Declines in serum PBDEs in older California women may have reached a plateau (2011-2015)

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INTRODUCTION

Since the1970s, flame retardants have been added to consumer products to meet flammability standards, including California's Technical Bulletin 117. Due to the widespread use, Americans have much higher levels of flame retardants in their bodies than others, and California children have some of the highest levels ever reported[1]. Regulatory and voluntary measures resulted in the discontinuation of the use of PBDEs[2], but few US data are available to evaluate the success of the phase-out. Using serum collected between 2011 and 2015 from over 1,200 older California women, we conducted a temporal analysis of serum PBDEs.

MATERIALS AND METHODS

The study population consisted of 1,253 participants drawn from the California Teachers Study (CTS), a prospective cohort study of 133,479 female school employees[3]. Participants had no prior history of breast cancer, lived in California, and completed a questionnaire at blood draw.

Blood was collected into a 10 mL BD® tube (catalog#367985, Becton Dickinson). At the laboratory, specimens were stored at -20 °C until analysis. Samples were analyzed using automated solid phase extraction (Biotage) and gas chromatography/high resolution mass spectrometry (DFS, ThermoFisher).[4] Briefly, samples (2 mL) were fortified with labeled standards and formic acid and water were added. Oasis HLB cartridges (3 cc, 500 mg, Waters Co.) and acidified silica were used for sample extraction and clean-up. The final eluates were concentrated and spiked with recovery standards. Bovine serum pre-spiked with target analytes and NIST SRM 1958 were used for QA/QC.

Only three congeners with detection frequencies (DF) greater than 75% were included in the current analysis. Temporal trends were initially evaluated by plotting the concentration versus the date of collection. Linear models were used to regress the $\log_{10}$-transformed serum concentration on serum collection date. Time trend coefficients (β) were converted to annual percent increase (API) by $\text{API} = 100*(10^{\beta} - 1)$.

RESULTS AND DISCUSSION

Summary statistics are shown in Table 1 and concentrations are plotted against date of serum collection (Figure 1). Concentrations of all three congeners displayed considerable variability. While no dramatic temporal trends are obvious, linear and spline fits suggest a modest increase in concentrations.

For both BDE-47 and BDE-100, the final regression models included only race/ethnicity; for BDE-153 it included only age. Table 2 presents results from linear regression models, expressed as the estimated average annual percent increase (API) in PBDE concentrations. Our

results indicate that, in this population of older adult California women, average PBDE levels modestly increased between 2011and 2015.

While our study population is the largest ever studied, some limitations are worth noting. Although we adjusted for temporal differences in age and race/ethnicity, our results could be biased by confounding by unmeasured factors. Our regression models only captured a small proportion of the overall variability in PBDE levels and the confidence intervals for our beta coefficients were wide. Consequently, estimates of average API should be interpreted with caution. A strength of our study is that all participants were selected from the same well-defined underlying population of CTS participants.

Our results differ from those of three studies that reported secular decreases in US PBDE levels.[5-7] One possible reason for the discrepancy is the marked difference in age groups that were evaluated. Our population was comprised entirely of older women while these other studies focused on newborns, pregnant and lactating women. It is possible that observed differences reflect age-related differences in the uptake, metabolism or elimination of PBDEs. Few studies have examined PBDEs among older women as did ours. An analysis of NHANES (2003-2004) did note a two-fold increase in the proportion of participants over the age of 60 with BDE-47 concentrations above the 95th-percentile.[8] Our results suggest that identifying determinants of PBDE levels among older individuals may be important.

It has been hypothesized that, following the PBDE phase-out, temporal trends in PBDE body burdens would mirror trends observed for PCBs, with an initial sharp decline, followed by a plateau.[9] Our results support this hypothesis. The fact that we do not observe declines, and see some evidence for increases, suggests that any initial declines following the PBDE phase-out may no longer be occurring.

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Table 1. PBDE serum concentrations among 1,253 study participants.

Compound	Detection Frequency	Serum Concentration (ng/g lipid)			
		Mean	Median	Minimum	Maximum
BDE-47	88%	25.24	13.37	1.94	749.67
BDE-100	78%	5.04	2.33	0.30	186.31
BDE-153	80%	11.88	4.89	0.74	379.31

Table 2. Annual Percent Increase (API) in PBDE serum concentrations: results from linear models.

	Unadjusted			Adjusted [a]		
Compound	API [b]	95% CI[c]	p-value	API[b]	95% CI[c]	p-value
BDE-47	4.0	−0.42, 8.6	0.0770	5.6	0.99, 10	0.0170
BDE-100	10.0	5.5, 16	<0.0001	12.0	6.8, 17	<0.0001
BDE-153	7.4	2.4, 13	0.0036	7.1	2.1, 12	0.0047

[a] BDE-47 and BDE-100 adjusted for race/ethnicity; BDE-153 adjusted for age.
[b] Annual Percent Increase (API) converted from time trend coefficients (β) obtained from regressing $\log_{10}$ PBDE concentration (ng/g lipid) on date of sample, expressed as year and fraction of a year, where API = $100*(10^{\beta} - 1)$.
[c] CI = 95% confidence interval.

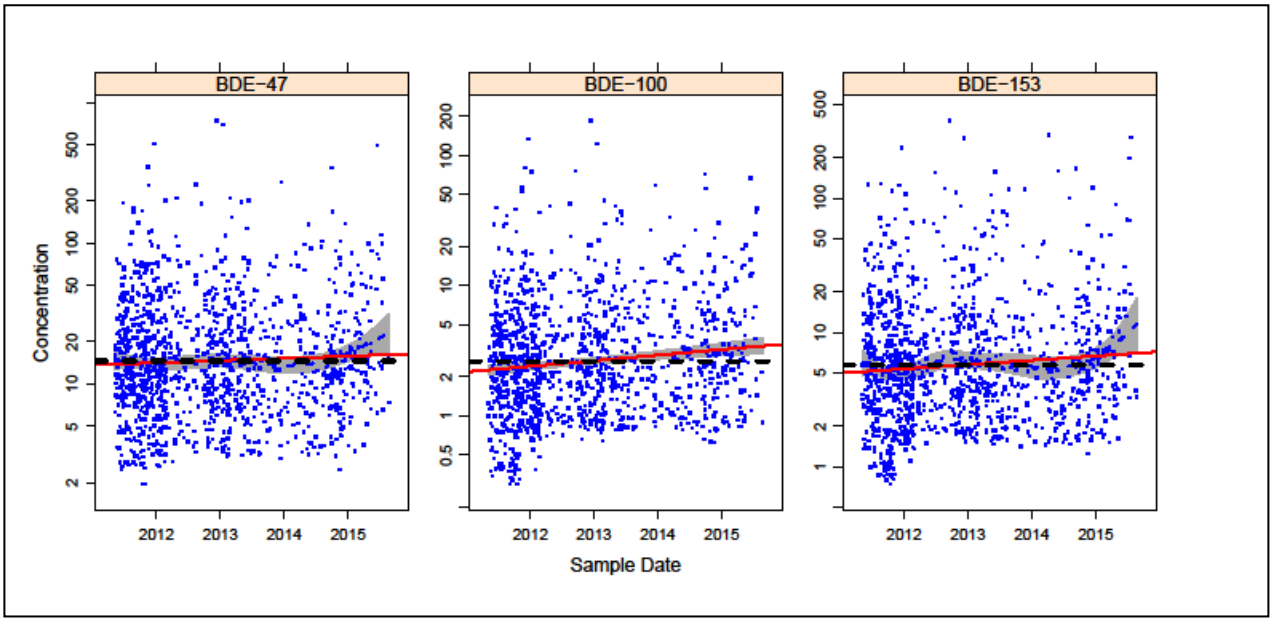

Figure 1. PBDE serum concentrations (ng/g lipid) by date of serum collection.[a]

[a] Dashed blue line and gray shading in plots for BDE-47 and BDE-153 denote spline fit and 95% confidence interval (spline for BDE-100 was identical to the linear fit); red line denotes linear fit; Dashed black line denotes overall mean (i.e., a null association). Percent of variance accounted for by marginal spline fits ranged from 1% for BDE-47 to 2% for BDE-153.