

Arlene Blum, PhD
Dept of Chemistry UC, Berkeley,
Green Science Policy Institute, California

**Halogenated Flame Retardants
Do the Fire Safety Benefits Justify
the Health and Environmental Risks?**

And What We Can Do to Solve the Problem

For more information
www.greensciencepolicy.org

THE PROBLEM:

Most Chemicals Are NOT Effectively Regulated in the U.S.

- The U.S. Toxic Substances Control Act (1976)
- 62,000 chemicals in commerce “grandfathered”
- 20,000 new chemicals have been introduced
 - 85% have no health data
 - 67% no data at all





- 21 chemicals banned by the Stockholm Convention on Persistent Organic Pollutants (POPs)
- All are **organohalogen**s with carbon bonded to bromine, chlorine, or fluorine,

Organohalogen Pesticides and Flame Retardants

(Carbon bound to Bromine, Chlorine, Iodine)

- Pesticides

- mostly banned at PBTs

- DDT, Mirex, Dieldrin, Aldrin, etc

- found in very low and decreasing levels in food

- Flame Retardants

- still in common use

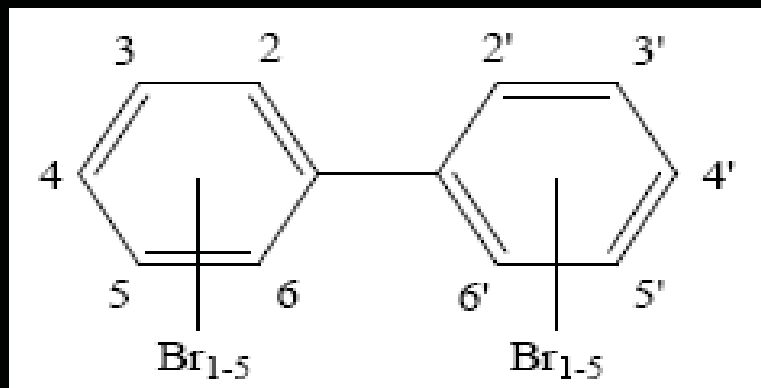
- similar or identical to pesticides

- Dechlorane flame retardant is Mirex; Dechlorane Plus in use

- in home furniture, insulation up to pound levels

- found in very low and increasing levels in food

Michigan and Polybrominated Biphenyls (PBBs)



**Divided into ten homolog groups, mono to deca
209 theoretically possible congeners**

Firemaster (PBBs,) mixed with livestock feed in 1973. Reproductive problems, elevated cancer risks, miscarriage, and genitourinary conditions
PBB production ceased in 1976.

The Poisoning of Michigan by Joyce Egginton reprinted 2009

Brominated Tris Flame Retardant

Tris (2,3-dibromopropyl) phosphate

- used to treat U.S. children's sleepwear from 1975 to 1977
- up to 10% of the weight of fabric
- not covalently bonded to fabric
- absorbed in children's bodies; metabolite found in their urine
- mutagen and possible carcinogen



Science, January 7, 1977

Flame-Retardant Additives as Possible Cancer Hazards

The main flame retardant in children's pajamas is a mutagen and should not be used.

Arlene Blum and Bruce N. Ames

Thousands of chemicals to which humans have been exposed have been introduced into the environment without adequate toxicological testing.

Some chemical flame retardants provide a good example of a technological innovation where adverse environmental effects may outweigh some of the benefits.

Until recently, little attention was paid to the long-term biological effects of these flame-retardant compounds. The main organic chemicals used in flame retardants contain bromine or chlorine or they are phosphate esters. Some have chemical structures (discussed below) that are closely related to compounds known to cause cancer or to be toxic to animals. Several compounds previously used as flame retardants have been shown to be teratogenic, carcinogenic, mutagenic, or highly toxic (4).

Brominated Tris Flame Retardant

Tris (2,3-dibromopropyl) phosphate



**U.S. Consumer Product
Safety Commission**

CPSC Bans TRIS-Treated Children's Garments

April 7, 1977

CPSC Release # 77-030

Replacement for Brominated Tris was Chlorinated Tris or TDCPP

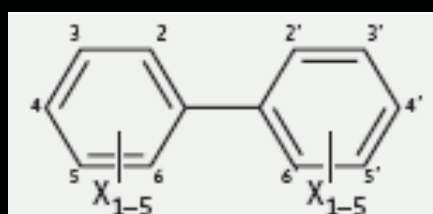


CALIFORNIA FURNITURE FLAMMABILITY STANDARDS

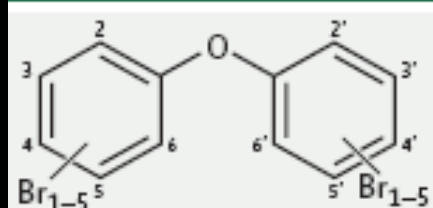
- TB 116:
Voluntary standard for furniture fabric
- TB 117:
Twelve second open flame and smolder standard for filling materials used in upholstered furniture.
Only such standard in the U.S.

209 Congeners

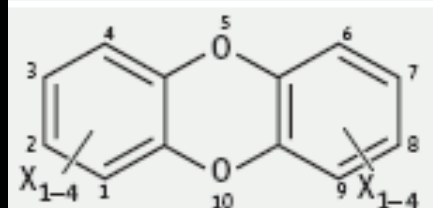
PentaBDE is a mixture of 47, 99, 100, 153



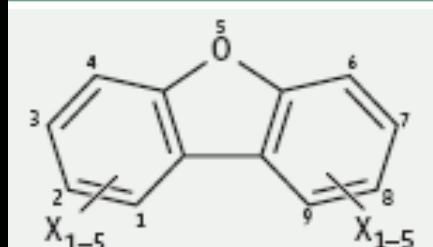
PCBs (X = Cl) and PBBs (X = Br)



PBDEs



Dioxins (X = Cl or Br)



Furans (X = Cl or Br)

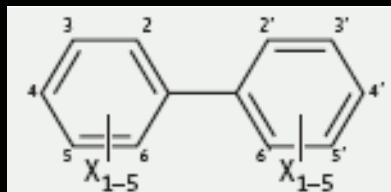
X

X
X

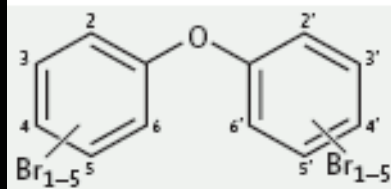
X

| | |
|---------------|--|
| BDE 47 | 2,2',4,4'-Tetrabromodiphenyl ether |
| BDE 49 | 2,2',4,5'-Tetrabromodiphenyl ether |
| BDE 66 | 2,3',4,4'-Tetrabromodiphenyl ether |
| BDE 71 | 2,3',4',6-Tetrabromodiphenyl ether |
| BDE 77 | 3,3',4,4'-Tetrabromodiphenyl ether |
| BDE 85 | 2,2',3,4,4'-Pentabromodiphenyl ether |
| BDE 89 | 2,2',4,4',5-Pentabromodiphenyl ether |
| BDE 100 | 2,2',4,4',6-Pentabromodiphenyl ether |
| BDE 119 | 2,3',4,4',6-Pentabromodiphenyl ether |
| BDE 126 | 3,3',4,4',5-Pentabromodiphenyl ether |
| BDE 138 + 168 | 2,2',3,4,4',5'-Hexabromodiphenyl ether + 2,3,4,4',5,6'-Hexabromodiphenyl ether |
| BDE 139 | 2,2',3,4,4',6-Hexabromodiphenyl ether |
| BDE 140 | 2,2',3,4,4',6'-Hexabromodiphenyl ether |
| BDE 153 | 2,2',4,4',5,5'-Hexabromodiphenyl ether |
| BDE 154 | 2,2',4,4',5,6'-Hexabromodiphenyl ether |
| BDE 158 + 169 | 2,3,3',4,4',5-Hexabromodiphenyl ether + 3,3',4,4',5,6'-Hexabromodiphenyl ether |
| BB 153 | 2,2',4,4',5,5'-Hexabromobiphenyl |
| BDE 171 | 2,2',3,3',4,4',6-Heptabromodiphenyl ether |
| BDE 180 | 2,2',3,4,4',5,5'-Heptabromodiphenyl ether |
| BDE 183 | 2,2',3,4,4',5',6-Heptabromodiphenyl ether |
| BDE 184 | 2,2',3,4,4',6,6'-Heptabromodiphenyl ether |
| BDE 191 | 2,3,3',4,4',5',6-Heptabromodiphenyl ether |
| BDE 196 | 2,2',3,3',4,4',5,6'-Octabromodiphenyl ether |
| BDE 197 | 2,2',3,3',4,4',6,6'-Octabromodiphenyl ether |
| BDE 201 | 2,2',3,3',4,5',6,6'-Octabromodiphenyl ether |
| BDE 203 | 2,2',3,4,4',5,5',6-Octabromodiphenyl ether |
| BDE 204 | 2,2',3,4,4',5,6,6'-Octabromodiphenyl ether |
| BDE 205 | 2,3,3',4,4',5,5',6-Octabromodiphenyl ether |
| BDE 206 | 2,2',3,3',4,4',5,5',6-Nonabromodiphenyl ether |
| BDE 207 | 2,2',3,3',4,4',5,6,6'-Nonabromodiphenyl ether |
| BDE 208 | 2,2',3,3',4,5,5',6,6'-Nonabromodiphenyl ether |
| BDE 209 | 2,2',3,3',4,4',5,5',6,6'-Decabromodiphenyl ether |

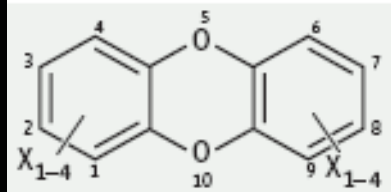
PentaBDE used in North America to meet TB117



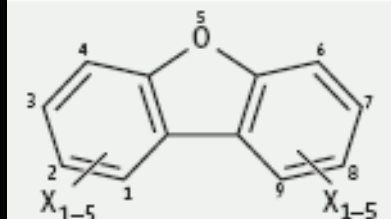
PCBs (X = Cl) and PBBs (X = Br)



PBDEs



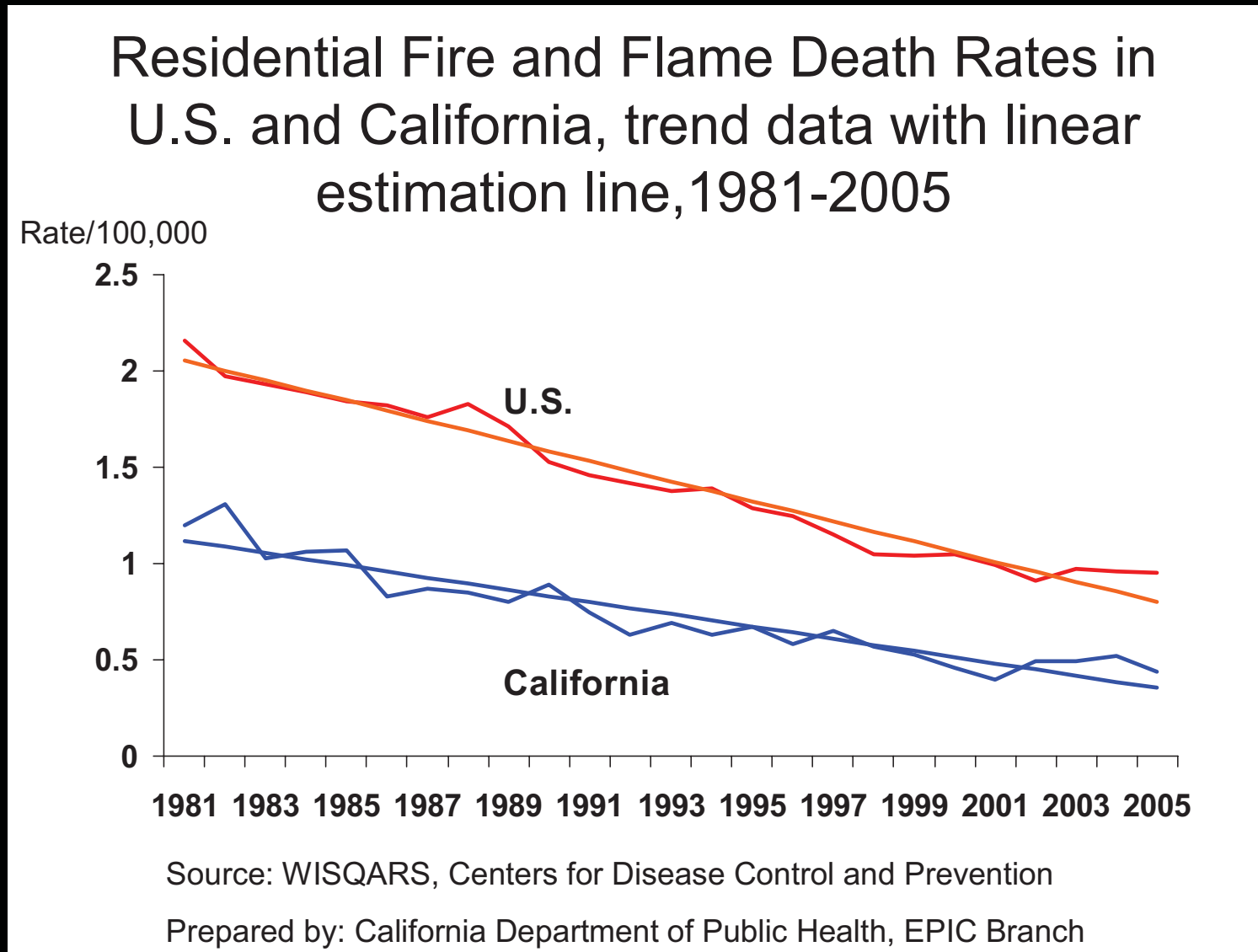
Dioxins (X = Cl or Br)



Furans (X = Cl or Br)

- In 2002, **95% of the global use of pentaBDE was in North America**, mostly to meet TB117.
- Such chemical flame retardants delay, but usually do not stop, ignition.
- They increase fire toxicity and burn to form dioxins and furans
- Does TB117 save lives?

No Data to Show Furniture Flame Retardants Save Lives



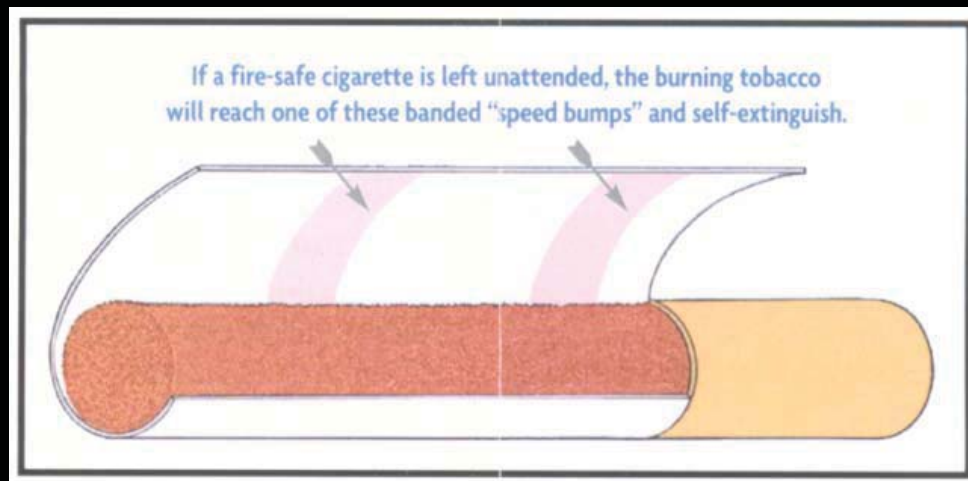
Decline in Fire Deaths 1980-2004

| | |
|--------------|-------|
| California | - 40% |
| Georgia | - 36% |
| Illinois | - 45% |
| Michigan | - 38% |
| New York | - 48% |
| Ohio | - 41% |
| Pennsylvania | - 41% |
| Texas | - 37% |

*“US Unintentional Fire Death Rates by State”
National Fire Protection Association, 2008*

Fire Safety Without Flame Retardants

- Preventing ignition is more effective and healthier
- Fire deaths in the US are rapidly declining due to:
 - 50% decrease in cigarette consumption since 1980
 - Enforcement of improved building, fire and electrical codes
 - Increased use of sprinklers and smoke detectors
 - Introduction of fire-safe cigarettes and candles



Fifteen Times Greater Escape Time? (Fifteen seconds compared to one)

Sample T (non-flame-retardant)
density 25 kg/m³



Sample S (flame-retardant)
density 64 kg/m³
contains CFRs, BFRs,
and 35% alumina trihydrate



Flame retardant foam is 2.5x more dense

According to Vyto Babruskas, “**Cal. TB 117 is an ineffective test which does not accomplish its intended purpose of averting furniture ignitions from small flaming sources.**” (personal communication 2010)

BFRs and CFRs can Increase Fire Toxicity

Base foam with no flame retardant

Foam treated with Tris flame retardant

Table 3. Cone calorimeter test results of modified foam materials at 25 kW/m² exposure.

| Sample ID | CJ4-8 | CJ4-54 | CJ4-18 | CJ4-12 | CJ4-32 | CJ4-31 |
|--------------------------------|----------------------|---|----------------------------------|---|---|---|
| Formulation (pbw) | Polyol 100 Iso 48 | Polyol 100 Iso 48 Fyrol [®] FR2 37 | Polyol 100 Iso 48 4-7105 8 | Polyol 100 Iso 48 Dec. Plus [®] 16 Sb ₂ O ₃ 5 1-9641 5 | Polyol 100 Iso 48 Dec. Plus [®] 28 Sb ₂ O ₃ 9 | Polyol 100 Iso 48 Sb ₂ O ₃ 37 |
| TTI (s) | 16 | 18 | 16 | 18 | 19 | 11 |
| Tmax (s) | 176 | 201 | 131 | 66 | 101 | 146 |
| Peak HRR (kW/m ²) | 412.2 | 326.1 | 340.3 | | | 372.6 |
| Ave. HRR (kW/m ²)# | 225.2 | 163.4 | 193 | | | 268.7 |
| THR (MJ/m ²) | 57.35 | 48.20 | | | | |
| Ave. HOC (MJ/kg) | 25.00 | 17.62 | | | | |
| Ave. SEA (m ² /kg) | 412.6 | 744.8 | | | | |
| Ave. MLR (g/s·m ²) | 11.33 | 13.77 | | | | |
| Initial mass (g) | 24.55 | 31.50 | 2 | | | 0 |
| Residue (%) | 6.58 | 13.17 | 10.4 | | | 27.8 |
| Ave. CO (kg/kg) | 0.0178 | 0.0814 | 0.0205 | | | 0.0277 |
| Ave. CO ₂ (kg/kg) | 1.3782 | 0.8251 | 1.4112 | 1.0457 | 0.8505 | 1.2959 |
| Ave. Soot (kg/kg) | 0.0127 | 0.1043 | -0.0821 | 0.3141 | 0.0327 | 0.0218 |

The flame retarded foam takes 2 seconds longer to ignite (TTI). It generates 5 times the Carbon Monoxide and 8 times the smoke levels of the non-flame retarded foam.

TTI (s) is the time to ignition in seconds, Ave. CO is Carbon Monoxide, Ave. Soot is a measure of smoke produced. (continued)

Chandra Jayakody, Dan Myers, Usman Sorathia, and Gordon L. Nelson. "Fire-Retardant Characteristics of Water-Blown Molded Flexible Polyurethane Foam Materials" J. Fire Sciences, Vol. 18, pp 430-455, 2000.

NOAA Finds Penta in Sediments and Bivalves



Brominated flame retardants are global contaminants



Arctic Monitoring & Assessment Programme (AMAP) & Arctic Council Action Plan to Eliminate Pollution (ACAP): Jan 2005



Kurunthachalam, K, et al. J Environ Monit. 2008 Apr;10(4):552-8.



. Drouillard KG, et al. Environ Toxicol Chem. 2007 Feb;26(2):313-24.



Fireproof killer whales. Peter S. Ross. Can. J. Fish. Aquat. Sci. 63: 224–234 (2006)



Unger, M.A. et al., Mar. Pollut. Bull. (2008), 10.1016/j.marpolbul.2008.04.018



Brominated Fire retardants found in Tasmanian devils. The Australian, January 22, 2008

HUMAN HEALTH IMPACTS of PentaBDE

- **Cryptorchidism**

- Main et al, 2007

- **Reproductive Hormone Effects**

- Meeker et al., 2009 –
Decrease in Androgens and LH;
Increase in FSH and Inhibin
- Meijer et al, 2008
Decrease in Testosterone

- **Reproductive Effects**

- Eskenazi et al., 2009
Low Birth Weight; Altered
Behaviors
- Harley et al, 2010

Increased time to pregnancy

- **Neurological Effects**

- Herbstman et al, 2010
Decreased IQ

Decreased Sperm Quality

- Akutse et al, 2008

Diabetes

- Lim et al, 2008
- Turyk et al, 2009 (only in
hypothyroid subjects)

Thyroid Homeostasis

- Herbstman et al, 2008 –
decrease in TT4
- Turyk et al, 2007 – elevated
T4
- Meeker et al, 2009 –
elevated T4, TBG
- Dallaire et al, 2009 -Elevated
T3 ~BDE47
- Eskenazi et al, 2009 – Low
TSH

PBDE Exposure Assessment, Vulnerable Populations, and Implications for Health

Ami Zota, Sc.D.

Program on Reproductive Health and Environment
Department of Obstetrics, Gynecology and
Reproductive Sciences
University of California, San Francisco

CHE/WHEI Call April 15, 2010

Flame Retardants: Emerging Science and Policy Considerations



Seminar Overview

- **PBDE Exposure Assessment 101**
- **Highly Exposed Subpopulations**
- **Ongoing PBDE and thyroid research at UCSF**

PBDEs: *Production & Use*

- Uses: polyurethane foam in furniture, car seats, electronics, and carpet padding
- Not chemically bound so can easily migrate out of product
- penta and octa being phased out but deca still in use
- Persistent compounds + slow turnover of consumer products = long-term exposure reservoirs

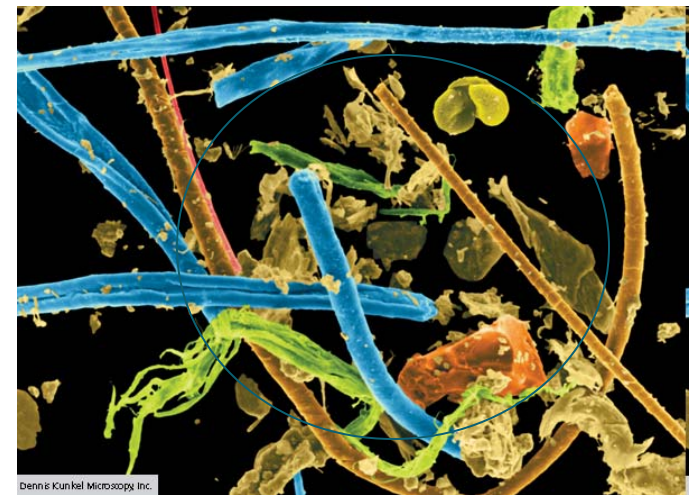


© Leona Kanaskie



PBDEs and Indoor House Dust

- Dust inhalation and ingestion - major route of human exposure (Lorber et al. 2008)
- XRF measured bromine in foam furniture correlated with penta-BDEs in dust (Allen et al., 2008)
- PBDE dust concentrations correlated with PBDEs in breast milk (Wu et al., 2007)



PBDEs and Diet

- Diet also contributes to PBDE body burden
- PBDEs are persistent, lipophilic compounds and have been measured in the food supply
- Potential dietary sources of PBDEs:
 - Poultry (Fraser 2009; Rose 2010)
 - Red meat (Fraser 2009; Wu 2007)
 - Pork (Rose 2010)
 - Dairy (Wu 2007)
 - Breast milk (Carrizo 2007)



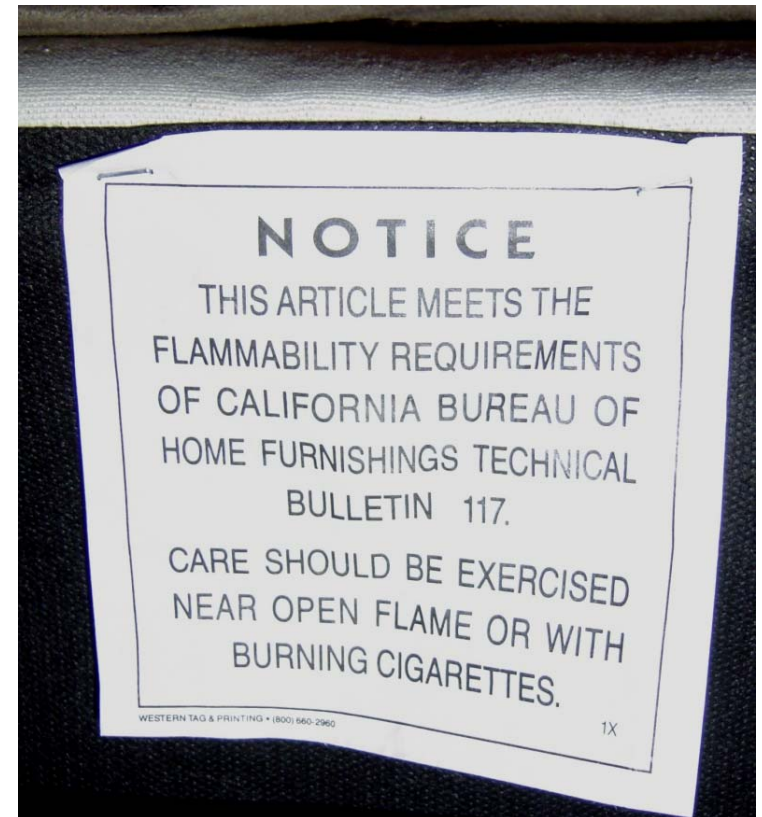
Highly Exposed Subpopulations

- PBDE exposures are not uniform across the US population
- Three subpopulations deserve attention:
 - California
 - Children
 - Socially vulnerable/ Low SES

CA Furniture Flammability Standards

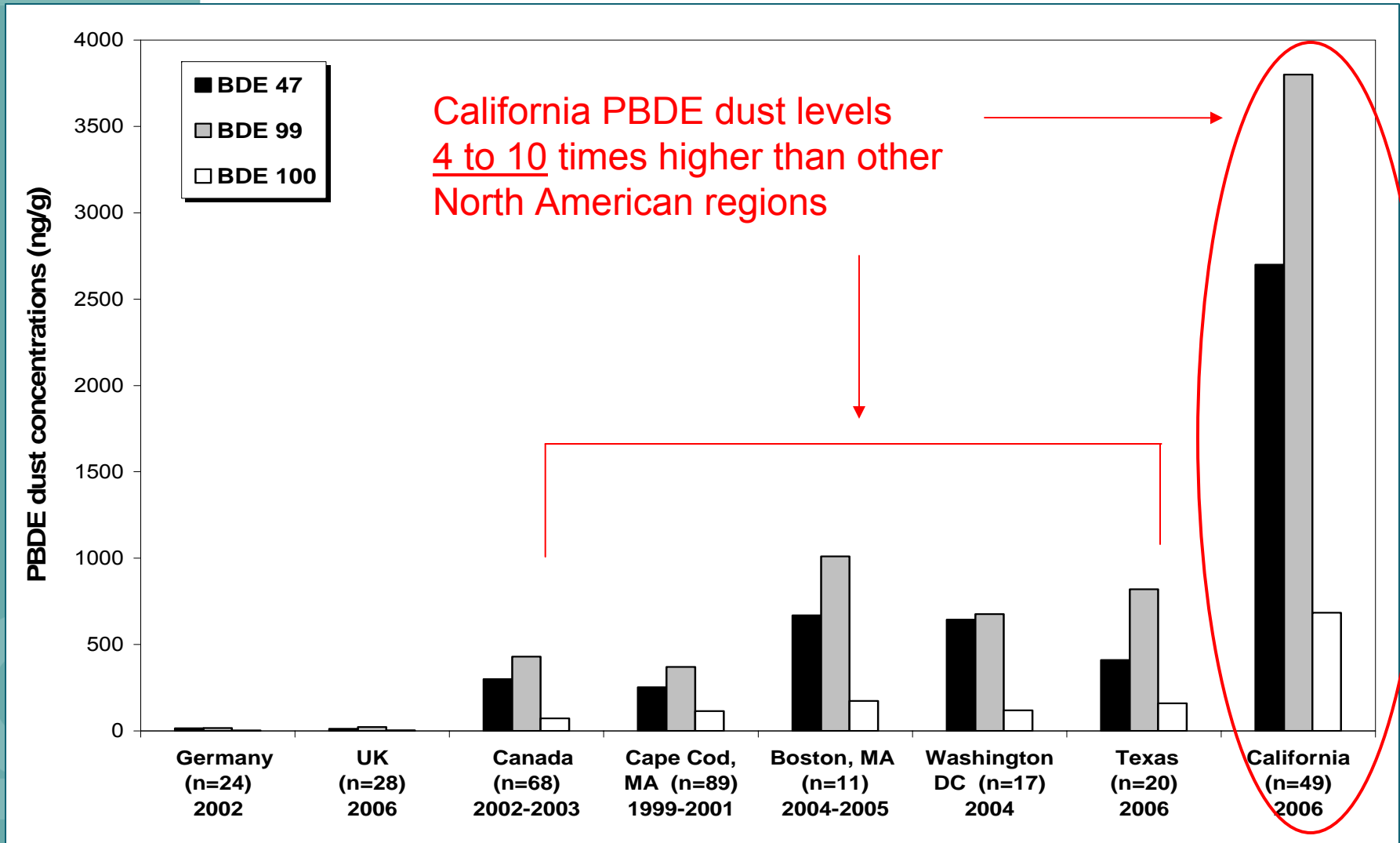
Technical Bulletin 117 (TB 117):

- 1975 performance-based standard
- Foam in furniture must withstand open flame for 12 seconds
- Historically, compliance achieved through use of Penta-BDE
- Unique standard; no other state has a parallel standard



As a result, majority of PUF products treated with penta-BDE in the U.S. were sold in California (ATSDR 2004)

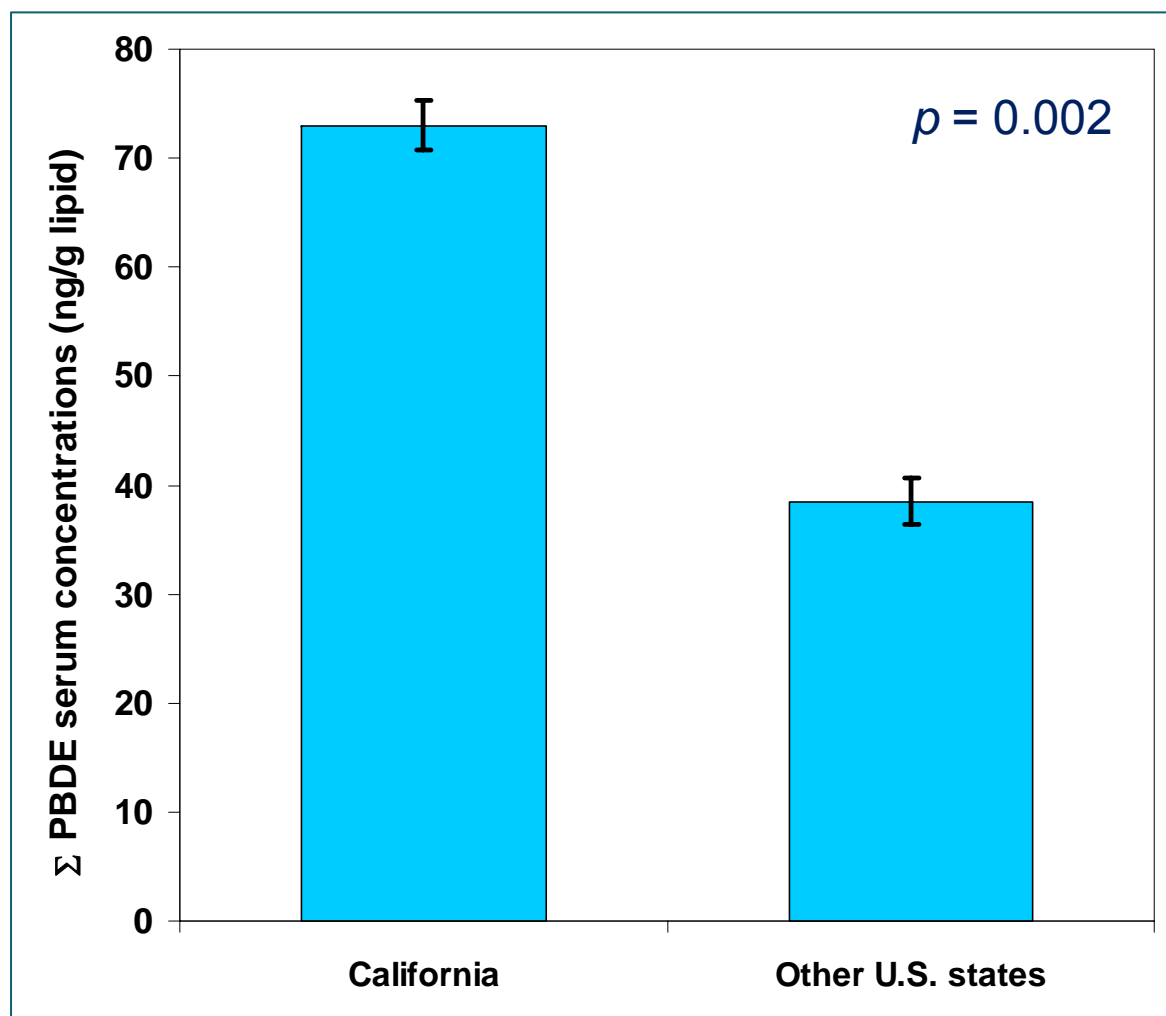
Median PBDE household dust concentrations across 8 regions in North America and Europe



PBDE body burden: California versus other U.S. states

PBDE levels in California nearly two fold higher than rest of the U.S. (N=2040) (Zota et al. 2008)

Other studies have also shown elevated levels in CA (Petreas 2003; Windham 2010; Rose 2010)



Σ PBDEs = sum of BDE-28, -47, -99, -100, -153, -154
Geometric mean adjusted for age, gender, income, country of origin, survey design and sample weights (NHANES 2003-04)

PBDE exposures in children

- Higher PBDE body burdens in young children
- Elevated levels may be attributable to:
 - Increased ingestion of dust (frequent hand to mouth behavior, etc.)
 - Increased exposure via breastfeeding

New study by Rose and colleagues in ES&T found that PBDE levels in California children aged 2-5 years were similar to levels in occupationally exposed adults



Are PBDE exposures elevated among lower SES groups?

At least 3 studies have shown elevated PBDE exposures among socially vulnerable groups

1. In NHANES data, higher PBDE body burden in people from lower income homes (Zota, 2008)
2. PBDE body burden higher in children whose parents are less educated (Windham 2010; Rose 2010)
3. Racial disparity in PBDE body burden: levels higher in black girls compared to white girls (Windham 2010)

Ongoing PBDE Research at UCSF:

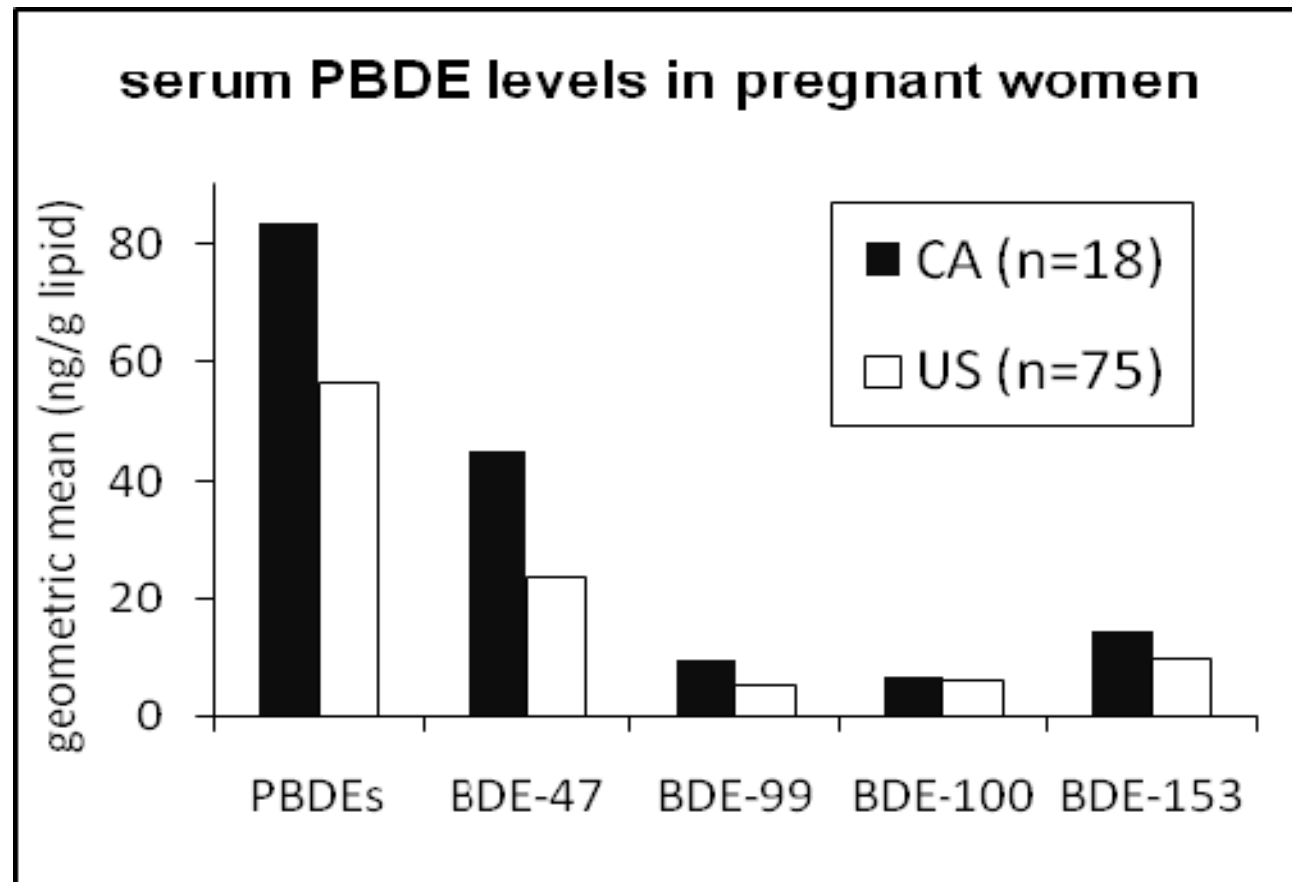
To examine the effects of PBDEs and OH-PBDEs on thyroid hormone levels among a socioeconomically and ethnically diverse group of second trimester pregnant women in California, where exposures are expected to be elevated

UCSF PBDE and Thyroid Study: Background/Rationale

- Maternal thyroid disruption during pregnancy has important implications for fetal development
- In animal studies, PBDEs cause lower free T4 and higher TSH (hypothyroidism)
- Associations between PBDEs and thyroid hormones in human studies are not consistent
- Few studies have looked at the effects of PBDEs on thyroid hormones among highly exposed subpopulations
- OH-PBDEs are more potent thyroid disrupters than parent PBDEs, but no epidemiologic study has examined relationship between OH-PBDEs and thyroid hormones

Preliminary Data

PBDE levels among our CA study population are elevated compared to pregnant women from NHANES 2003-2004



Acknowledgements

UCSF

Dr. Tracey Woodruff
Jackie Schwartz
Dr. Jody Steinauer
Tanya Pasternak
Jason Harless

Silent Spring Institute

Dr. Julia Brody
Ruthann Rudel
Sarah Dunagan

California Department of Toxic Substances Control

Dr. Myrto Petreas
Dr. June-Soo Park
Weihong Guo

Communities for a Better Environment

Jessica Tovar
Carla Perez
Marleen Quint

UC Berkeley

Dr. Rachel Morello-Frosch

Brown University

Dr. Phil Brown

Funding provided by NIEHS (5R25ES13258-4), New York Community Trust, and Passport Foundation

UCSF Program on Reproductive Health and the Environment

<http://prhe.ucsf.edu/prhe/>

Mission

To create a healthier environment for human reproduction and development through advancing scientific inquiry, clinical care, and health policies that prevent exposures to harmful chemicals in our environment.

Department of Obstetrics, Gynecology and Reproductive Sciences/Center of Excellence in Women's Health

THANK YOU



Effects of PBDEs on Women's Reproductive Health

Kim Harley

**Center for Children's Environmental Health Research
School of Public Health
University of California, Berkeley**

Center for the Health Assessment of Mothers And Children Of Salinas

1998 - present



**CENTER FOR THE HEALTH ASSESSMENT OF
MOTHERS AND CHILDREN OF SALINAS**



Enrollment: 1999-2000

601 pregnant women living in the Salinas Valley:

- 92% Spanish-speaking
- 85% born in Mexico
- 54% \leq 5 years in U.S.
- 96% within 200% of poverty
- 44% 6th grade education or less
- 44% worked in agriculture
- 84% lived with agricultural workers





Methods

- Analyzed 10 PBDE congeners in serum from:
 - Mothers during pregnancy
 - Children at age 7 years
- Analysis conducted by CDC (GC-IDHRMS).
- Results expressed on a serum lipid basis (ng/g lipids).



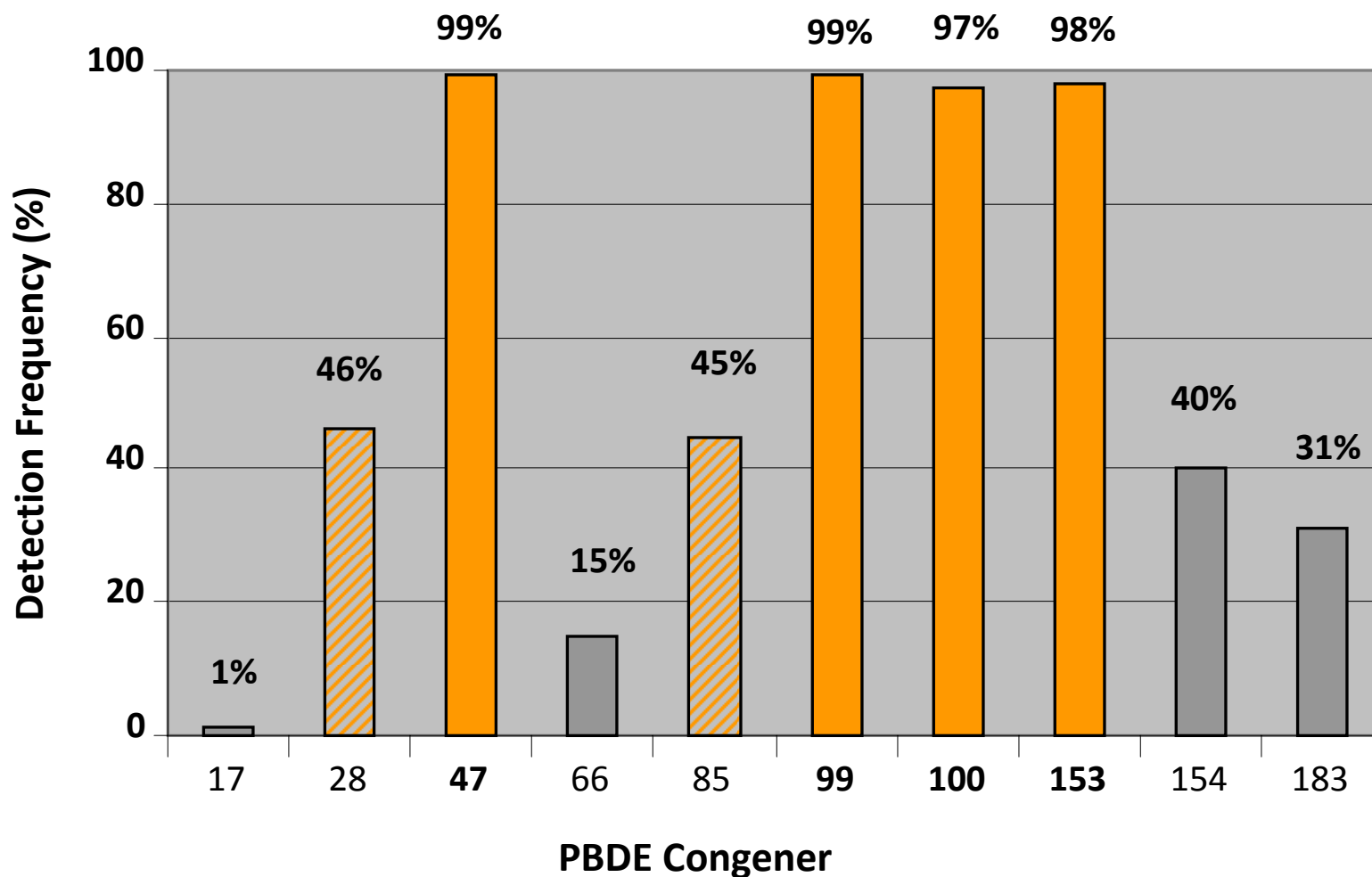


Research Questions

- What are mothers' and children's exposures?
- What are the associations of PBDEs with:
 - Fertility
 - Birth outcome
 - Thyroid hormone function
 - Neurobehavioral development
 - Obesity and metabolic syndrome
 - Timing of puberty

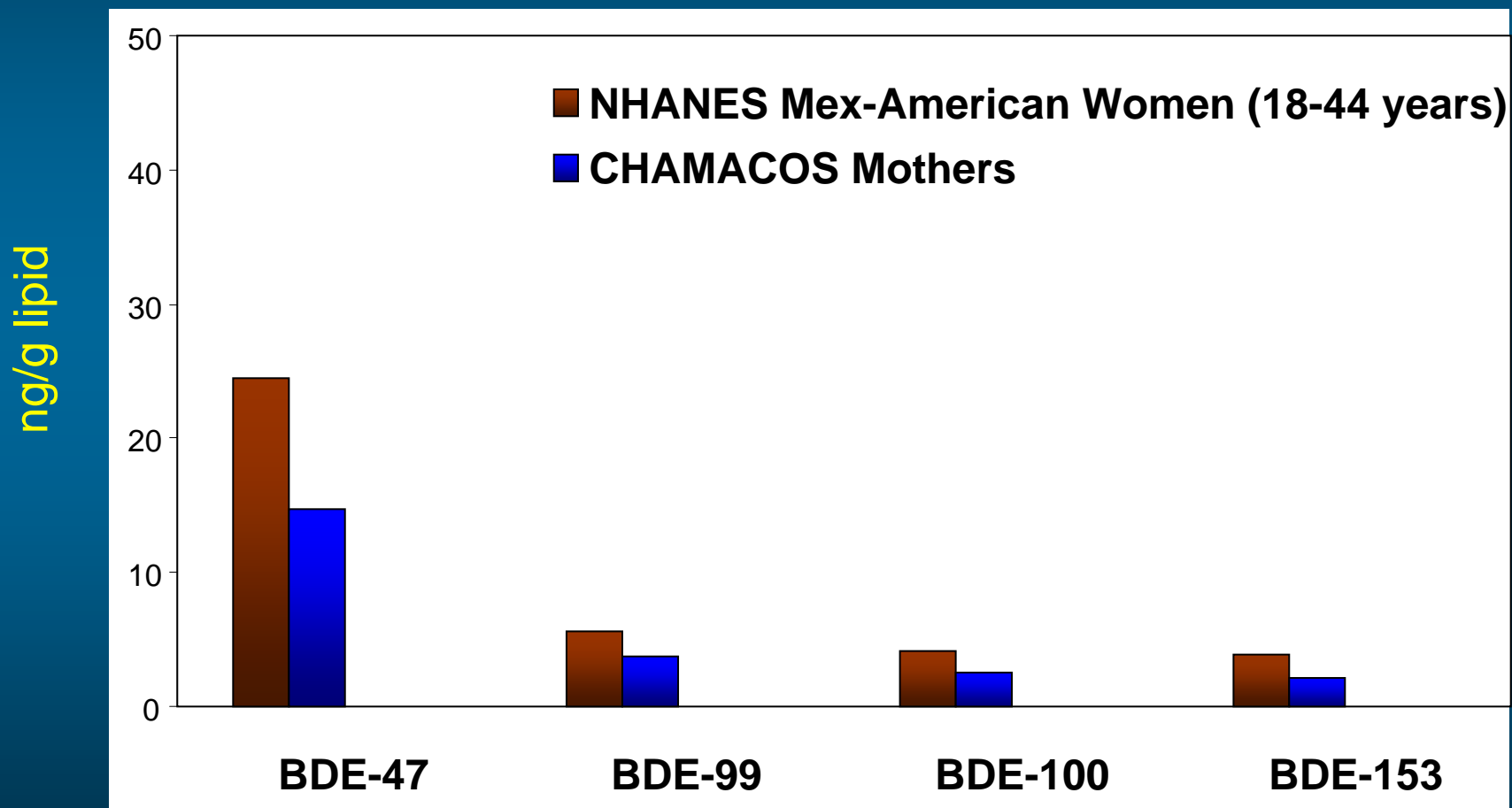


Detection Frequencies of PBDEs in Maternal Serum





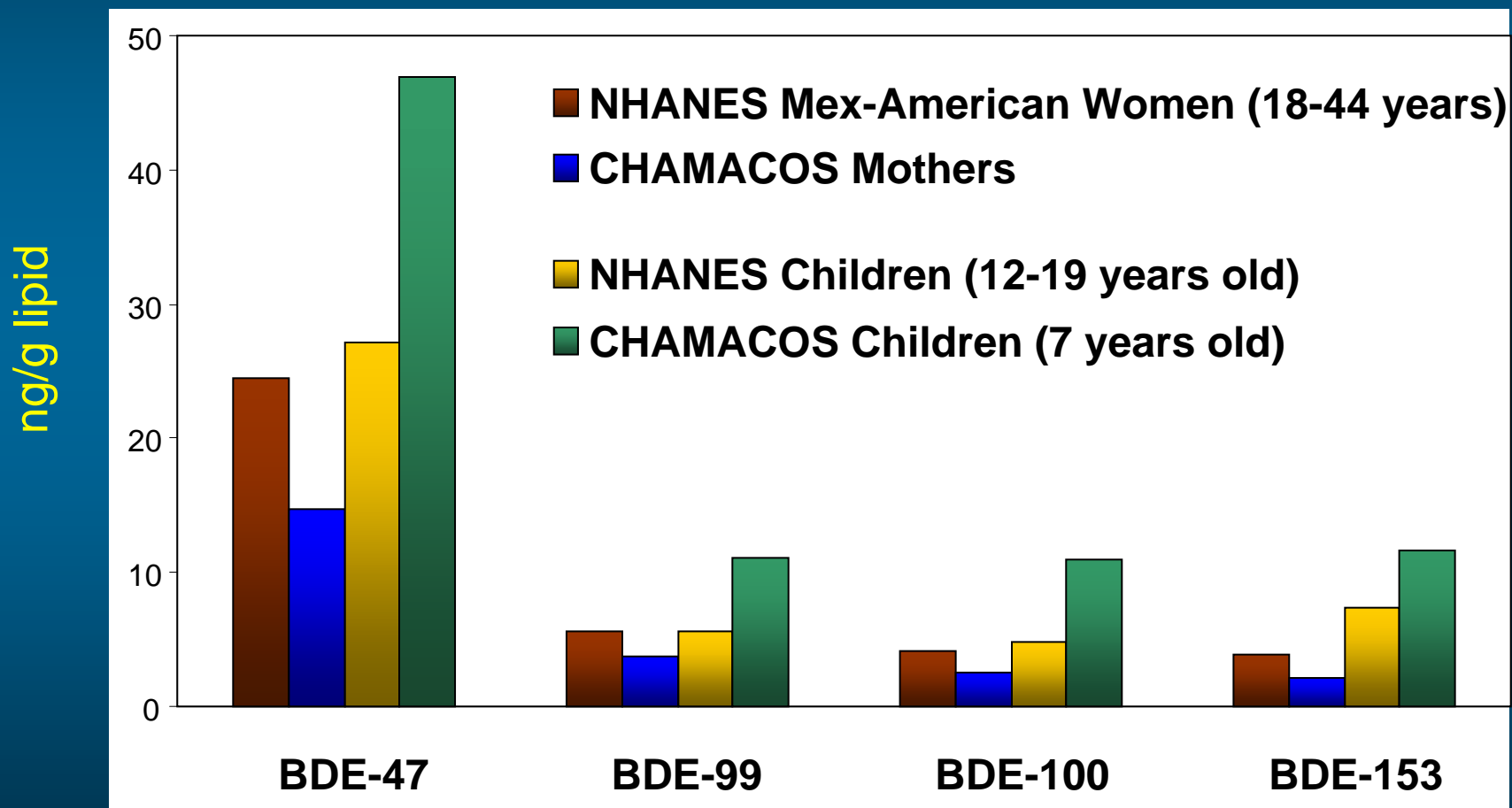
Serum PBDEs in CHAMACOS and NHANES Women and Children



¹ Sjodin, et al. 2008
Bradman, in prep



Serum PBDEs in CHAMACOS and NHANES Women and Children



¹ Sjodin, et al. 2008
Bradman, in prep

Studies of PBDEs and Fertility

Studies in animals

- Decrease in ovarian follicles
- Delayed onset on menses
- Decreased circulating estrogen

Studies in humans

- Shorter menstrual cycles (Chao, 2007)





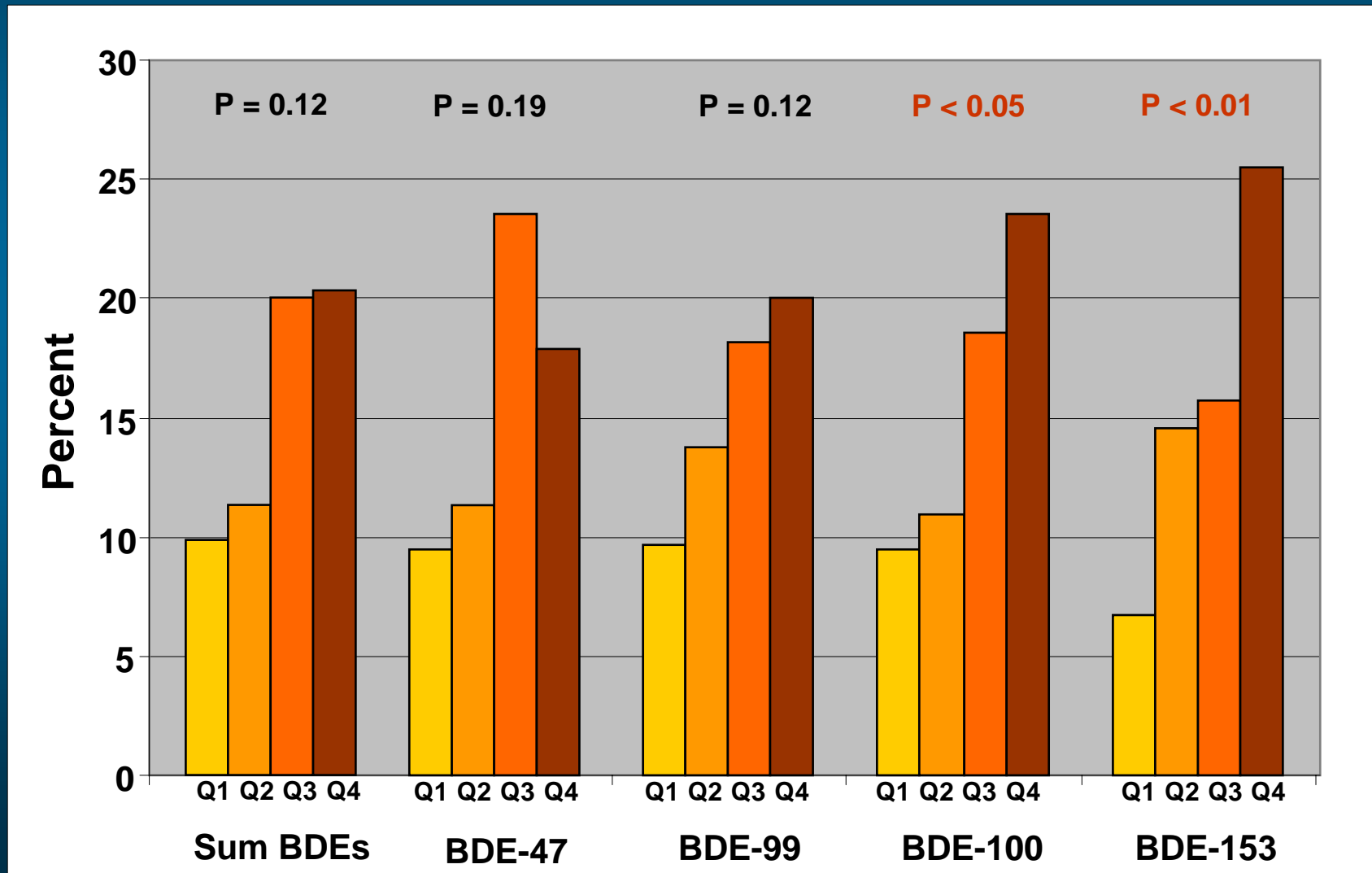
Data Collection

- Women interviewed at end of first trimester of pregnancy:

“How many months did it take to become pregnant? In other words, for how many months had you been having sexual intercourse without doing anything to prevent pregnancy?”



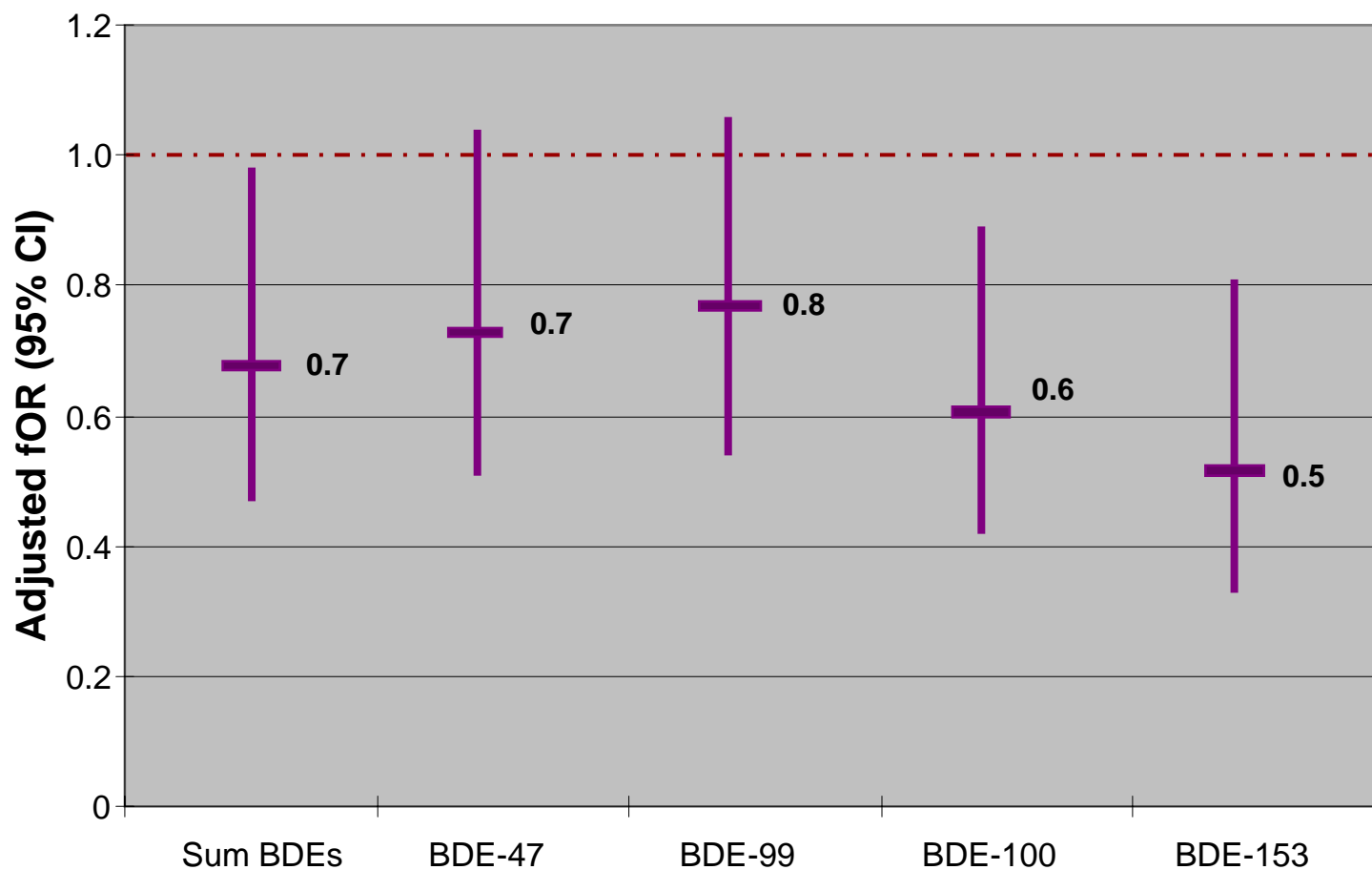
Women Taking More than 12 Months to Conceive (N=223)





PBDEs were Associated with Lower Fecundability (N = 223)

Fecundability Odds Ratios (\log_{10} PBDEs)



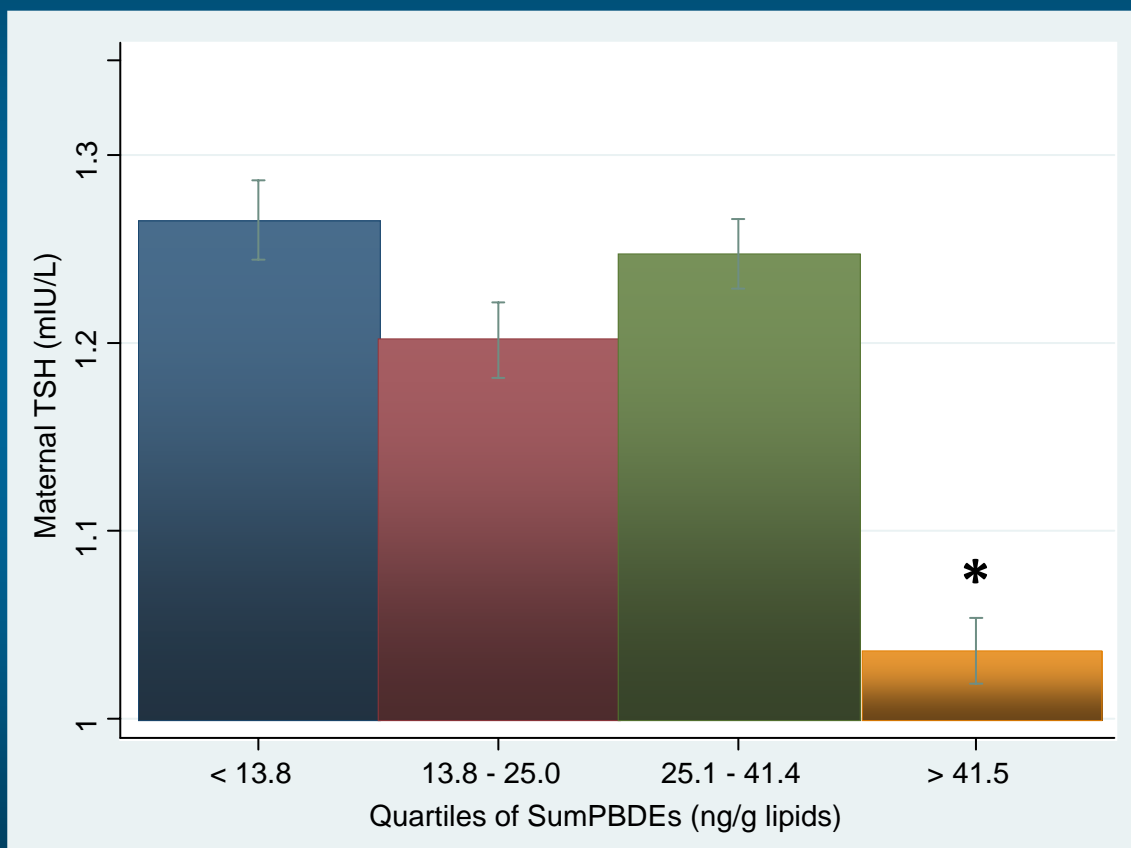
- Controlling for:
- mother's age
 - years in the U.S.
 - gynecologic conditions
 - hormonal contraceptives (previous year)
 - breastfeeding (previous 2m)
 - caffeine consumption
 - pesticide exposure

Studies of PBDEs and Thyroid Hormone

- PBDEs and thyroxine (T4) are chemically similar
 - PBDE related to:
 - ↓ Total T4 in animal dams and pups
 - ↓ T4 in human neonates
- but*
- ↑ T4 ↓ TSH in human adults



Association Between Sum of PBDEs and Maternal TSH (n=272)



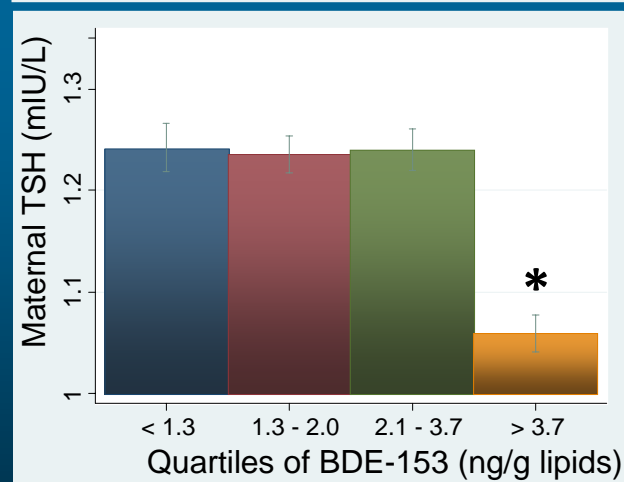
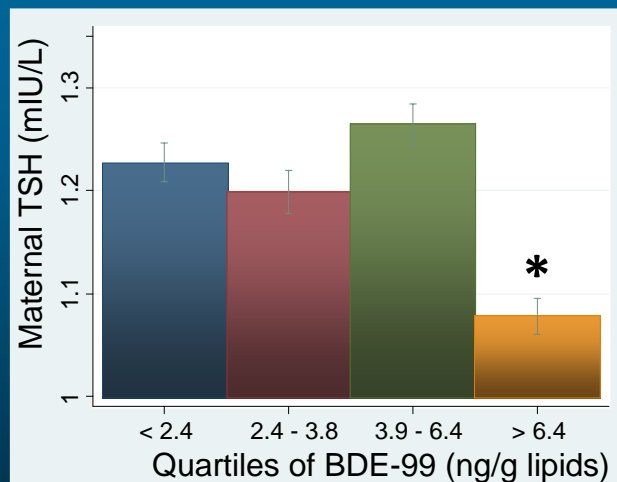
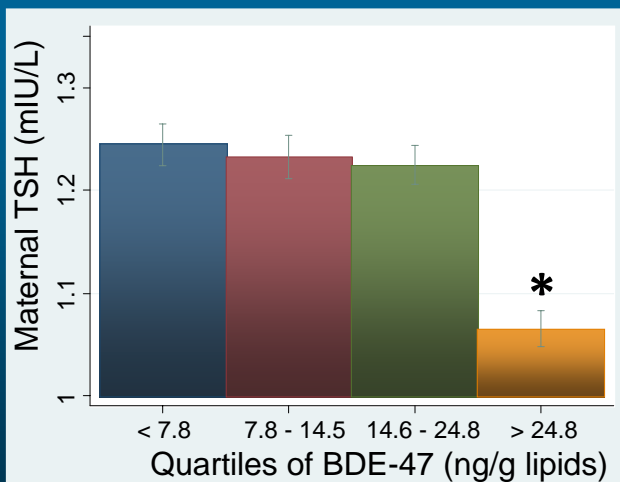
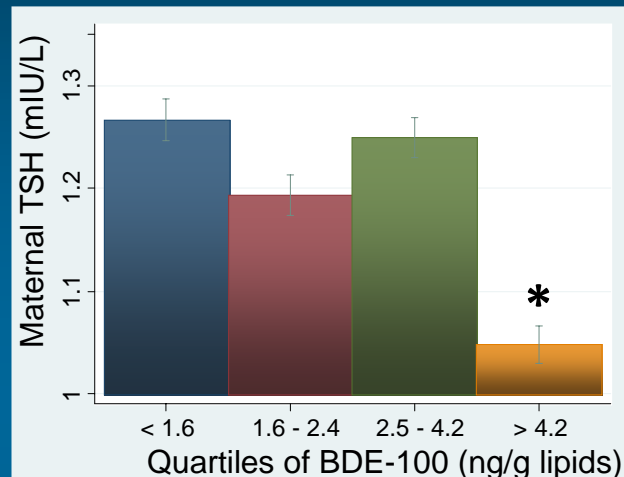
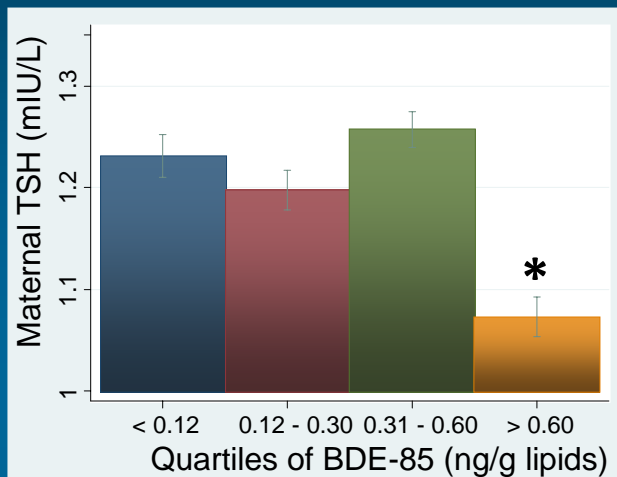
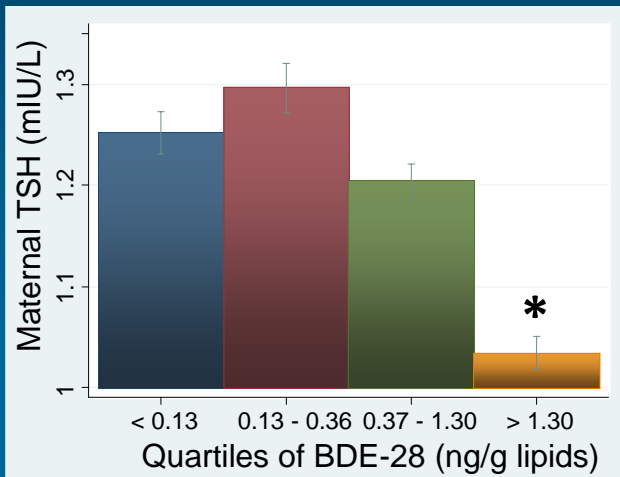
Controlling for:

- mother's age
- race
- education
- income
- country of birth
- years in the U.S.
- pre-pregnancy BMI
- gestational age at blood collection

* $p < 0.05$ compared with first quartile of exposure



High PBDE levels are associated with low maternal TSH (n=272)



Studies of PBDEs and Birth Outcome

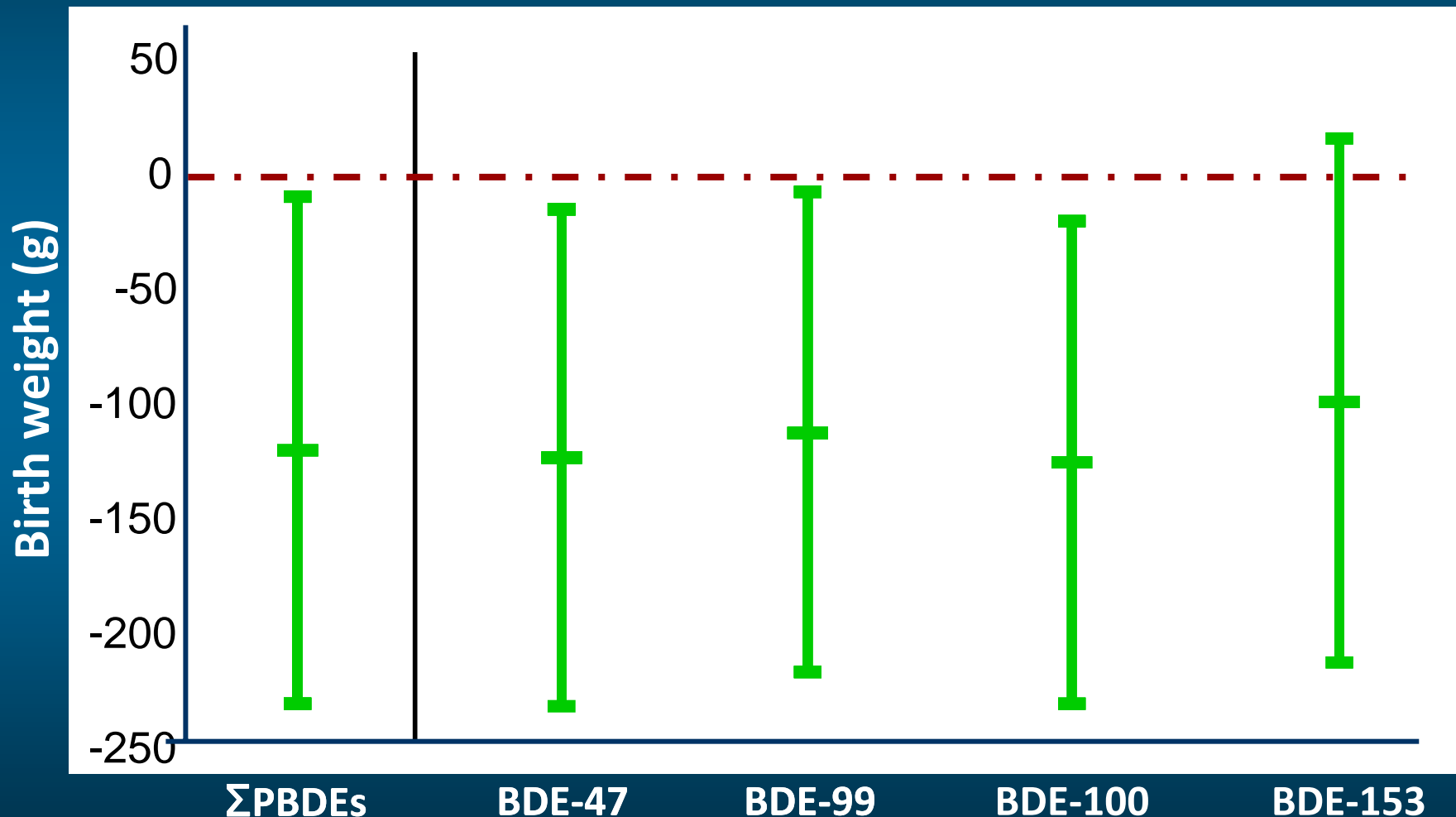
Studies in humans

- 2 PBDEs associated with adverse birth outcomes or LBW (Wu, 2010; Chao, 2007)
- 3 no association





PBDEs Associated with Lower Birth Weight (N = 288)



Adjusted for maternal age, gestational age, gestational age², race, education, income, pre-pregnancy BMI, pregnancy weight gain, marital status, smoking, parity and child sex.

In Conclusion...

- Children may have higher exposure to PBDEs
- Birth cohort studies are a good design to look at a wide array of health endpoints
- PBDE exposure may be (needs replication) related to:
 - Infertility
 - Hyperthyroidism in pregnant women
 - Lower birth weight

There are very few studies examining PBDEs in human populations.

Thank You

- **Investigators**

Brenda Eskenazi
Asa Bradman
Jonathan Chevrier
Rosemary Castorina
Nina Holland
Amy Marks
Celina Trujillo
Katie Kogut
Lesliam Quiros
Laura Fenster (CDPH)
Andreas Sjödin (CDC)

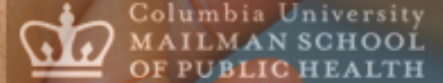
- **Funders**



- **The CHAMACOS staff and participants**



COLUMBIA CENTER for CHILDREN'S ENVIRONMENTAL HEALTH



Prenatal Exposure to PBDEs and Neurodevelopment

Julie B. Herbstman

Andreas Sjödin*, Matthew Kurzon, Sally A. Lederman, Richard Jones*,
Virginia Rauh, Larry L. Needham*, Deliang Tang, Megan Niedzwiecki,
Richard Y. Wang*, and Frederica Perera

[Environmental Health Perspectives, Volume 118, Number 5, May 2010]



Department of Health and Human Services

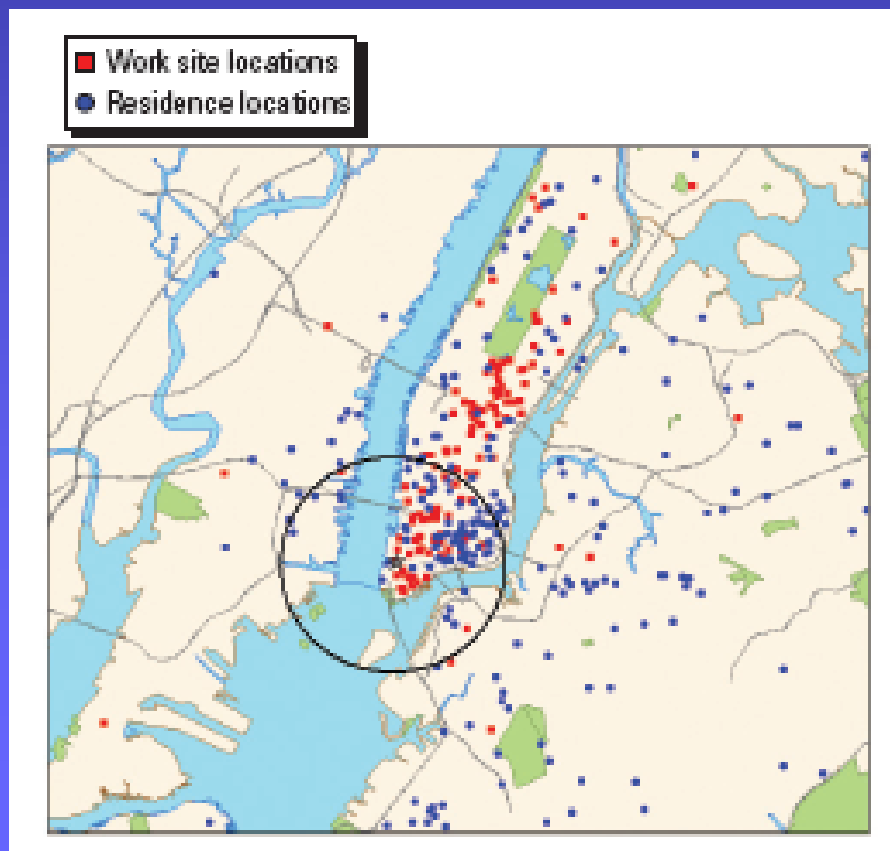
*Centers for Disease Control and Prevention

Study Objective

- While the association between prenatal exposure to PBDEs and adverse neurodevelopment has been observed in animal models, this association has not been adequately explored in human populations.
- We explored the relationship between prenatal PBDE exposure measured in umbilical cord blood and indicators of neurodevelopment at ages 1, 2, 3, 4, and 6 years.

World Trade Center Pregnancy Study

Women pregnant with a single child were enrolled between December 2001 and June 2002 during labor at 3 participating hospitals located within 2 miles of the WTC site.



Eligibility:

- Healthy
- 18-39 years old
- not a smoker, drug user
- No known HIV infection

Complete enrollment:

- Cord or maternal blood
- Postpartum interview
(in English, Spanish, or Mandarin)
- Allowed access to their medical record information

[Lederman et al. EHP 2004]

Methods: Data Collection

- Information about the pregnancy and delivery was collected from the medical records of the mother and newborn.
- Neurodevelopmental testing:
 - Ages 12, 24, and 36 months using Bayley Scales of Infant Development II
 - Mental and Psychomotor Developmental Index
 - Age 48 and 72 months using Wechsler Preschool and Primary Scale of Intelligence-Revised
 - Verbal, Performance, and Full Scale IQs

Methods: Biological Sample Analysis

Cord blood samples were processed at Columbia University

Shipped to the laboratories of the Centers for Disease Control and Prevention for plasma measurements of:

- PBDEs
 - semiautomated high-throughput extraction and cleanup method
 - quantified using gas chromatography isotope dilution high resolution mass spectrometry (GC-IDHRMS). [Sjodin et al. Anal Chem 2004]
- Lipids (total triglycerides and cholesterol)
 - commercially available test kits from Roche Diagnostics Corp. (Indianapolis, IN)
- Cotinine
 - liquid chromatography in conjunction with atmospheric pressure ionization tandem mass spectrometry [Bernert et al. Clin Chem 1997]

Methods: Statistical Analyses (1)

- Lipid- and natural log-adjusted
- For BDE-47, 99, 100, and 153:
 - values below LOD were imputed using the $\text{LOD} / \sqrt{2}$ BDE-47, 99, 100, and 153.
 - compared participants in the highest quintile of exposure to those in the lowest 80% of the population distribution.
- For BDE-85 and 183:
 - treated as dichotomous measures: detected versus non-detected.

Methods: Statistical Analyses (2)

- Multivariate linear regression analyses
- Inclusion of covariates based on their *a priori* association with neurodevelopment
 - child's exact age at test administration, ethnicity, maternal IQ, sex of child, ETS (yes/no)
- Inclusion of additional covariates based on >10% change in BDE beta coefficient
 - Gestational age at birth, maternal age, maternal education, material hardship during pregnancy, breast feeding index
- Additional model including language and location of assessment

Results: PBDE Exposure

Table 1. Concentrations (ng/g lipid) of PBDEs and BB-153 in cord blood.

| | Cord blood measurements (<i>n</i> = 210) | | | | Cord measurements with > 1 neurodevelopmental test (<i>n</i> = 152) | | | |
|---------|---|---------|--------|---------|--|---------|--------|---------|
| | <i>n</i> | % > LOD | Median | Maximum | <i>n</i> | % > LOD | Median | Maximum |
| BDE-47 | 210 | 81.4 | 11.2 | 613.1 | 152 | 83.6 | 11.2 | 613.1 |
| BDE-85 | 189 | 18.5 | 0.7 | 16.6 | 141 | 17.7 | 0.7 | 16.6 |
| BDE-99 | 210 | 59.5 | 3.2 | 202.8 | 152 | 57.9 | 3.2 | 202.8 |
| BDE-100 | 209 | 63.6 | 1.4 | 71.9 | 152 | 69.1 | 1.4 | 71.9 |
| BDE-153 | 201 | 49.8 | 0.7 | 28.9 | 143 | 55.9 | 0.7 | 28.9 |
| BDE-154 | 200 | 6.0 | 0.6 | 11.1 | 146 | 6.2 | 0.6 | 11.1 |
| BDE-183 | 204 | 3.9 | 0.6 | 2.8 | 147 | 4.1 | 0.6 | 2.8 |
| BB-153 | 197 | 11.2 | 0.6 | 8.0 | 145 | 13.1 | 0.9 | 8.0 |

Characteristics of cohort members

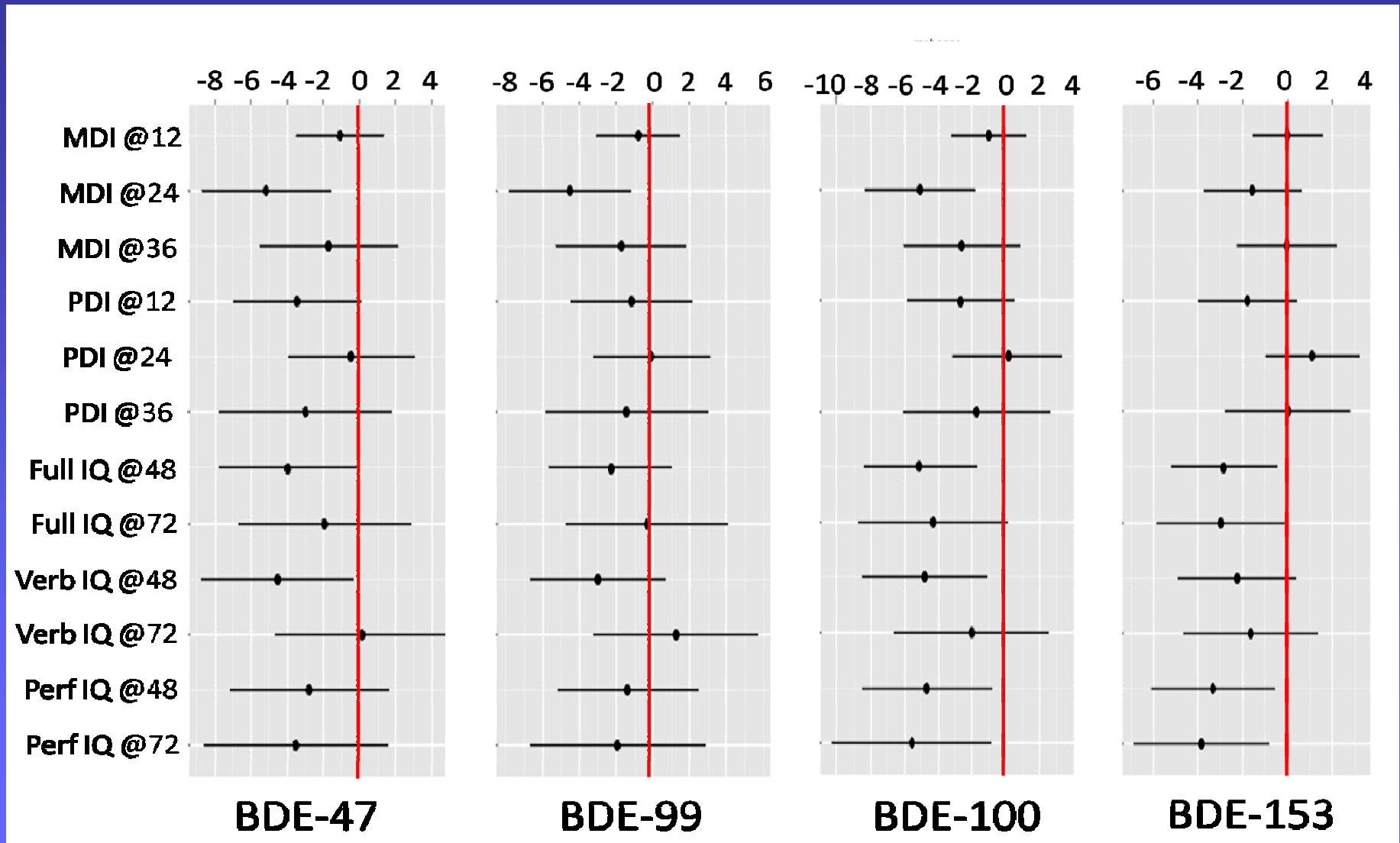
Table 2. Characteristics of all cohort members ($n = 329$), participants with cord blood measurement of PBDEs ($n = 210$), and those included in our study sample ($n = 152$).

| | All participants ($n = 329$) | Cord PBDEs ($n = 210$) | Cord measurements > 1 neurodevelopmental test ($n = 152$) |
|--|-----------------------------------|-----------------------------|---|
| Maternal characteristics | | | |
| Maternal age (years) | 30.2 ± 5.2 | 30.4 ± 5.1 | 31.2 ± 4.9** |
| Maternal education | | | |
| < High school | 61 (18.5) | 45 (21.4) | 21 (13.8) |
| High school | 56 (17.0) | 36 (17.1) | 25 (16.4) |
| Some college | 73 (22.2) | 46 (21.9) | 34 (22.4) |
| Four year college degree | 72 (21.9) | 41 (19.5) | 34 (22.4) |
| Post college education | 67 (20.4) | 42 (20.0) | 38 (25.0) |
| Race/ethnicity | | | |
| Chinese | 92 (28.0) | 72 (34.3)* | 41 (27.0) |
| Asian (non-Chinese) | 21 (6.4) | 13 (6.2) | 9 (5.9) |
| Black | 50 (15.2) | 27 (12.8) | 23 (15.1) |
| White | 133 (40.4) | 77 (36.7) | 62 (40.8) |
| Other | 33 (10.0) | 21 (10.0) | 17 (11.2) |
| Married/ living with partner | 265 (80.6) | 172 (81.9) | 126 (82.9) |
| TONI-2 score | 95.8 ± 11.4 | 95.8 ± 11.3 | 95.8 ± 13.0 |
| Missing TONI | 118 (35.9) | 82 (39.0) | 26 (17.1)** |
| Maternal exposure to ETS, reported as smoker in the home (%) | 59 (17.9) | 36 (17.1) | 26 (17.1) |
| Ate fish during the pregnancy | 233 (70.8) | 150 (71.4) | 110 (72.4) |
| Material hardship | 31 (9.4) | 20 (9.5) | 16 (10.5) |
| Infant characteristics | | | |
| Birth weight (g) | 3419.5 ± 469.1 | 3399.2 ± 472.5 | 3412.0 ± 487.4 |
| Birth length (cm) | 50.8 ± 2.8 | 50.5 ± 2.7* | 50.6 ± 2.7 |
| Birth head circumference (cm) | 34.2 ± 1.5 | 34.2 ± 1.4 | 34.3 ± 1.5 |
| Gestational age (days) | 276.8 ± 9.9 | 276.4 ± 10.4 | 276.6 ± 9.5 |
| Male | 161 (48.9) | 105 (50.0) | 77 (50.7) |
| Proportion of first year breast-fed (% of 1 year) | 0.24 ± 0.28 | 0.22 ± 0.27 | 0.26 ± 0.28 |
| Residential characteristics | | | |
| Worked and/or lived within 1 mile of the WTC during any of the 4 weeks after 9/11 | 62 (18.8) | 43 (20.5) | 32 (21.0) |
| Worked and/or lived within 2 mile of the WTC during any of the 4 weeks after 9/11 | 141 (42.8) | 94 (44.8) | 73 (48.0) |

Those included in the study sample were similar to the underlying cohort except:

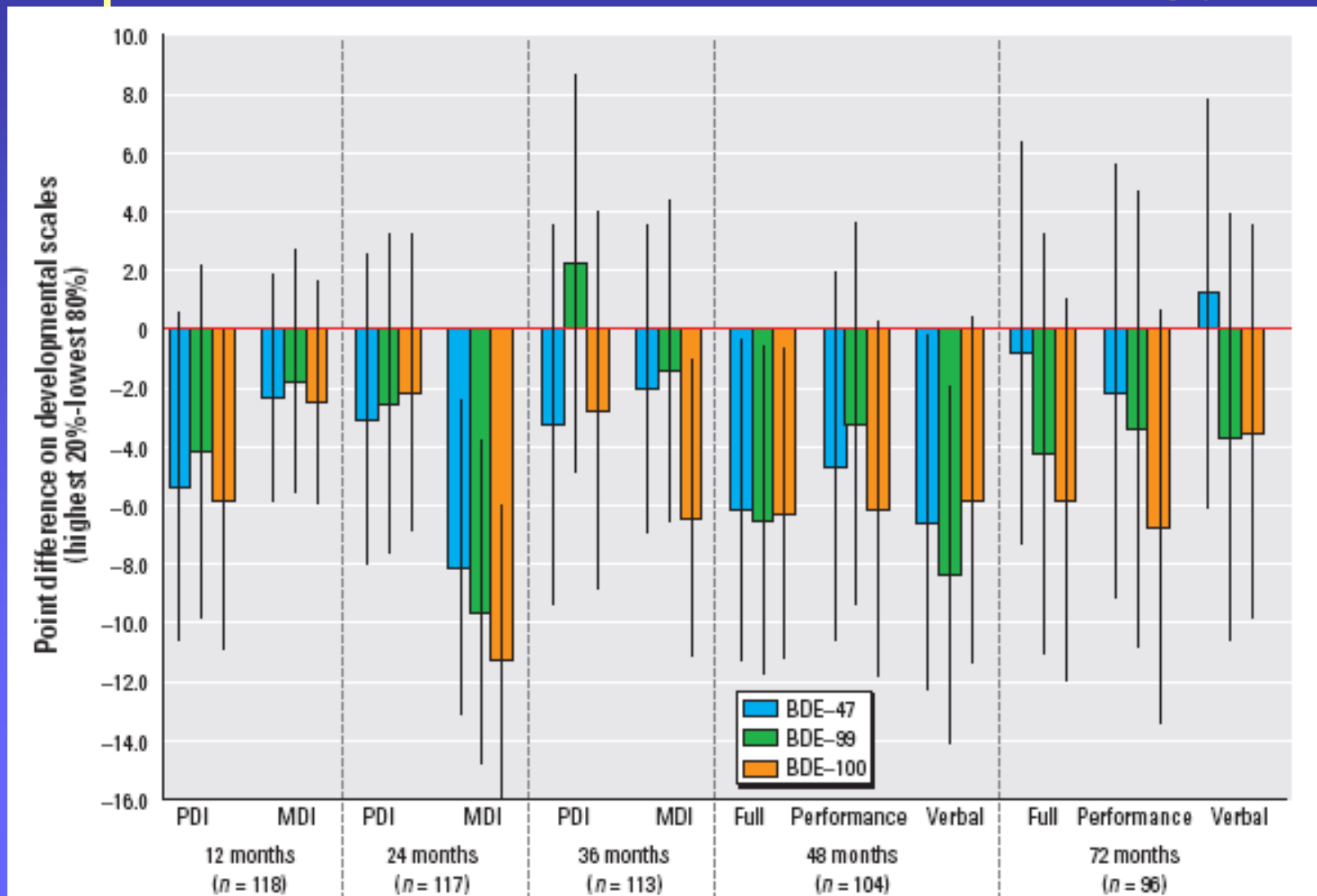
- slightly older
 - study: 31.2 yrs
 - cohort: 30.2 yrs)
- slightly more educated
 - study: 13.8% <HS
 - cohort: 18.5% < HS

Change* in score per increase in BDE IQR



* Adjusted for multiple confounders

Difference in (adj.) mean developmental scores comparing individuals in the highest quintile to those in the lower 80%



Discussion (1)


- Children who had higher cord blood concentrations of BDE 47, 99, and 100 scored, on average, lower on tests of mental and physical development at ages 12-48 and 72 months.
- Concentrations of cord blood PBDEs in this cohort are similar to other U.S. populations.
- Neurodevelopmental effects of prenatal PBDE exposure is consistent with what has been observed in animal models.
- Results are not consistent with the only other human study (Roze et al. 2009) ; however, differences in exposure concentrations, analytic approaches, and sample size limit comparability.

Discussion (2)

- Mechanisms by which prenatal PBDE exposure affect neurodevelopment are not completely understood:
 - direct neurotoxic effects on neuronal and glial cells [Costa et al. 2008]
 - changes in the quantity of cholinergic nicotinic receptors in the hippocampus [Viberg et al. 2003]
 - induction of apoptotic cerebellar granule cell death [Reistad et al. 2006]
 - thyroid hormone disruption
- Future work:
 - Replication in other study populations
 - Evaluation of effects on child behavior
 - Measurement of thyroid hormones as possible mediators
- While additional studies are underway, identification of opportunities to reduce PBDE exposure

Acknowledgements

- Study participants in the WTC cohort
- Current and former members of the WTC Research Team
- Funding: September 11th Fund of the New York Community Trust and United Way of New York City; the New York Times 9/11 Neediest Fund; the National Philanthropic Trust; N.I.E.H.S. grants ESO9089, 5P01 ESO9600, and 5R01 ESO8977, and U.S. E.P.A. grant R827027.
- The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the CDC.
- The authors have no actual or potential competing financial interests.



Arlene Blum, PhD
Dept of Chemistry UC, Berkeley,
Green Science Policy Institute, California

**Halogenated Flame Retardants
Do the Fire Safety Benefits Justify
the Health and Environmental Risks?**

And What We Can Do to Solve the Problem

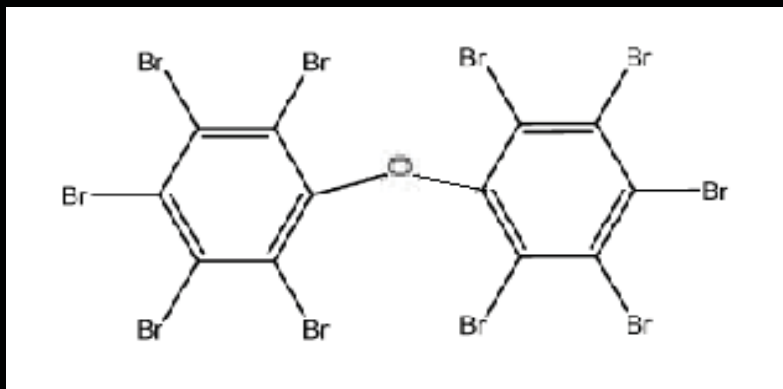
For more information
www.greensciencepolicy.org

- PART II

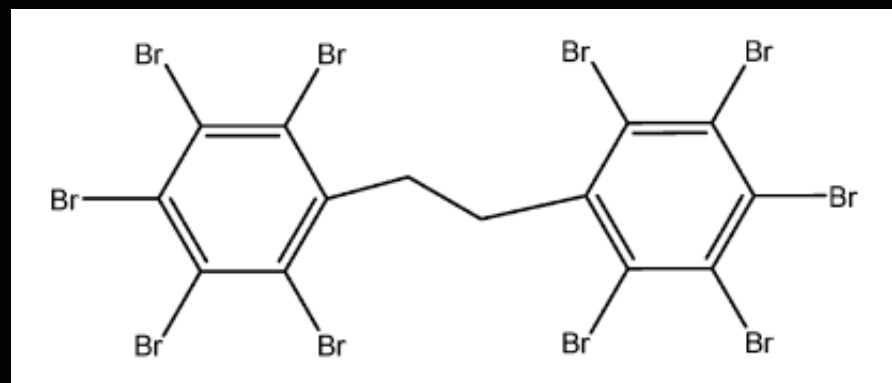
Old Model

Banning chemicals

Deca ether replaced by Deca ethane



Decabromodiphenyl ether



Decabromodiphenyl ethane

December 3, 2008

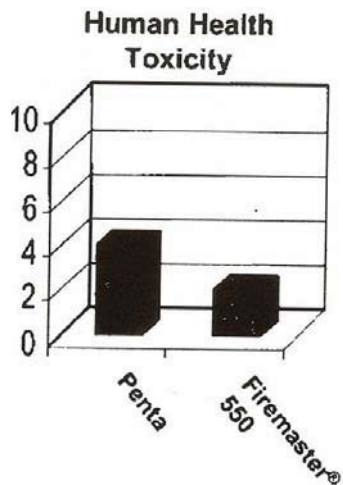
[Glut of data on “new” flame retardant documents its presence all over the world](#)



Now that DBDPE has been detected in more than a dozen species of animals in Asia and North America, scientists are calling for more research into its toxicology.

In 2003, California Banned PentaBDE

Chemtura



Replacements to meet TB117:

Firemaster 550

EPA Design for the Environment predicted reproductive, neurological, & developmental toxicity and persistent degradation products in 2004.

TDCPP or Chlorinated Tris

Estimated lifetime cancer risk from tris treated furniture foam is up to 300 cancer cases/million

What to do with a KILLER COUCH?

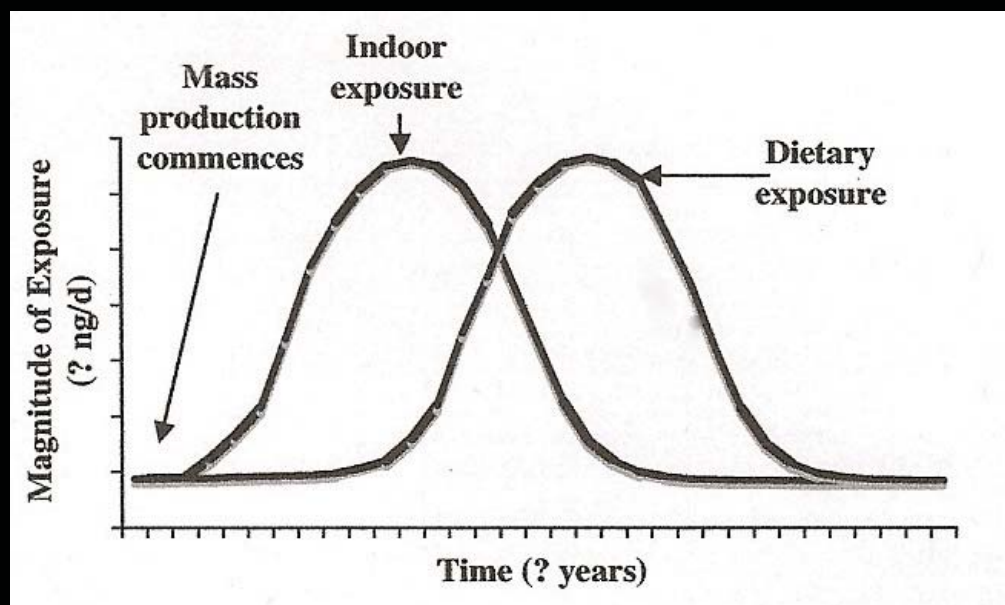


And how to replace it?



Where should all the flame retarded furniture go?

The Flame Retardant “Time Bomb”



- PentaBDE: 80% indoor air and dust, 20% diet.
- Penta is “bleeding” into the outdoor environment.
- Owing to its persistence, it will amplify in food chains.



**BFRs and CFRs “bleeding” into
the outdoor environment**

**All landfills will fail, whether they are lined or not,
because the geomembrane layer will lose its
characteristics and leaching will occur.**

based on Monica N. Danon-Schaffer, Ph.D. Thesis. UBC, 2010

Photo, courtesy

To Defuse the PBDE Time Bomb

- Research needed for end-of-life solutions
- Reduce the existing indoor reservoir in furniture, baby products, carpet cushion



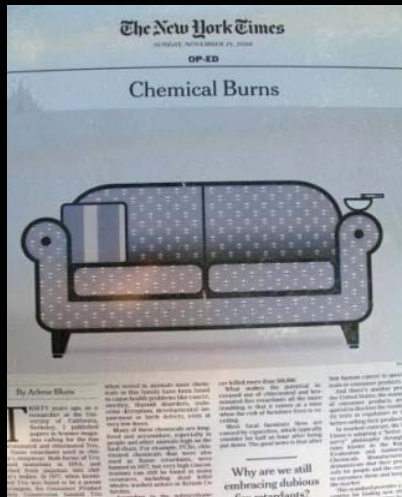
- Do we need California standard TB117?

New Model:

When do we need Flame Retardants?

Modify TB117 to Improve Fire Safety Without FRs

AB 706 would have replaced foam standard with fabric standard like proposed federal standard.



Based on Blum's Op-ed



Introducing bill with Mary Brune (MOMS), Russell Long (FOE), Mark Leno, and Andrew McGuire

A campaign flyer for AB 706. The top left features the text 'A DEADLY MISTAKE' in large, bold, yellow letters over a background of a fire. To the right, a red banner reads 'Help stop the bill that will ban material used to make flame resistant products.' Below this, a white box contains the text 'CALL YOUR STATE SENATOR TODAY AND TELL THEM TO VOTE NO ON AB 706'. A central white box says 'Call State Senator Tom Torlakson at 916-651-4007 and tell him to VOTE NO on AB 706.' To the right of this is a small photo of a firefighter. At the bottom, a dark red banner reads 'DON'T LET THE SACRAMENTO POLITICIANS BAN THE USE OF PROVEN FLAME RETARDANTS - IT COULD BE A DEADLY MISTAKE'. Small text at the bottom right includes 'P-05 021 *****SECRET*****' and 'Printed on Recycled 100% Post-Consumer Waste Paper 4/07'.

Industry \$10 million media blitz



Every Second Counts When Escaping A Fire

Presorted Standard
U.S. Postage
PAID
Rancho Cordova, CA
Permit #275

PAID FOR BY CALIFORNIANS FOR FIRE SAFETY

Paid for by Californians for Fire Safety

- Albemarle
- Chemtura,
- IC-Ltd Industrial Products (Dead Sea Bromine)



[Advanced Search](#)

[Cal-Access Home](#)

[Campaign Finance](#)

[Lobbying Activity](#)

[Individual](#)

[Lobbyists](#)

[Lobbying Firms](#)

[Lobbyist](#)

[Employers](#)

[\\$5,000+ Plus Payments To](#)

[Influence](#)

[Daily Filings/](#)

[Directory Changes](#)

[Resources](#)

[For Filers Only](#)

[Political Reform](#)

[User's Manual](#)

Lobbying Activity

BURSON-MARSTELLER, ON BEHALF OF THE BROMINE SCIENCE AND ENVIRONMENTAL FORUM, ALSO DBA CALIFORNIANS FOR FIRE SAFETY

View:

- General Information
- Financial Activity/Filing History

Legislative Session

- 2007 through 2008
- Historical

As disclosed in quarterly reports filed with the Secretary of State, payments made by an organization to its own in-house lobbyists or to lobbying firms are reported here. Links to legislative bills or state agencies lobbied also are available.

2007-2008 LEGISLATIVE SESSION

| LOBBYING PAYMENTS MADE | | | |
|------------------------|---------|------------------|-----------------|
| SESSION | QUARTER | GENERAL LOBBYING | P.U.C. LOBBYING |
| 2007-2008 | 5th | \$0.00 | \$0.00 |
| 2007-2008 | 4th | \$330,854.96 | \$0.00 |
| 2007-2008 | 3rd | \$6,169,810.99 | \$0.00 |
| 2007-2008 | 2nd | \$148,278.78 | \$0.00 |
| 2007-2008 | 1st | \$24,271.17 | \$0.00 |

TB117 furniture and baby products usually contain flame retardants
Major use of pentaBDE and FM550



Public Information Campaign about Baby Products



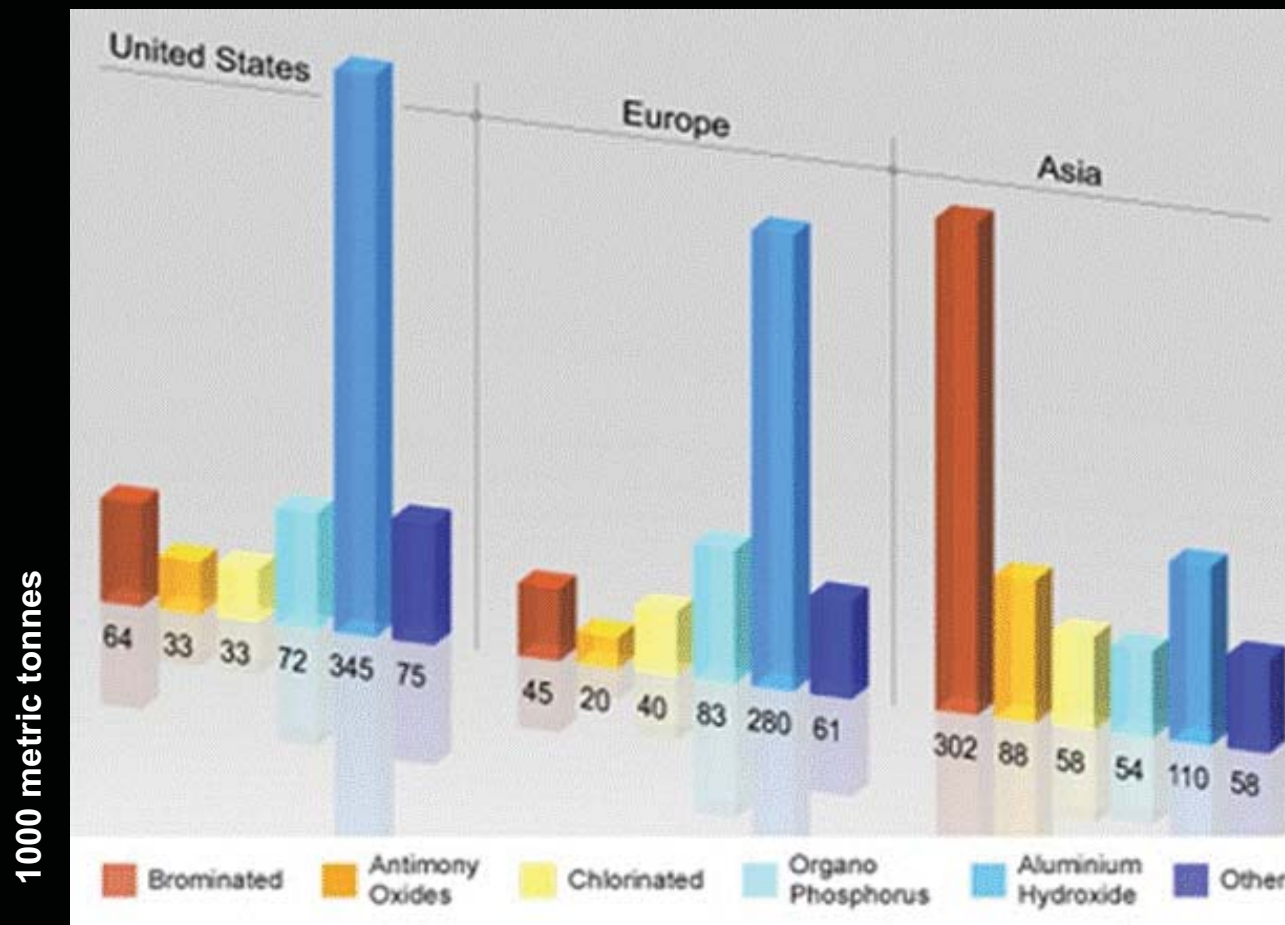
Graco baby stroller with 3% TDCP or chlorinated Tris in the foam in the padding.



“Brestfriend” nursing pillow with Antiblaze V6, 37% chlorine 2,2-Bis(Chloromethyl) Trimethylene Bis(Bis(2-Chloroethyl) Phosphate).

California Senate Bill 772 would stop a de facto requirement for flame retardants in the foam in baby products which have no fire hazard.

100 baby products being analyzed



SRI Consulting (2008) Fink, et al , SRI Consulting, 2008 Specialty Chemicals

2005 to 2008: Global 30 % increase in BFR production
Asia: BFR almost double, CFR five times up

2009 Albermarle's profits up 377% from an increase in BFR sales.


Some Suggestions

- Use flame retardant chemicals when a fire safety benefit is established
- More effective to reduce ignition sources than to add flame retardants.
- When needed, use non-halogenated rather than organohalogen flame retardants
- Use alternative technologies such as barriers
- Update flammability standards
- Public information

For more information

- California SB772
 - stop requirement for flame retardants in the foam in baby products with no fire hazard
- California SB1291
 - health information BEFORE flame retardants are used
 - an analysis of the costs and benefits of TB117

Contact : info@greensciencepolicy.com
www.greensciencepolicy.org

A high-altitude mountain climber is seen from behind, ascending a steep, snow-covered peak. The climber is wearing a yellow helmet and dark gear, and is secured by ropes. The sun is shining brightly in the upper left corner, creating a lens flare effect. The sky is a deep blue, and the snow is bright white with some shadows. The overall scene is one of a challenging and beautiful alpine environment.

For more information

info@greensciencepolicy.com
www.greensciencepolicy.org