Exposure to Flame Retardant Chemicals and Social Behavioral Outcomes in Early Childhood

- Authors -

Molly L. Kile, Shannon Lipscomb, Megan MacDonald, Megan McClelland,

Richard P. Scott, Steven G. O'Connell, Kim Anderson

College of Public Health and Human Sciences

OSU Oregon State University

Conflict of Interest Statement

Dr Kim Anderson invented the silicone passive sampler wristband.

• Received NIH Small Business Innovation Research and Small Business Technology Transfer grants to commercialize this technology

• Formed a MyExposome which is dedicated to creating an awareness of, and a market for, passive environmental monitors such as the silicone passive sampler wristband

• May financially benefit from the outcomes of this research

Dr Kim Anderson developed the analytical method for measuring 41 flame retardants and examining the analytical data quality.

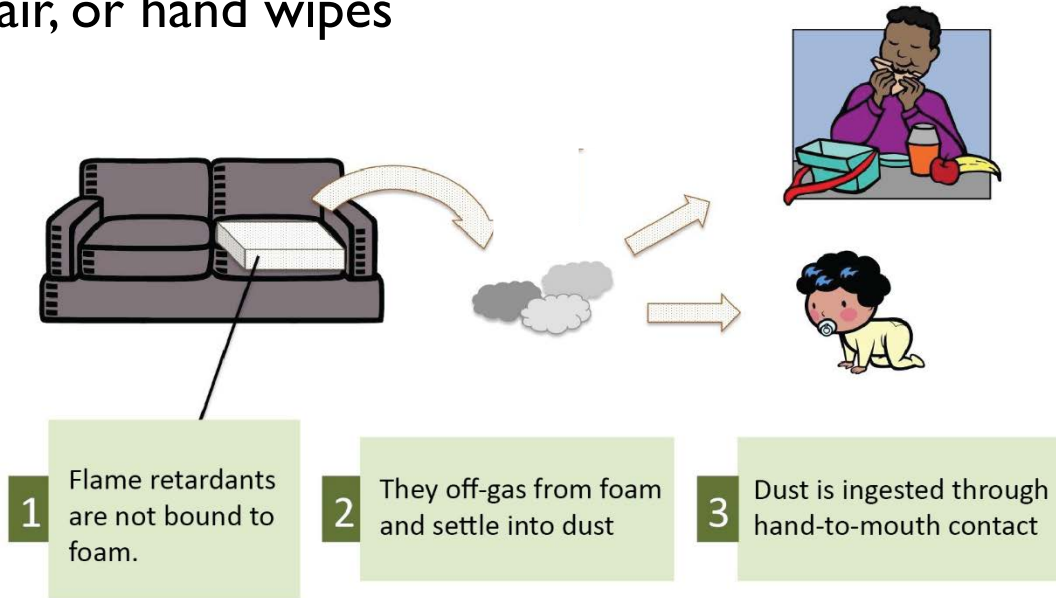• Blinded to all data collected on the participants and did not participate in any data analysis.

The other investigators declare no conflict of interest.

Outline

1. Background on sampling flame retardants

2. Introduce study design

3. Flame retardant exposure in Oregon preschool-aged children

4. Association between flame retardant exposure and social behaviors

5. Strengths and limitations

Background

- Polybrominated diphenyl ethers (BDEs) and organophosphate flame retardants (OPFRs) leach into the indoor environment

- There are concerns that exposure to these compounds contribute to adverse health effects

- Exposure to these compounds are typically measured in blood, house dust, indoor air, or hand wipes

| 1 | Flame retardants are not bound to foam. | 2 | They off-gas from foam and settle into dust | 3 | Dust is ingested through hand-to-mouth contact |

Silicone Passive Sampling Technology

O'Connell, Kincl and Anderson, ES&T, 2014

- Lipophilic organic compounds passively diffuse into the silicone

- Provides a time-weighted average exposure

- Can be worn in all conditions

- Can reflect dermal and inhalation pathways

- Can be transported at room temperature

- Have been tested for 1,527 analytes

- Details provided by Dr Anderson
  http://fses.oregonstate.edu/methods

Interplay Study Design

- Cross sectional study from Oct 2012 - Jan 2013

- Preschool children in two Oregon communities aged 3-5 years (N=92)

- Collected house dust, hand wipes, and child wore wristband for 7 days

- Parent completed socio-demographic questionnaires

- Preschool teacher completed Social Skills Improvement System Rating Scale to measure children's social behaviors in classroom settings

  - 7 subscales (Communication, Cooperation, Assertion, Responsibility, Empathy, Engagement, Self-Control, Externalizing, Bullying, Hyperactivity/Inattention, and Internalizing)

  - We combined the three subscales of externalizing behavior problems (externalizing, hyperactivity/inattention, and bullying) into an aggregated outcome

Interplay Study Design

- Created a standardized "family context" score
  - Aggregated of maternal education, paternal education, maternal employment, paternal employment, household income, and home learning environment

- Adverse social experiences aggregated score (range: 0 to 4)
  - Lived with an adult with substance abuse
  - Lived with an adult with a mental health issue
  - Experienced violence, trauma or neglect
  - Witnessed domestic violence

Ethical Statement

- All research activities were approved by Oregon State University's Institutional Review Board

- All parents gave informed written consent and children gave assent before partaking in any research activity

- Results from the chemical results from the wristbands were returned to the parents.

- All parents were given resources created by the Agency for Toxic Substances and Disease Registry and the Oregon Environmental Council's Eco-Health Homes Checkup Kit

Variables	N	%Male	%Female		
Child gender	92	64%	36%		
		%No	%Yes		
Mother employed	86	34%	66%		
Father employed	60	12%	88%		
	N	M	SD	Min	Max
Child age in years	88	4.31	0.68	3.12	5.75
Family context					
Mother's Education in years	86	16.30	3.67	10	34
Father's Education in years	64	16.08	3.02	10	24
Household income[a]	86	5.22	2.84	1	8
Home learning environment[b]	88	0.01	1.00	-2.80	1.82
Adverse experiences	90	0.40	0.81	0	4

	N	M	SD	Min	Max
Self-control	89	1.73	0.61	0.14	3.00
Externalizing aggregate	89	0.76	0.48	0.00	2.06
Internalizing	89	0.61	0.47	0.00	1.86
Teacher-rated social behavior					
Communication	89	1.94	0.50	0.29	3.00
Cooperation	89	1.96	0.61	0.67	3.00
Assertion	89	1.65	0.52	0.14	2.86
Responsibility	89	1.95	0.51	0.75	3.00
Empathy	89	1.93	0.58	0.50	3.00
Engagement	89	1.90	0.53	0.57	3.00

OSU Oregon State University

Exposure Assessment (n=72)

- 92 pre-cleaned wristbands were distributed and returned via mail in sealed PTFE bags

  - 77 were returned for analysis (83.7%)

  - 5 samples were excluded (6.5%)

- Extraction method described in O'Connell et al 2014, *Env. Sci. Technol. 46(6)*

- GC-MS method for 41 analytes

- Recovery surrogate of FBDE-118 (73±32%) or FBDE-126 (93±29%)

- LOQ ranged from 0.77 to 26.5 ng/g wristband

OSU **Oregon State University**
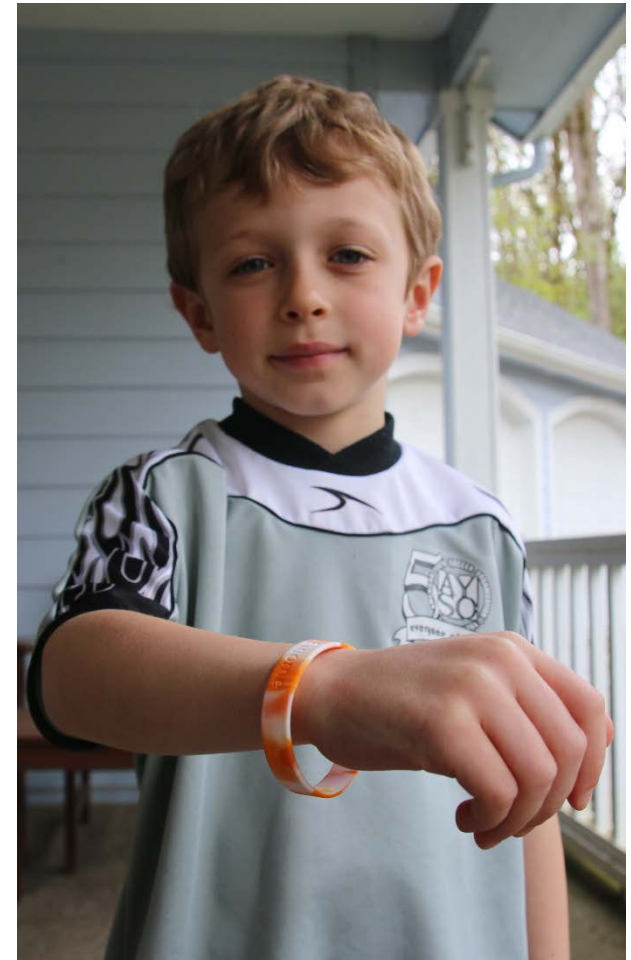
Most abundant flame retardants in wristbands (60% or more above detection limit)
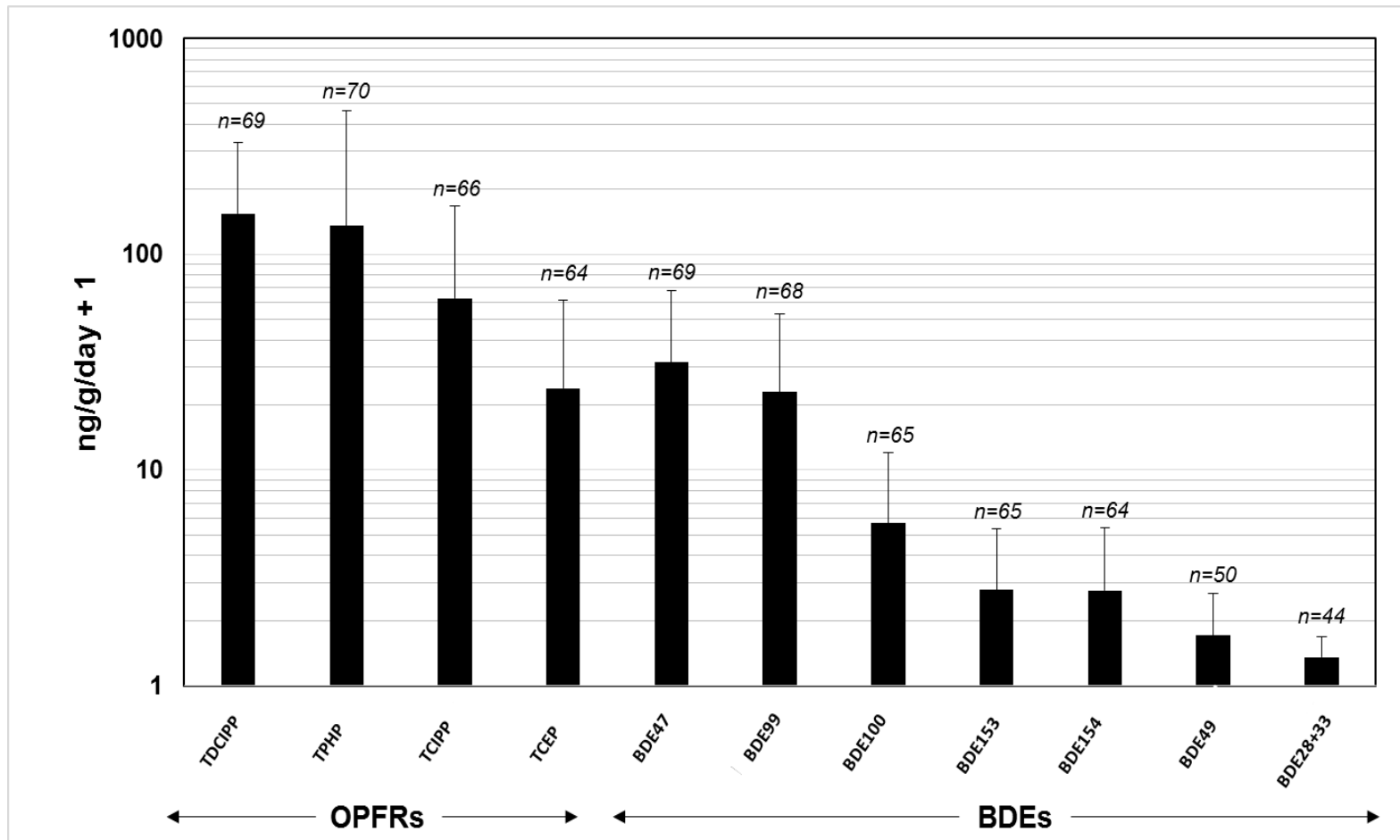
Kile et al, Env. Research 2016

Factors associated with total levels of different classes of flame retardants measured in wristbands based on multivariate linear regression models

Ln ΣOPFR (ng/g/d)	Estimate (β)	SE	p-value
Intercept	4.67	0.36	<0.01
Vacuum frequency (≥ 6 times/month)	-0.10	0.23	0.68
Home age (≥ 2005)	0.74	0.27	0.01
Family context	-0.36	0.18	0.05
Ln ΣBDE (ng/g/d)	Estimate (β)	SE	p-value
Intercept	4.53	0.46	<0.01
Vacuum frequency (≥ 6 times/month)	0.48	0.29	0.10
Home age (≥ 2005)	-0.65	0.35	0.06
Family context	-0.28	0.23	0.21

Family Context = standardized aggregated score that includes parental education, parental employment status, annual household income, 14 items related to the home learning environment.

OSU Oregon State University

Multiple regression analyzes that examined the relationship between two classes of flame retardants and social behavior subscales (n= 69) adjusted for gender, age, family context, and child's exposure to adverse experiences.

	Assertion	Responsibility	Externalizing
	B (SE) â	B (SE) â	B (SE) â
Covariates			
Gender [a]	0.21 (0.10) 0.21*	0.44 (0.10) 0.43**	-0.29 (0.10) -0.30**
Age	0.32 (0.07) 0.44**	0.24 (0.07) 0.33**	-0.12 (0.10) -0.18
Family Context	0.13 (0.08) 0.18[†]	0.21 (0.08) 0.27**	-0.21 (0.11) -0.32[†]
Adverse Experiences	0.04 (0.07) 0.06	-0.04 (0.07) -0.05	0.31 (0.10) 0.42**
Flame Retardants			
Ln ΣPBDE	**-0.13 (0.04) -0.31****	**0.03 (0.04) 0.07**	**-0.05 (0.10) -0.04**
Ln ΣOPFR	**0.09 (0.06) 0.15**	**-0.16 (0.06) -0.25****	**0.24 (0.10) 0.31***
R square	0.41	0.44	0.35
R square for model without Flame Retardant variables	0.28	0.29	0.19

[a] 0 = male, 1=female   *Note*. B = Unstandardized Estimate. *SE* = Standard Error. *â* = Standardized Estimate [†]$p < .10$. *$p < .05$. **$p < .01$.

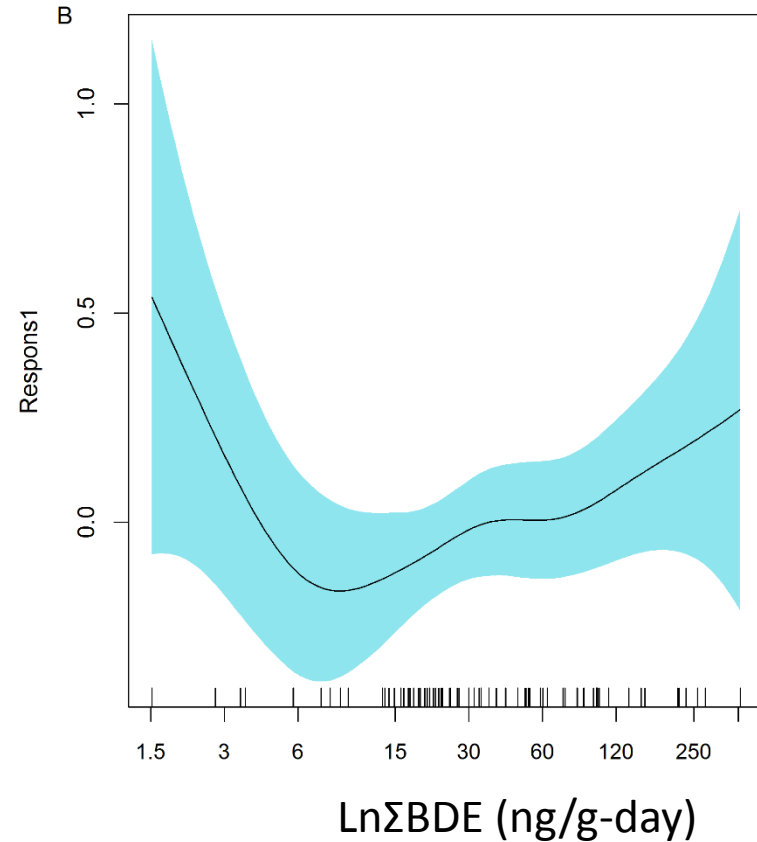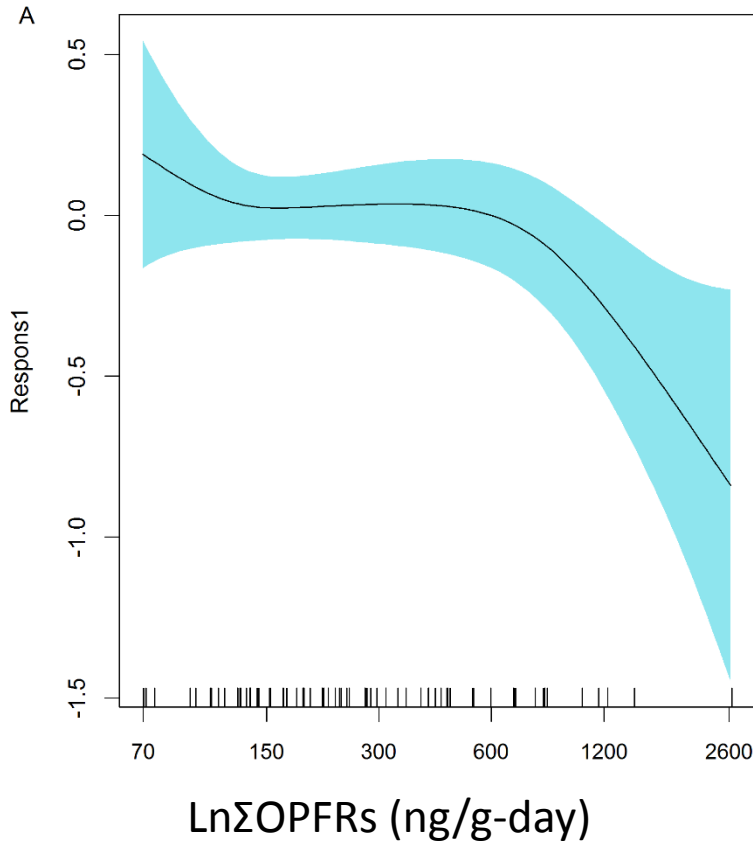# Associations between LnΣOPFRs and LnΣBDE with Externalizing Behavior Subscale

Adjusted for family context, age, sex, and child adverse social experiences
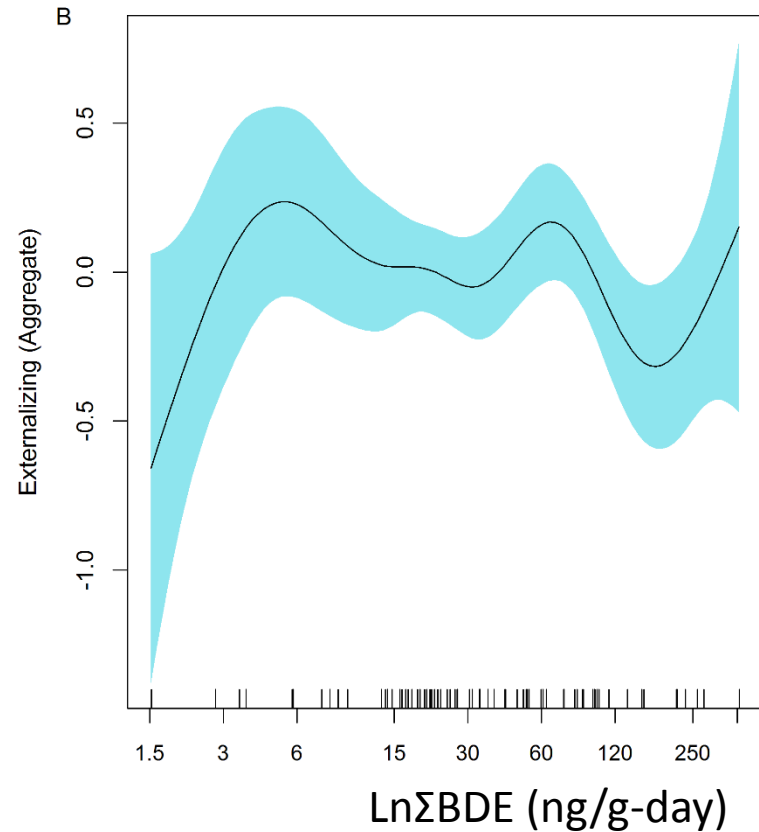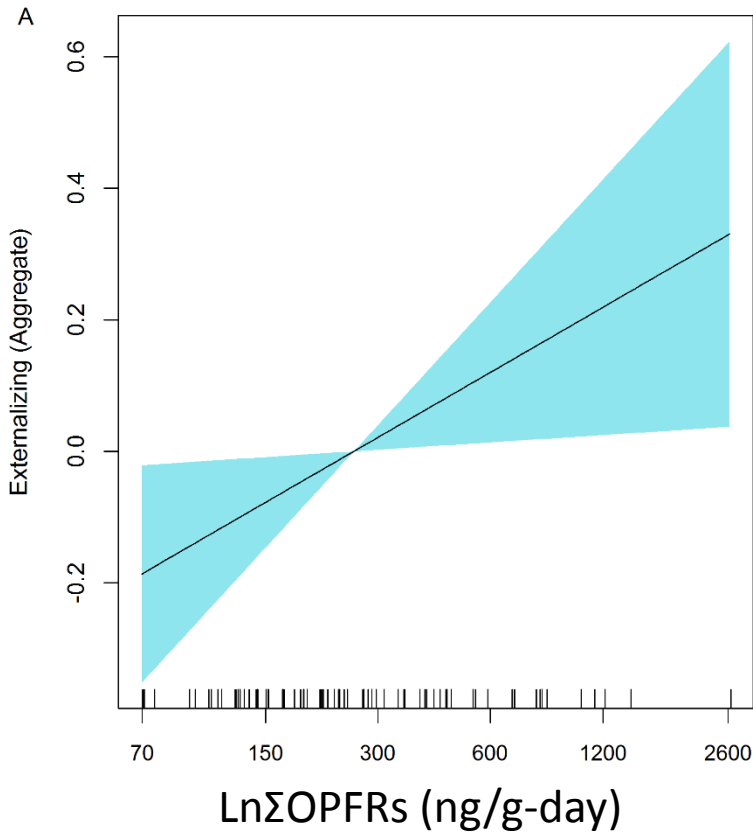
Curve	% of deviance explained	Sample size (n)	P-value
A) LnΣOPFRs (ng/g-day)	34.8%	69	0.027
B) LnΣBDEs (ng/g-day)	46.8%	69	0.303

OSU Oregon State University

# Associations between LnΣOPFRs and LnΣBDE with Responsibility Behavior Subscale

Adjusted for family context, age, sex, and child adverse social experiences

Curve	% of deviance explained	Sample size (n)	P-value
A) LnΣOPFRs (ng/g-day)	47.8%	69	0.069
B) LnΣBDEs (ng/g-day)	48.8%	69	0.243

Associations between LnΣOPFRs and LnΣBDE with Assertion Behavior Subscale

Adjusted for family context, age, sex, and child adverse social experiences
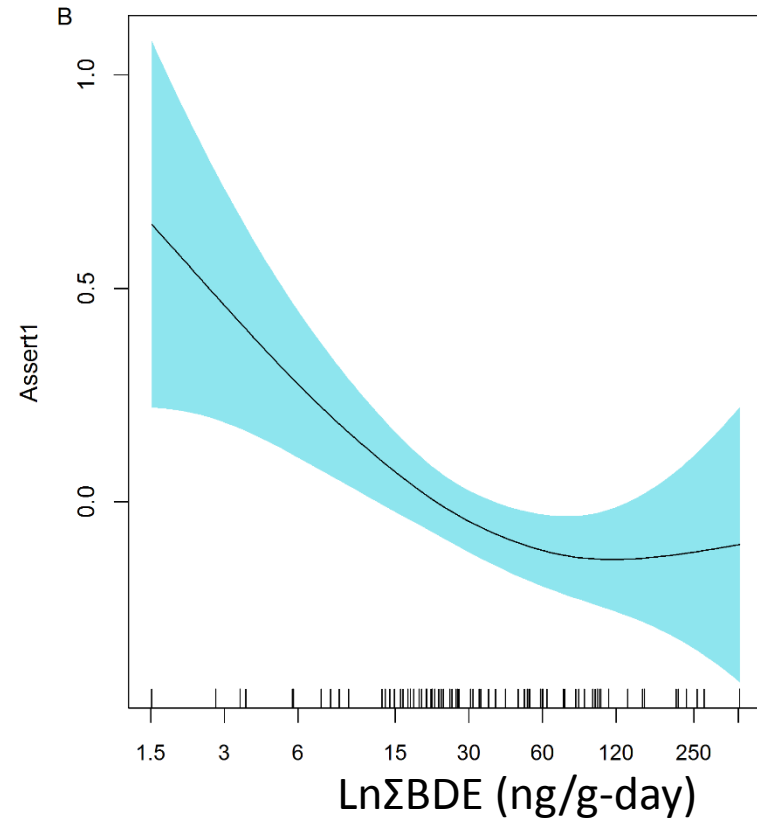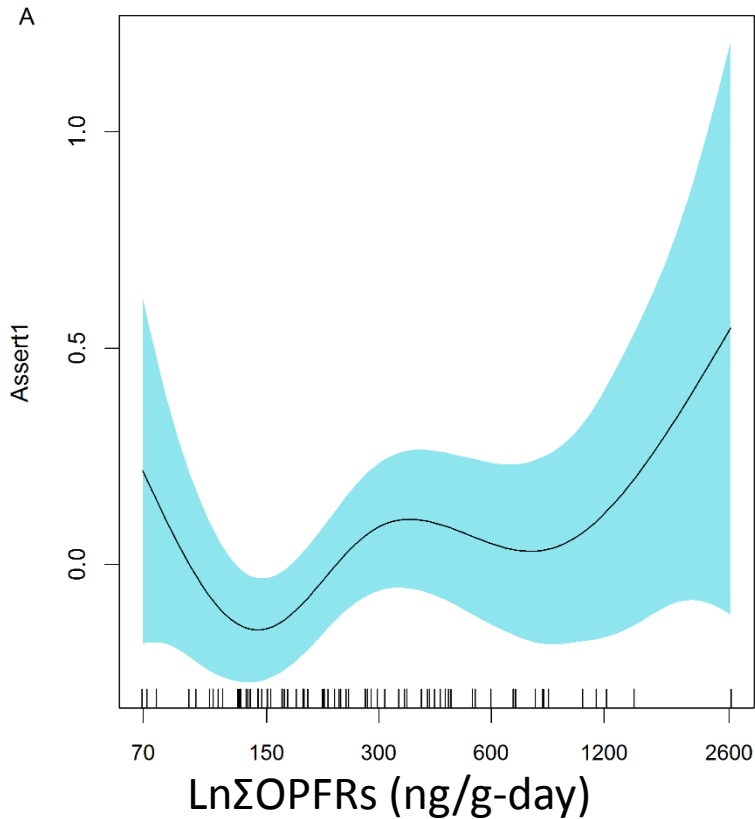
Curve	% of deviance explained	Sample size (n)	P-value
A) LnΣOPFRs (ng/g-day)	49.9%	69	0.116
B) LnΣBDEs (ng/g-day)	46.6%	69	0.007

Strengths and Limitations

Strengths

- Measured personal exposures that captured all microenvironments encountered by the child

- Inhalable fraction

- Controlled for negative social experiences

- Teacher blinded to child's exposure

Limitations

- Cross sectional

- Small sample size

- Non-generalizable population

- Only inhalable fraction (no particles or ingestion)

- Did not include performance reference compounds so cannot calculate concentrations in air

Conclusions

- Children in Oregon are exposed to flame retardants and the most abundant compounds detected in the wristbands were organophosphate-based flame retardants

- OPFR exposure measured in the wristband which reflects inhalation pathway was associated with more externalizing behavior problems including aggression, defiance, hyperactivity, inattention and bullying and with poorer personal responsibility after controlling for other risk factors

- BDR exposure measured in the wristband which reflects inhalation pathway was associated with less assertive behavior after controlling for other risk factors

Acknowledgements

- Jennifer Przybyla
- Jacqueline Irwin
- Jennifer Morgan
- Amanda Tepfer
- Kiley Tyler
- Karley Lewis
- Jennifer Finders
- Andrea Gomez
- Guadalupe Diaz

- Sara Schmitt
- Megan Pratt
- Megan Childs
- Schyler Sprague
- Olivia Paradis
- Michael Health
- Justin Holmes
- Kevin Eischen
- Lots of preschool teachers!!!!

Lipscomb TS, McClelland MM, MacDonald M, Cardenas A, Anderson KA, Kile ML. (2017) Cross-sectional study of social behaviors in preschool children and exposure to flame retardants. Environmental Health, 16:23
http://link.springer.com/article/10.1186%2Fs12940-017-0224-6

College of Public Health and Human Sciences

OSU Oregon State University