0.43	0.18	0.70	0.13	0.13	0.11	0.97	0.11	0.97
Sum of TV/Computers in home	0.15	0.43	0.18	0.70	0.13	0.13	0.11	0.97	0.11	0.97
Sum of electronics in home[†]	0.21	0.36	0.17	0.63	0.06	>0.99	0.26	0.08	0.17	0.67
Hours spent on computer	0.23	0.69	0.22	0.51	0.22	0.51	0.33	0.09	0.24	0.20
Dietary habits (times consumed per week)										
Beef	0.15	0.82	0.12	0.83	0.12	0.83	0.19	0.49	0.13	0.24
Chicken	0.15	0.97	0.12	0.66	0.12	0.66	0.18	0.84	0.14	0.24
Pork	0.16	0.57	0.14	0.32	0.14	0.32	0.18	0.94	0.14	0.20
Fish	0.16	0.68	0.13	0.59	0.13	0.59	0.18	0.76	0.14	0.18
Dairy	0.15	0.86	0.12	0.60	0.12	0.60	0.19	0.40	0.13	0.19
Milk Type (skim, 1%, 2%, whole)	0.15	0.78	0.11	0.87	0.11	0.87	0.18	0.98	0.14	0.19
Fast Food	0.17	0.48	0.13	0.57	0.13	0.57	0.20	0.35	0.14	0.19
Alcohol consumption[‡]	0.15	0.90	0.11	0.88	0.11	0.88	0.18	0.60	0.14	0.18
Environment										
Type residence[††]	0.16	0.58	0.13	0.48	0.13	0.48	0.18	0.92	0.14	0.18

	BDE 47		BDE 99		BDE 100		153		Total PBDE	
	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P
Pets in home	0.15	0.50	0.11	0.51	0.11	0.51	0.19	0.15	0.14	0.11
New furniture in home	0.15	0.93	0.15	0.06	0.15	0.06	0.18	0.74	0.13	0.18
Vacuum frequency	0.18	0.25	0.13	0.61	0.13	0.61	0.19	0.47	0.15	0.13
Flooring type**	0.16	0.56	0.13	0.80	0.13	0.80	0.20	0.42	0.14	0.18
Air conditioning type	0.15	0.95	0.11	0.99	0.11	0.99	0.18	0.72	0.13	0.20

[1] Model is adjusted for mother's country of birth, race, education level, employment status, and smoking status.

[2] The variables number of TVs and number of computers were categorized into 0, 1–2, 3–4, ≥5.

Table 5

Results of an adjusted ordinary least squares regression model[1] using both the presence of electronics in home and hand-to-mouth behaviors as predictors of lipid-adjusted BDE congener serum levels in pregnant women.

	BDE 47			BDE 99			BDE 100			BDE 153			Total PBDE		
	R^2(p)	B (SE)	P	R^2(p)	B (SE)	P	R^2(p)	B (SE)	P	R^2(p)	B (SE)	P	R^2(p)	B (SE)	P
Model 1	0.12 (0.02)			0.13 (0.01)			0.15 (0.004)			0.24 (<0.0001)			0.13 (0.01)		
Lick fingers		0.13 (0.12)	0.28		0.11 (0.14)	0.43		0.16 (0.11)	0.14		0.17 (0.09)	0.05		0.17 (0.10)	0.09
Bite nails		0.20 (0.12)	0.08		0.35 (0.14)	0.01		0.32 (0.11)	0.003		0.27 (0.08)	0.002		0.25 (0.09)	0.01
Model 2	0.14 (0.006)			0.14 (0.005)			0.11 (0.02)			0.24 (<0.0001)			0.16 (0.002)		
Large screen TV		0.55 (0.23)	0.02		0.66 (0.28)	0.02		0.52 (0.22)	0.02		0.52 (0.17)	0.003		0.49 (0.19)	0.01
Model 3	0.16 (0.006)			0.18 (0.003)			0.18 (0.002)			0.28 (<0.0001)			0.20 (0.0006)		
Lick fingers		0.11 (0.12)	0.37		0.09 (0.14)	0.55		0.17 (0.11)	0.14		0.15 (0.08)	0.08		0.12 (0.10)	0.21
Bite nails		0.16 (0.12)	0.18		0.33 (0.14)	0.02		0.30 (0.11)	0.009		0.23 (0.08)	0.008		0.20 (0.10)	0.04
Large screen TV		0.54 (0.23)	0.02		0.62 (0.27)	0.03		0.49 (0.21)	0.02		0.47 (0.16)	0.004		0.47 (0.19)	0.01

[1] Model is adjusted for mother's country of birth, race, education level, employment status, and smoking status