

# Association between Serum Polybrominated Diphenyl ether (PBDE) levels and Residential Proximity to Solid-Waste Facilities

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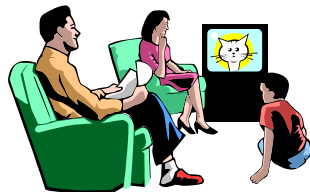
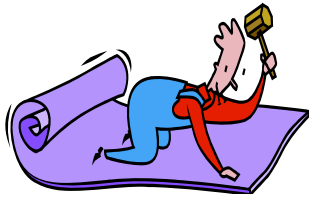
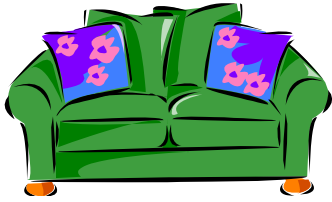
# Outline

- Background of PBDEs and of our study
- Study methods
- Study results
- Discussion
- Acknowledgements

# Background: PBDEs – what are they?

- Polybrominated diphenyl ethers (PBDEs)
- Class of over 200 brominated compounds
- Flame retardants added to a variety of consumer and building products
- Introduced in the 1970s, they now represent one of the most pervasive environmental global contaminants

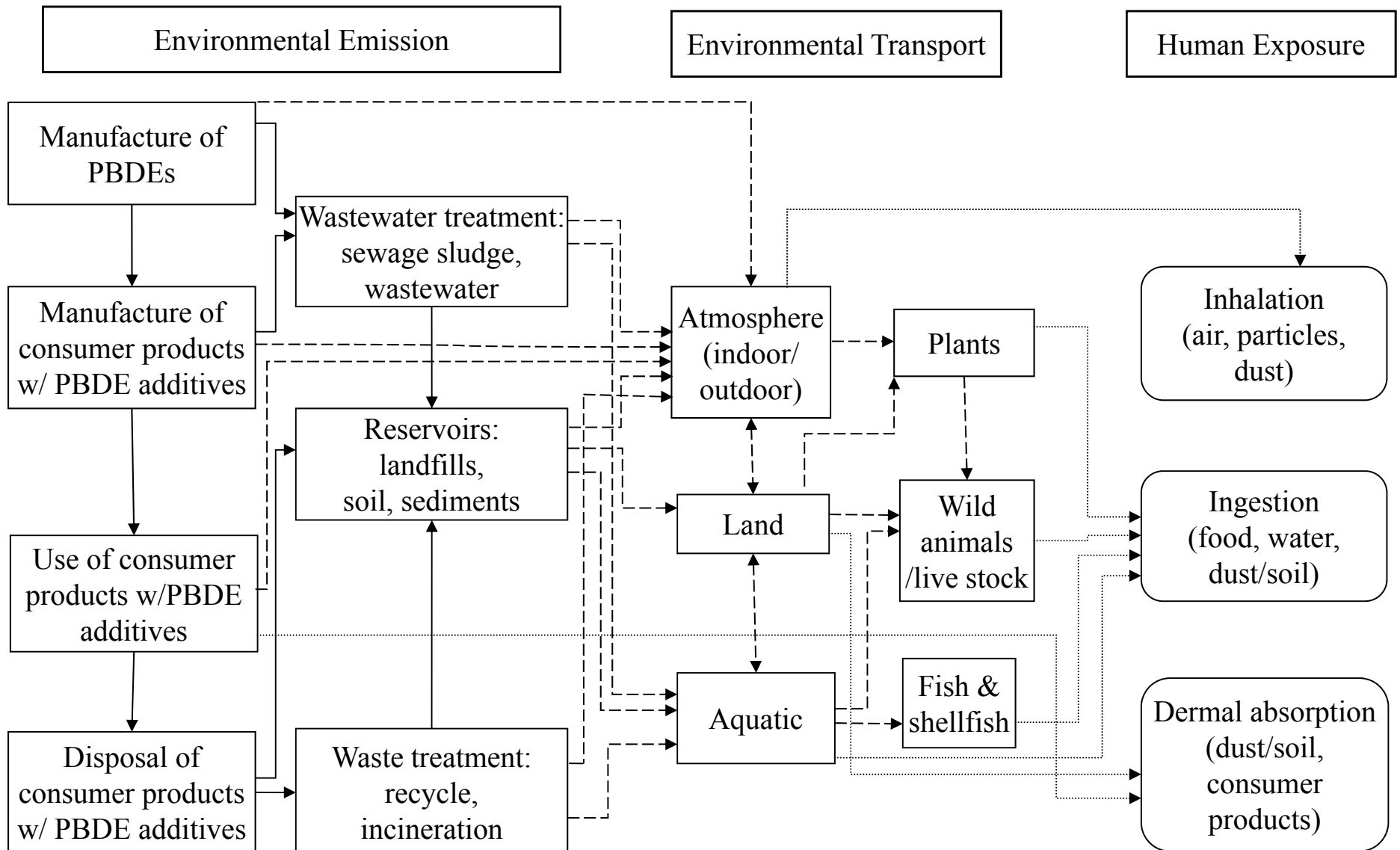
# Background: PBDE Uses



Up to 20% by weight, not chemically-bound to products

- Penta-BDE (-47, -99, -100, -153, -154):  
Polyurethane foam in furniture, mattresses, carpet padding
- Octa-BDE (-153, -154):  
Electrical hard plastic casings in computers, electronic equipment
- Deca-BDE (-209):  
High-impact polystyrene in TVs, computers, textiles

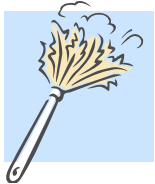
# PBDE emission, transport and human exposure related to its life cycle



Adapted from Weber, et al, 2011

# Background: Human Exposures

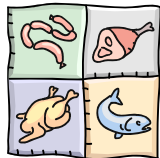
- Sources of exposure include:



Dust: inhalation and ingestion of dust



Direct dermal absorption



Diet: consumption of meat, fish, etc.

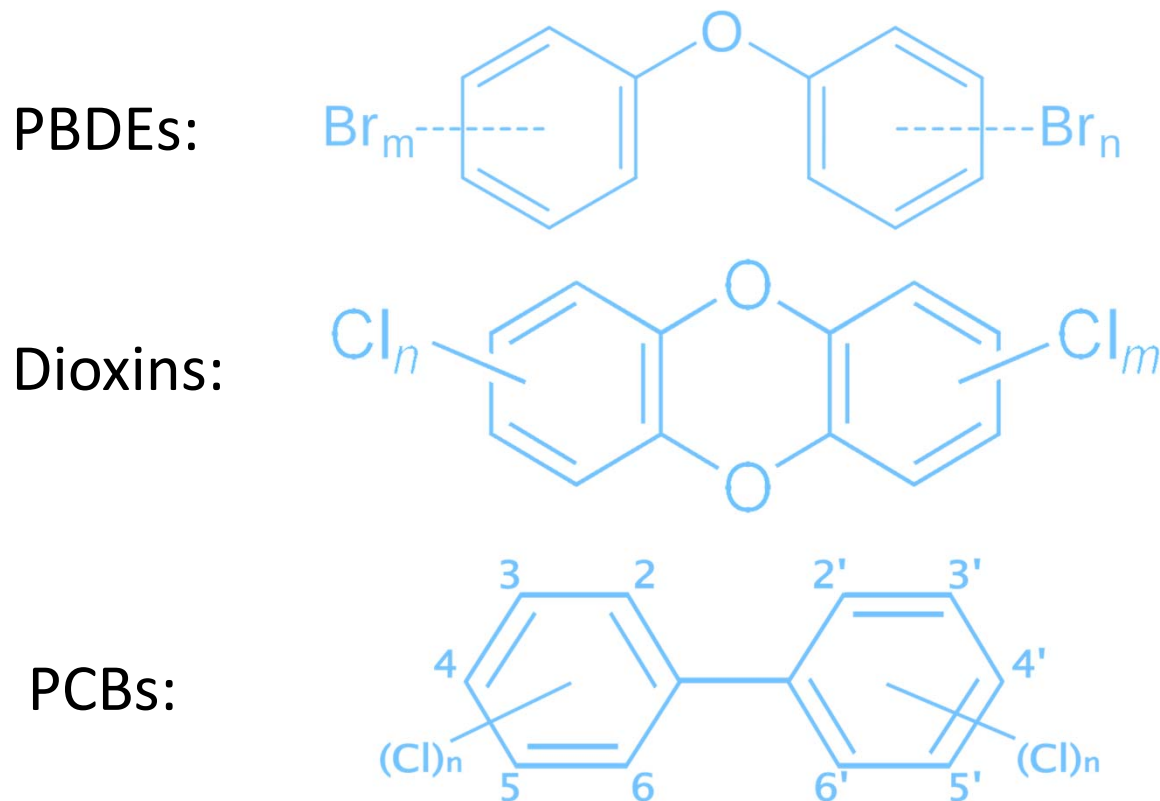
- Relative contribution of sources likely changing

# Background: Disparities in PBDE Exposure

- Emerging evidence that:
  - Levels higher in younger ages
  - Californians have highest levels in the world
- Limited data suggest levels may be higher in:
  - Urban settings
  - Non-white populations
  - U.S. born
  - Lower socioeconomic groups

# Background: Toxicology of PBDEs

- Varies by congener
- Structurally similar to other organohalogenated compounds

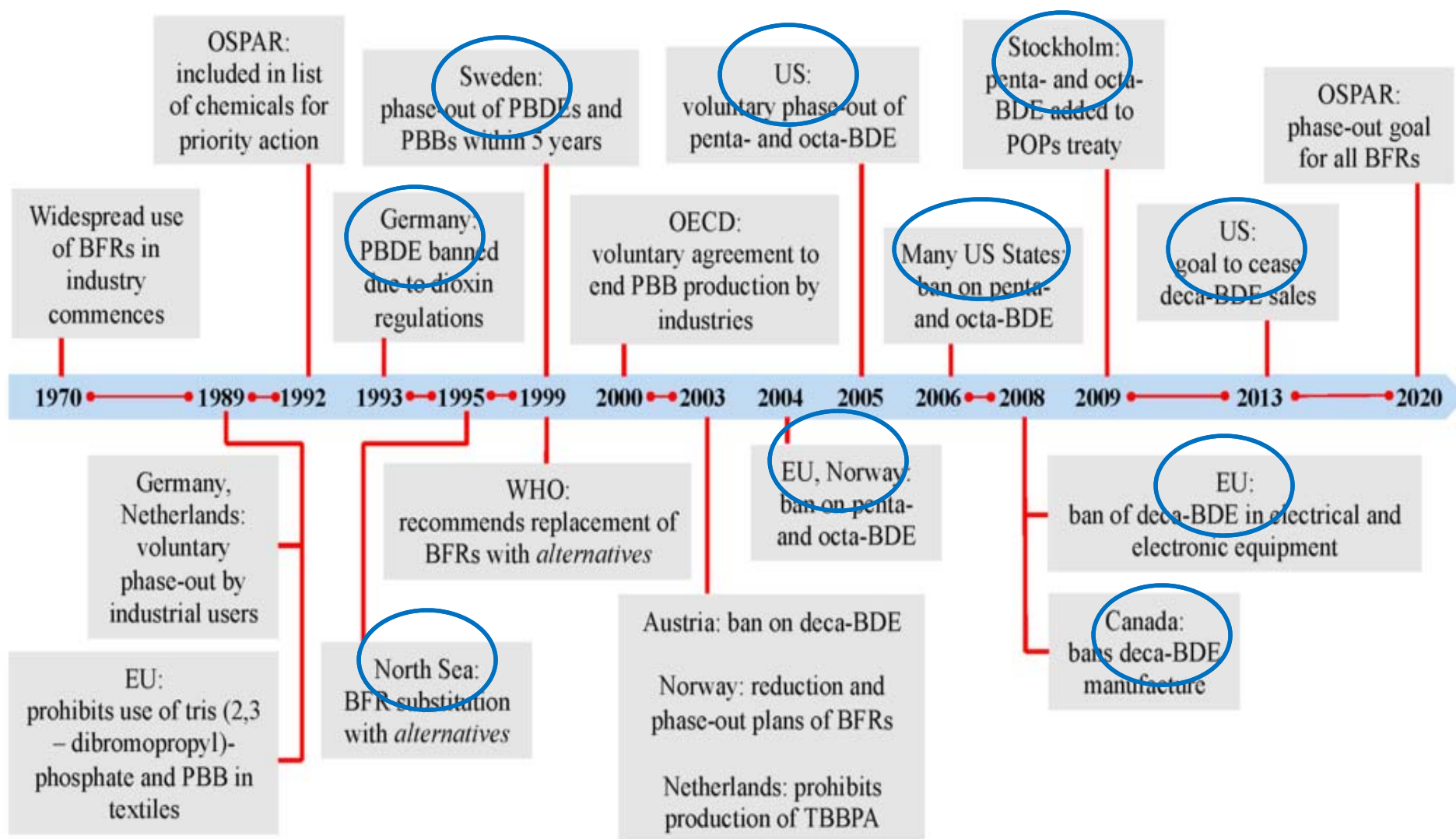




# Background: Health Concerns

- Endocrine disrupting effects
  - Thyroidal effects
  - Strong anti-androgenic effects
  - Estrogenic and anti-estrogenic effects
- Developmental effects
  - octa-BDE may be a potential prenatal developmental toxin (Darnerud , 2001; He 2006)
- Carcinogenic effects
  - evidence of carcinogenic potential is suggested for deca-BDE (EPA 2009)

# Background: Regulations of PBDEs



Source: Int. J. Environ. Res. Public Health 2015, 12(9), 10549-10557

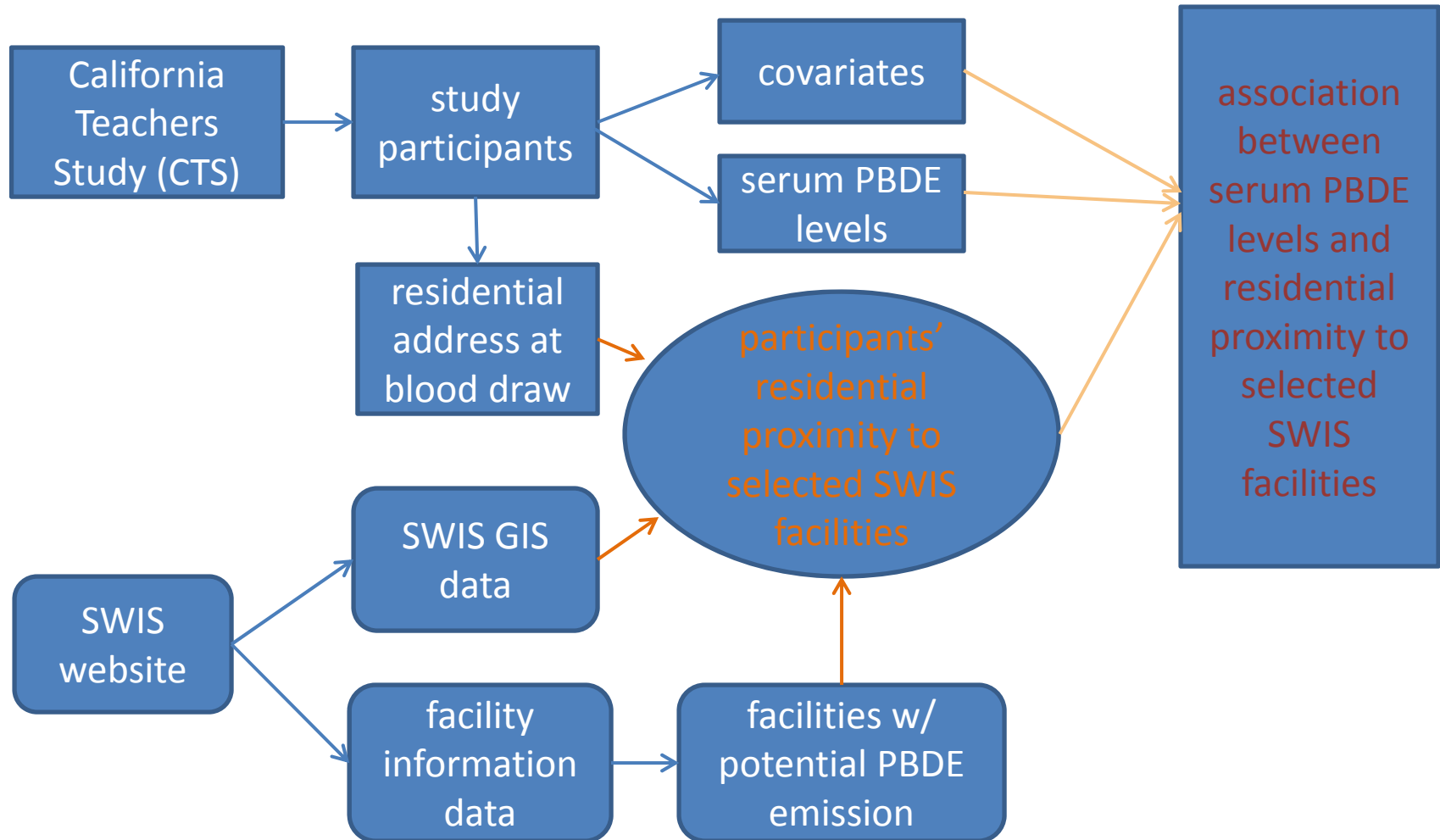
# Background: Impact of PBDE Regulations on Human Exposure

- Blood levels of some congeners are declining (Darnerud, 2015, Ma, 2013)
- Fewer products with PBDE additives are being used
  - Indoor exposures are likely to become less important
  - Outdoor exposures may become more predominant
- Exposures of PBDEs from solid waste disposal sites may become a more important public health issue
- Limited studies on body levels of PBDEs and potential residential exposures related to waste disposal sites

# Objective of our study

- To evaluate the association between residential proximity to solid waste facilities and serum levels of PBDEs among the general population
  - To our knowledge, this study was the first of its kind in the U.S.

# Study methods: overview



# Methods : study participants

- California Teachers Study (CTS):
  - a prospective cohort study on breast cancer
  - 133,479 female professional public school employees
  - initiated in 1995-1996, with 5 surveys so far
- Study participants : A convenience sample from CTS
  - Enrolled 2011-2013
  - Oversampled to ensure racial/ethnic diversity
  - Eligibility criteria:
    - No history of breast cancer diagnosis
    - Lived in California at time of blood draw
    - Residential address at time of blood draw could be geocoded
  - n=923

# Methods: blood collection and analysis

- Blood collected from participants during 2011-2013
- 19 PBDE congeners were analyzed by the Environmental Chemistry Laboratory (ECL) at the California Department of Toxic Substances Control
- Automated solid phase extraction (SPE) and gas chromatography/high resolution mass spectrometry (GC-HRMS) were used for the analysis of PBDEs

# Methods: Identification of Solid Waste Disposal Facilities with Potential Emission of PBDEs

- Information source: database from the Solid Waste Information System (SWIS) of California's Department of Resources Recycling and Recovery
- Database updated regularly and including
  - SWIS facility data
  - SWIS facility GIS data
- Data used in this study were downloaded on 5/28/2013





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- » SWIS Home
- » Search Facility Database
- » Download Data File
- » Facility Database Definitions
- » Data Entry Form:
  - » Fillable PDF (526 KB), updated 5/7/12
  - » Fillable Word (109 KB), updated 5/7/12
- » Required Data: New SWIS #
- » LEA Central
- » Inventory
- » Enforcement Orders
- » Digital Inspection Program

## SWIS Facility/Site Search

The Solid Waste Information System (SWIS) search page allows searching of all facilities/sites by multiple criteria, or location of a specific facility by name or SWIS number. The advanced search function allows for specific site selection from the categories searched. The database is continuously updated.

**Complete the search criteria to generate a list of solid waste facilities/sites/operators:**

County:  OR LEA Jurisdiction:

Regulatory status:

Facility type:

Operational status:  Display By:  General  Detail

SWIS site name:

SWIS number:  -  -

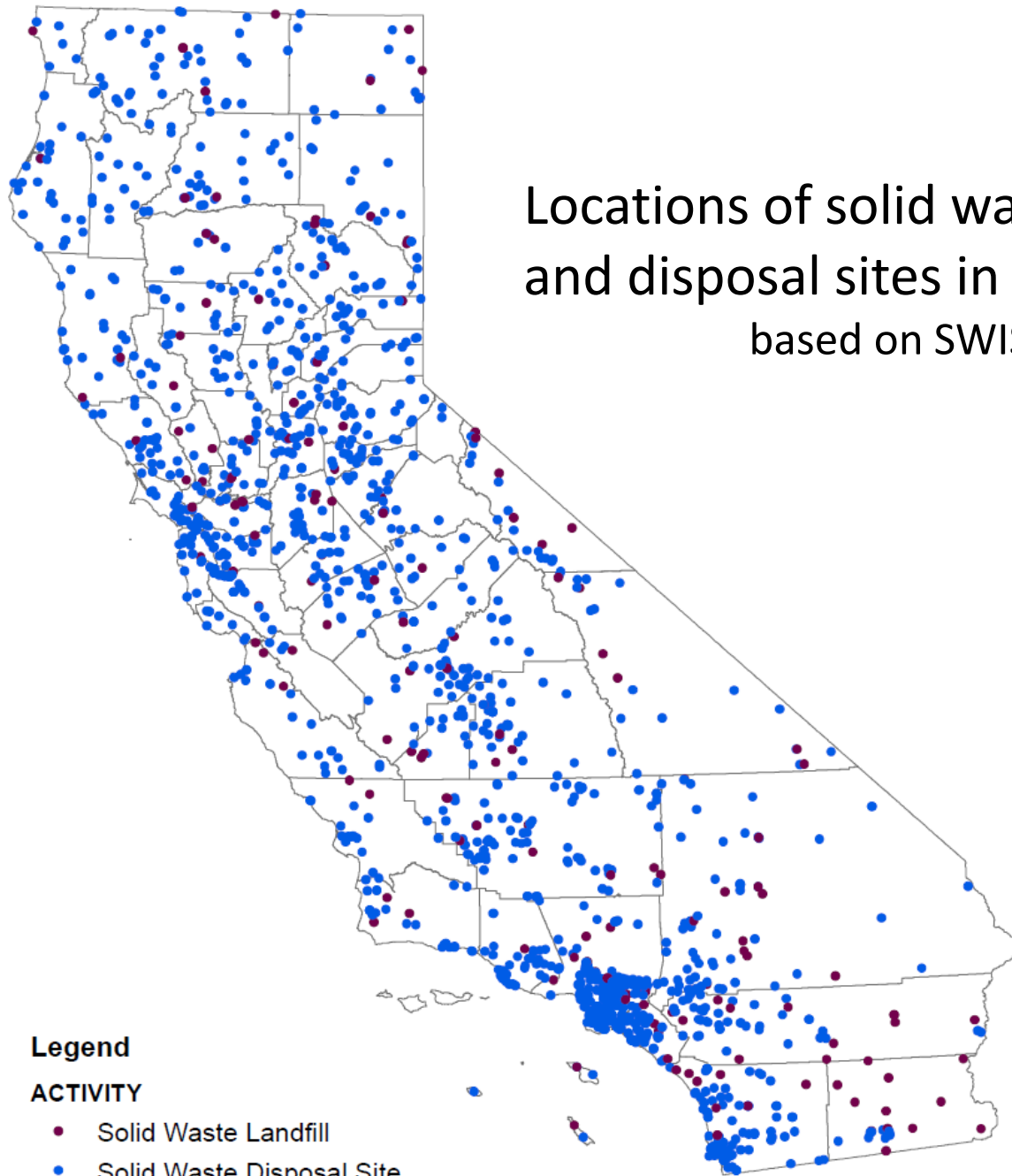
### Downloadable Files:

**SWIS Data File (MS Excel 97/2000, 2 MB)** Includes basic information on each facility in the database including site, enforcement agency, operator, land owner, throughput, capacity, acreage, permit date, waste types, activity type, regulatory status and operational status. This file is updated every Monday, Wednesday, and Friday at 6:00 a.m. The [data dictionary](#) includes a description of each of the data fields.

**Excel Display Note:** In some instances the client workbook display will not be maximized within the Excel container. When this happens you will not see the multiple sheets contained within the workbook. To maximize the workbook, double click on the workbook header.

**SWIS GIS Data File (Text, 1 MB)** This delimited text file is designed for inclusion into GIS software as a data table. Includes basic information on each facility in the database including site, enforcement agency, operator, activity type, regulatory status, operational status and latitude/longitude coordinates. The source latitude/longitude coordinates are geographic decimal degrees (GCS\_North\_American\_1983). This file is updated every Monday, Wednesday, and Friday at 6:00 a.m. The [data dictionary](#) includes a description of each of the data fields.

Locations of solid waste landfills  
and disposal sites in California  
based on SWIS data



**Legend**

**ACTIVITY**

- Solid Waste Landfill
- Solid Waste Disposal Site

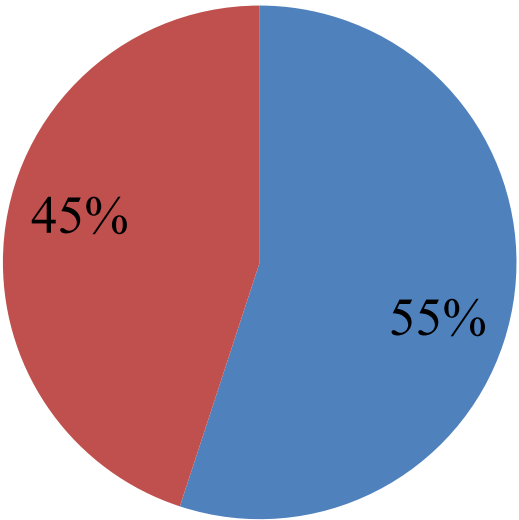
# Methods : Selection of SWIS Facilities

- A total of 3186 SWIS facilities in the datasets
- SWIS facilities excluded if they were (n=1616):
  - 1) closed before Jan 01, 1980
  - 2) “pre-regulations” (ceased operations prior to 1977.8)
  - 3) “in planning stages” or “clean closed”
  - 4) involving activities w/o potential emission of PBDEs
  - 5) duplications with the same facility address

# SWIS Facilities Included in our Study (n=1570)

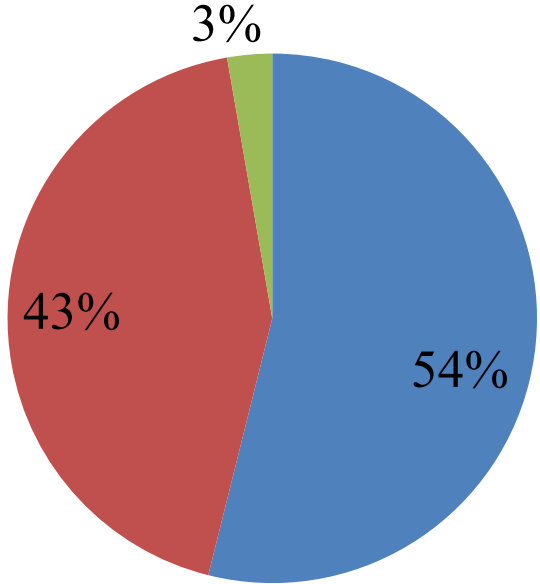
## Category

■ Disposal ■ Transfer/Processing



## Operation status

■ Active ■ Closed ■ Others\*



\* Closing, inactive, abandoned, absorbed, or to be determined

# Methods: Exposure Assessment

- Residential proximities (RPs) were used as an approximation of participants' potential exposure to PBDEs from selected SWIS facilities
- Participants' residential addresses at time of blood draw were geocoded
- GIS information of SWIS facilities was downloaded from SWIS website

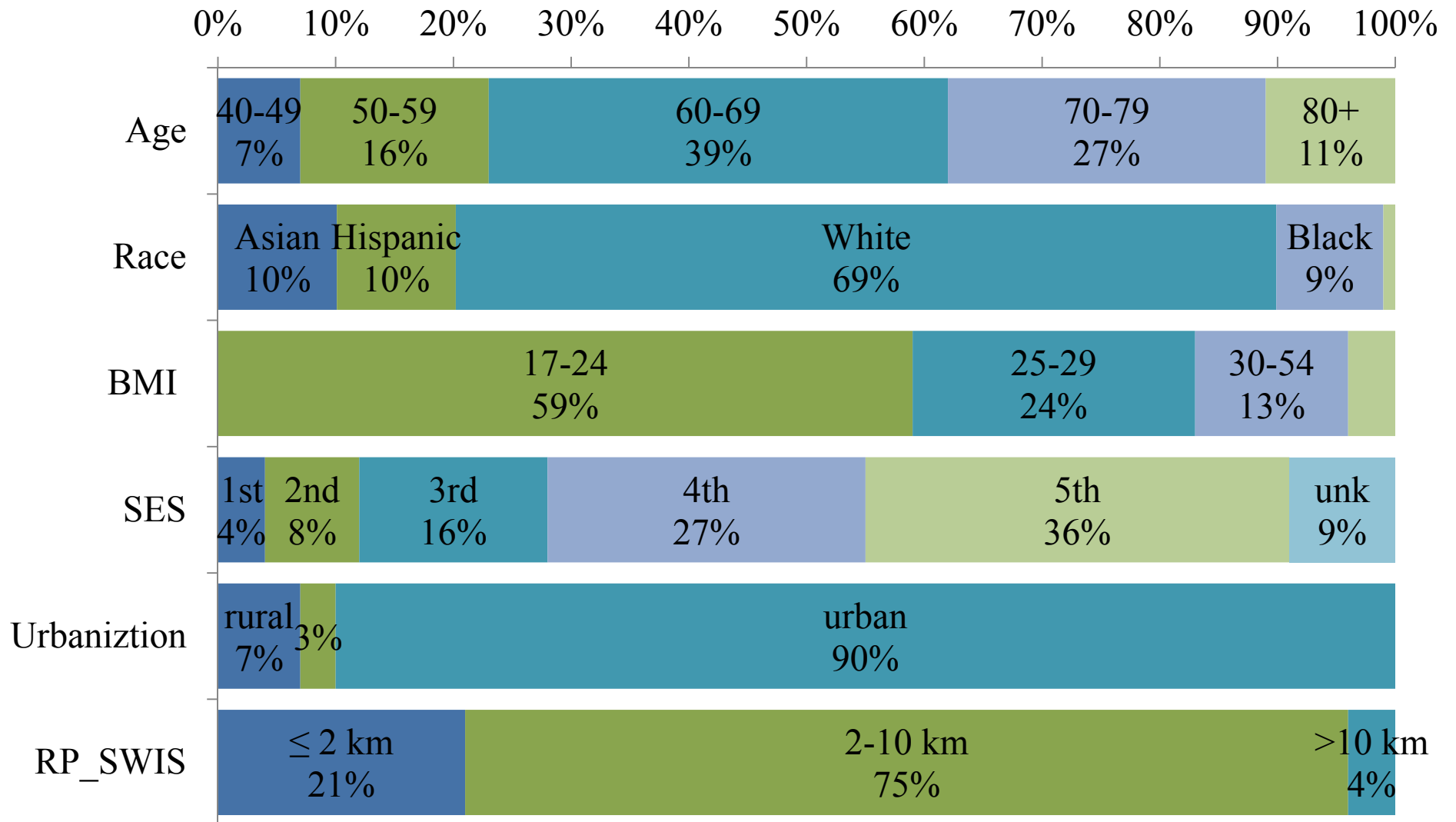
# Methods: Data analysis

- Serum PBDEs:
  - Only congeners with detect frequency >75% included:  
BDE 47, 100, 153
  - levels were lipid-adjusted: ng/g lipid
  - Levels <LOD replaced by LOD/ $\sqrt{2}$
  - Log<sub>10</sub> transformed
- Residential proximity to SWIS facilities included as a continuous variable and a categorical variable
- Adjusted for covariates: age, race, BMI, neighborhood SES and urbanization

## Methods: Data analysis (con't)

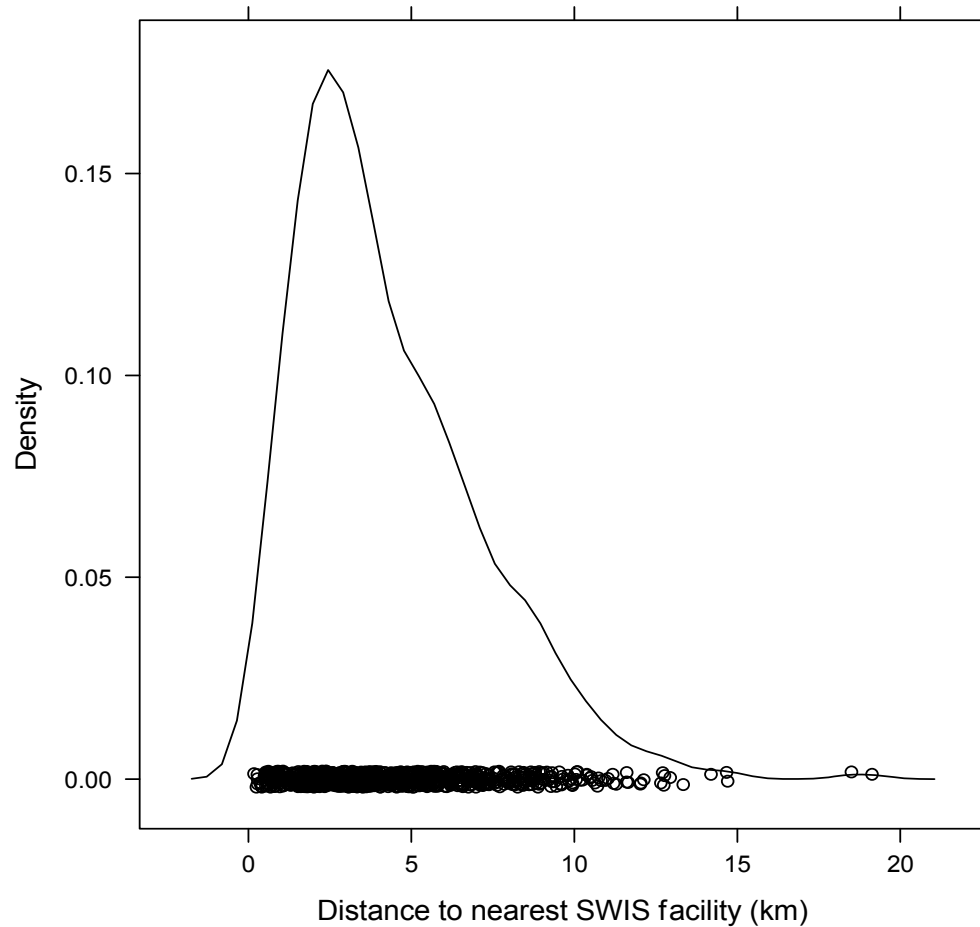
- Residential proximities (RPs) first used as a continuous variable in generalized additive models (GAM) to check linearity and monotonicity
- RPs then used as a categorical variable in generalized linear models (GLM)
  - $\leq 2$  km, 2-10km and  $>10$ km, based on GAM analysis results and *a priori* reasons
- Subset data analysis including nonmovers only

# Results: Features of study participants (n=923)

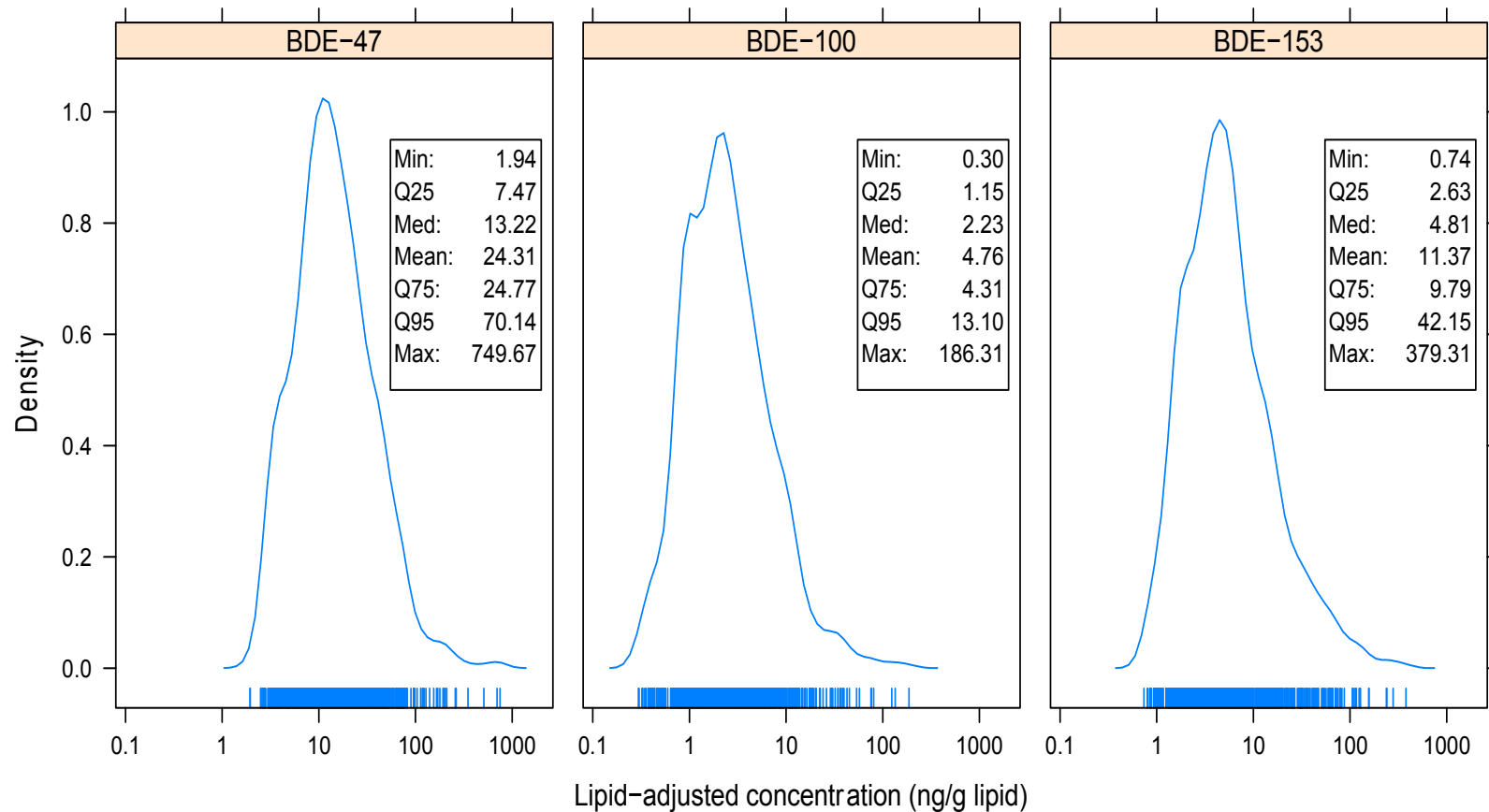




# Results: Distribution of residential proximity to nearest SWIS facilities

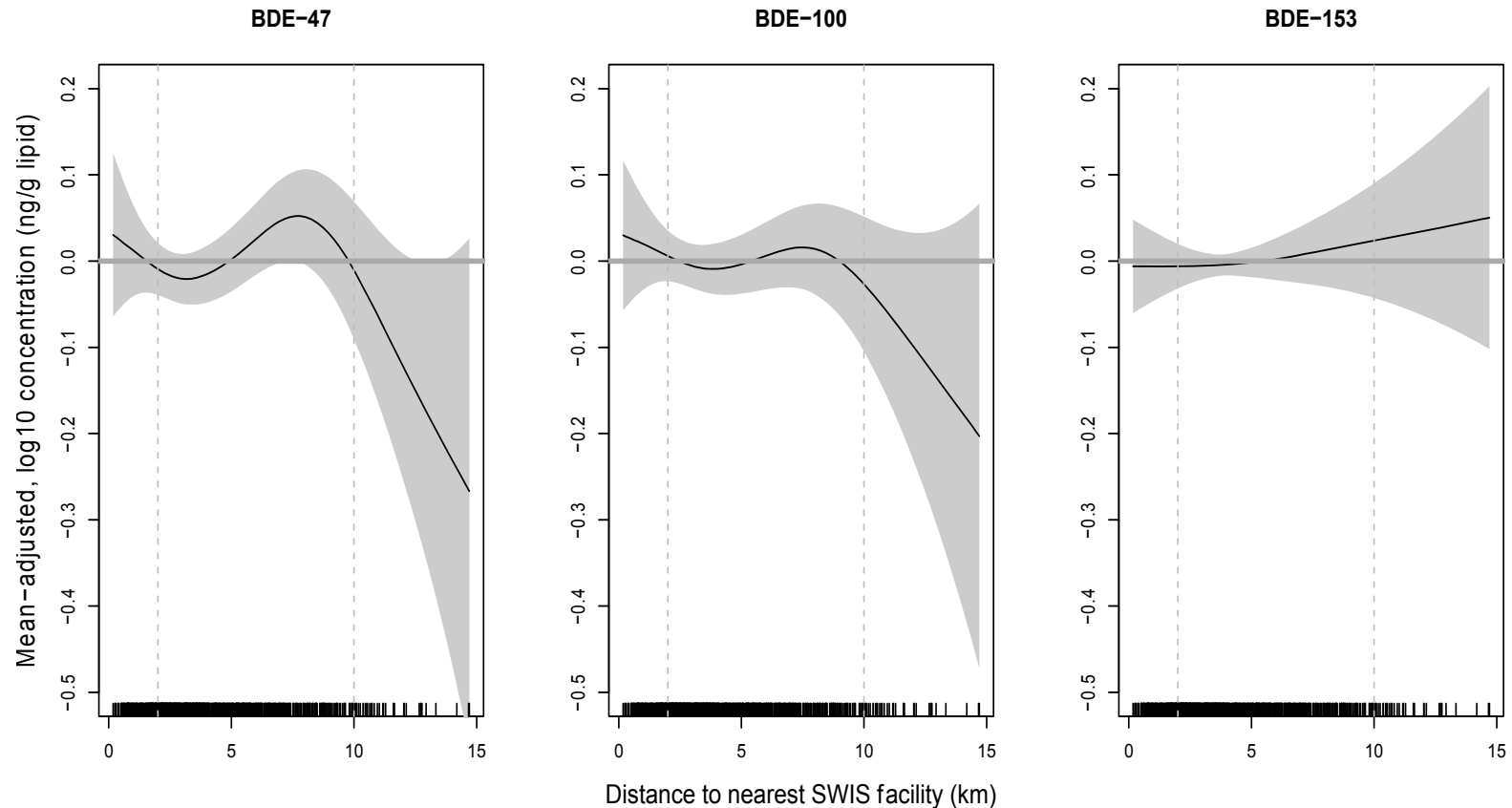


# Results: Distribution of serum PBDE levels among participants (n=923)

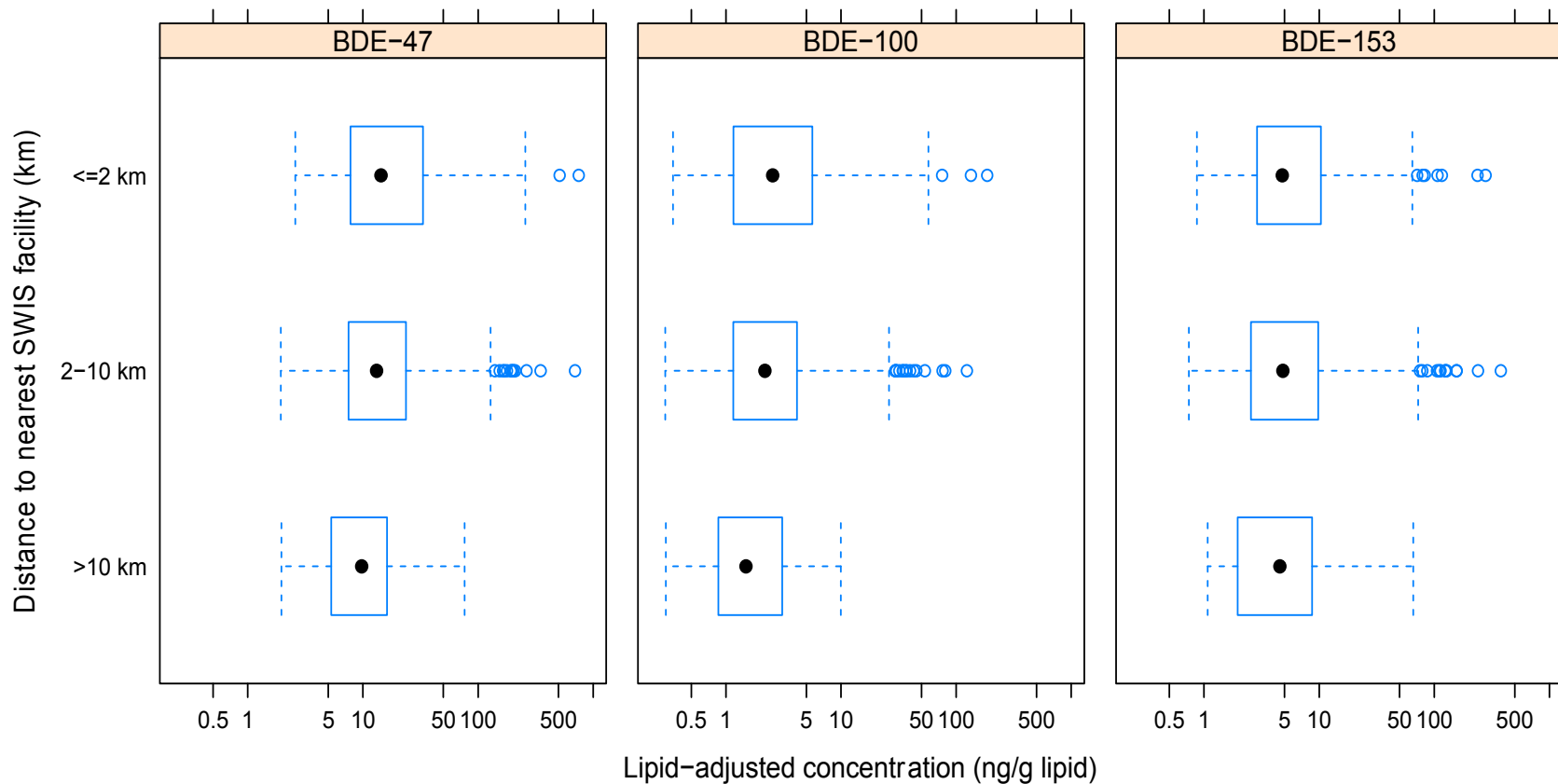


# Results: Generalized additive model (GAM)

- regressing log concentration on smoothed distance to the nearest SWIS facility, smoothed age and race

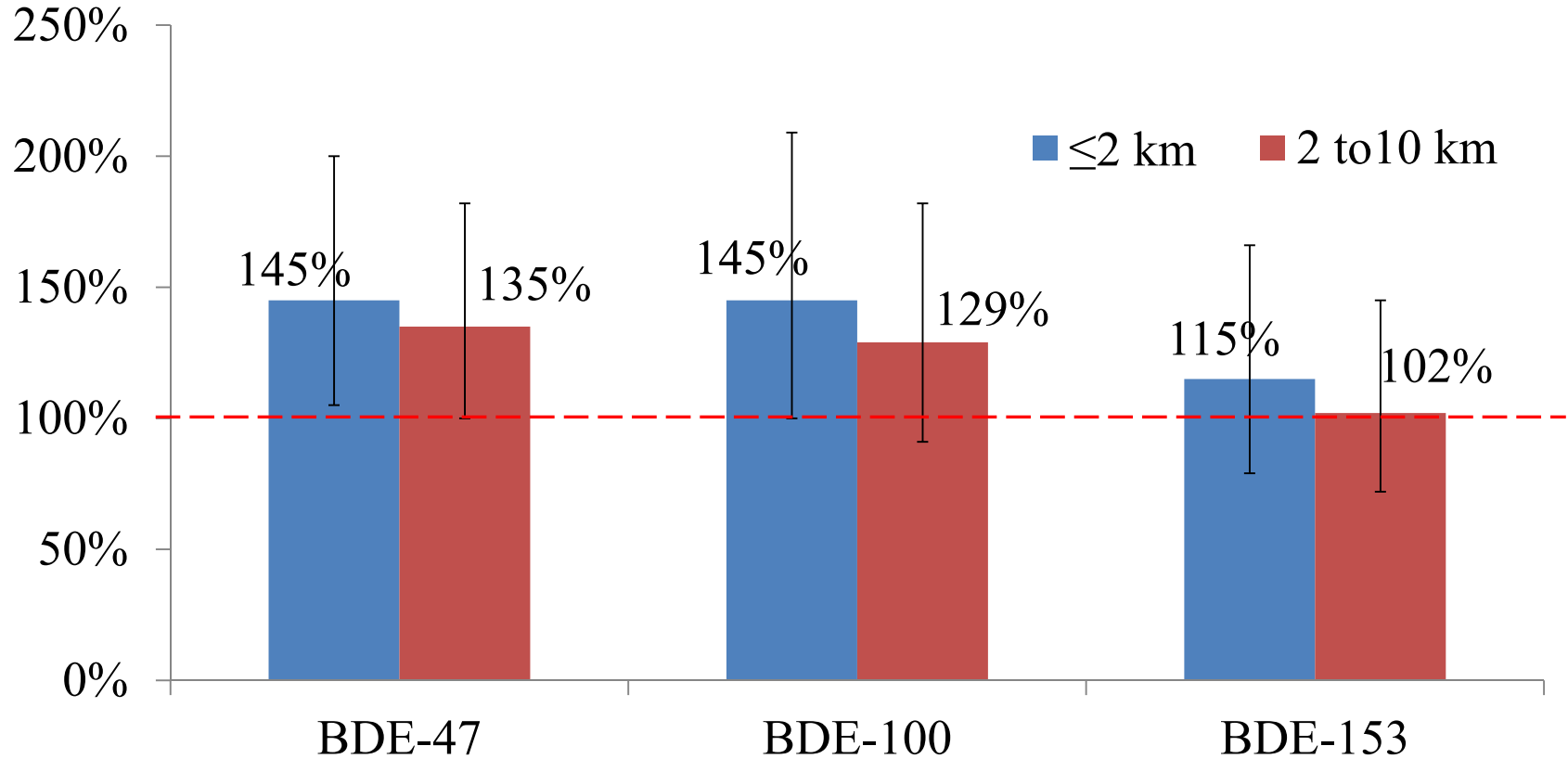


# Results: Serum PBDE levels by 3 groups of RPs to nearest SWIS facilities



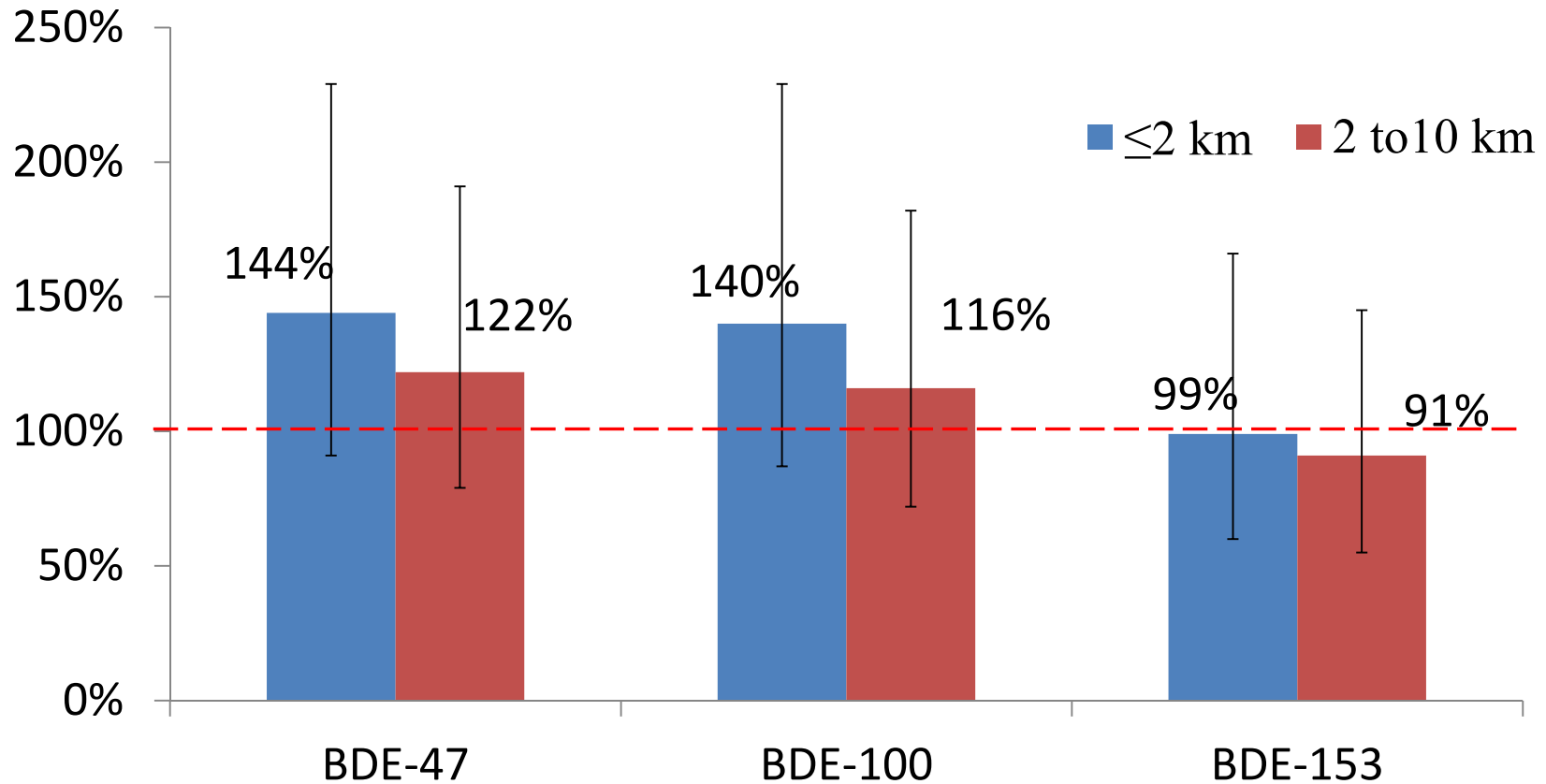
# Results: GLM model on association between serum PBDE levels and RPs to SWIS facilities

- RPs:  $\leq 2$ km, 2-10 km,  $> 10$ km
- $>10$  km as the reference group
- Adjusted for all covariates



# Results: analysis restricted to non-movers(n=531)

- similar association observed among non-movers



# Discussion

- The first U.S. study on potential association between solid waste disposal landfills and nearby residents' body burden PBDE level
- Both BDE-47 and -100 may be associated with close residential proximity to solid waste sites
- Implications for public health and waste management

# Discussion

- Strengths of the study:
  - Large sample size for bio-monitoring study
  - Participants from a single occupation
- Limitations of the study:
  - Participants: a convenience sample from the CTS
  - SWIS facilities: limited info on PBDE emission
  - Unable to adjust for other exposure sources
  - Exposure pathway not clear
- Further investigation with more refined exposure assessment is warranted



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<http://pubs.acs.org/doi/abs/10.1021/acs.est.5b04715?src=recsys>

## Association between Serum Polybrominated Diphenylether Levels and Residential Proximity to Solid-Waste Facilities

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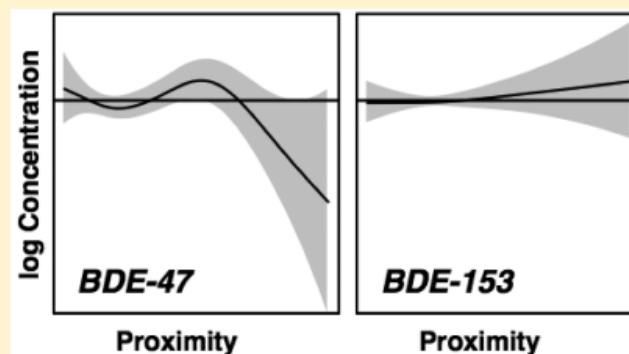
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### Supporting Information

**ABSTRACT:** As consumer products treated with polybrominated diphenyl ethers (PBDEs) reach the end of their life cycle, they often are discarded into solid-waste facilities, offering a potential reservoir for exposure. The likelihood of exposures to PBDEs by residents living near those sites rarely has been explored. This study collected blood samples from 923 female participants in the California Teachers Study in 2011–2013 and examined the association between participants' residential proximity to solid-waste facilities with potential release of PBDEs and serum levels of three congeners (BDE-47, BDE-100, and BDE-153). General linear regression analysis was used to examine the association, adjusting for age, race, body-mass index, neighborhood

socioeconomic status, and urban residency. Compared to participants living >10 km from any selected site, those living within 2 km had 45% higher BDE-47 (95% CI: 5–100%) and BDE-100 (95% CI: 0–109%) levels, and those living between 2 and 10 km had 35% higher BDE-47 (95% CI: 0–82%) and 29% higher BDE-100 (95% CI: –9 to 82%) levels. No associations were found for BDE-153. Living close to some solid waste sites may be related to higher serum BDE-47 and BDE-100 levels. Studies with comprehensive exposure assessments are needed to confirm these initial observations.



# Acknowledgments

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- Participants in the CTS
- Co-authors of our paper
- Other researchers, analysts and staff who have contributed for the success of CTS and this research project.