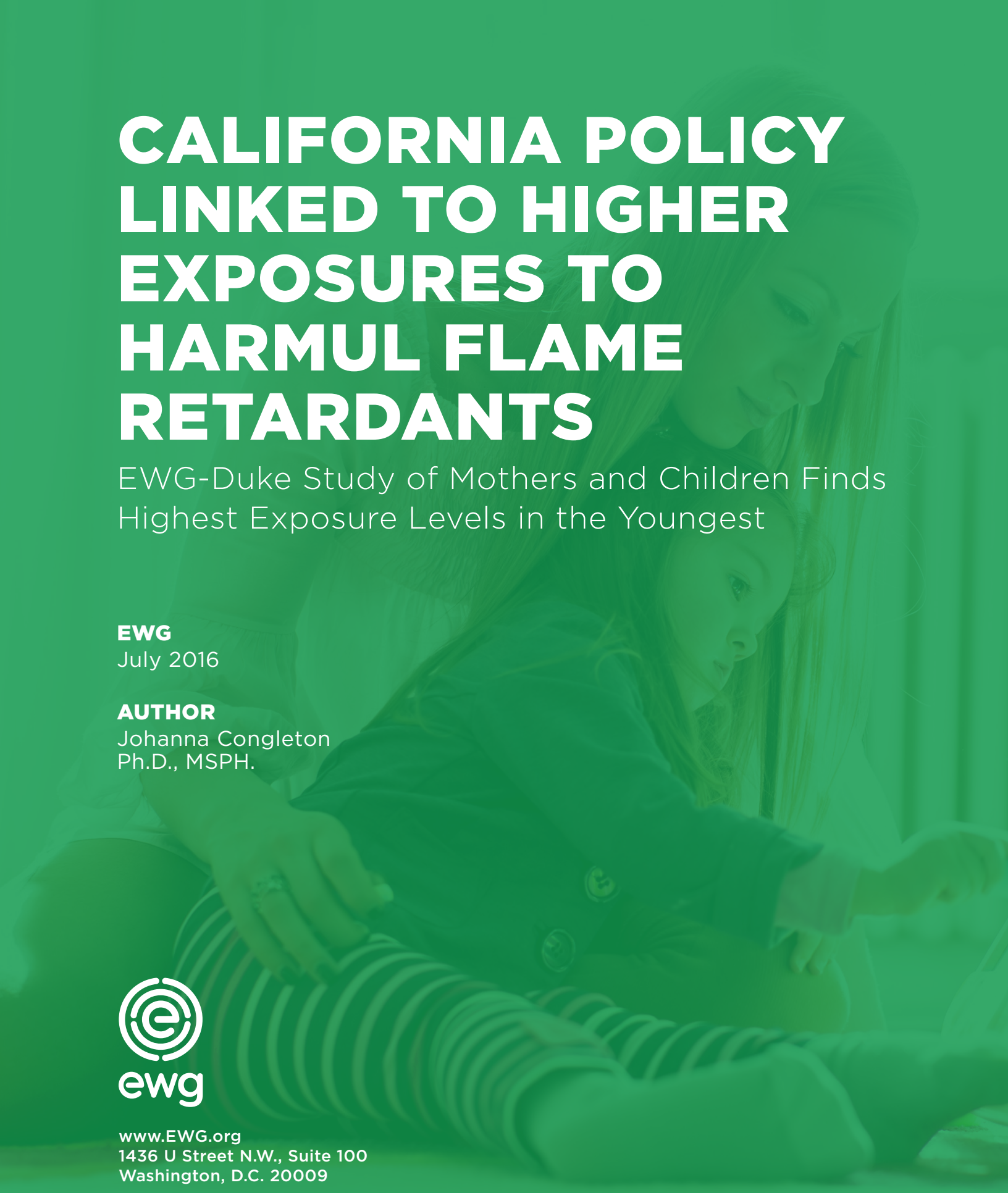

CALIFORNIA POLICY LINKED TO HIGHER EXPOSURES TO HARMUL FLAME RETARDANTS

EWG-Duke Study of Mothers and Children Finds Highest Exposure Levels in the Youngest

EWG
July 2016

AUTHOR
Johanna Congleton
Ph.D., MSPH.

www.EWG.org
1436 U Street N.W., Suite 100
Washington, D.C. 20009

CONTENTS

ABOUT EWG

The Environmental Working Group is the nation's most effective environmental health research and advocacy organization. Our mission is to conduct original, game-changing research that inspires people, businesses and governments to take action to protect human health and the environment. With your help—and with the help of hundreds of organizations with whom we partner—we are creating a healthier and cleaner environment for the next generation and beyond.

REPRINT PERMISSION

To request reprint permission, please email a completed request form to permissionrequests@ewg.org

HEADQUARTERS

1436 U Street N.W., Suite 100
Washington, D.C. 20009
(202) 667-6982

CALIFORNIA OFFICE

2201 Broadway, Suite 308
Oakland, CA 94612

MIDWEST OFFICE

103 E. 6th Street, Suite 201
Ames, IA 50010

SACRAMENTO OFFICE

1107 9th Street, Suite 625
Sacramento, CA 95814

ACKNOWLEDGEMENTS

EWG thanks Drs. Heather Stapleton, Kate Hoffman and Craig Butt for reviewing this report and conducting analysis of the urine samples.

Editor Nils Bruzelius

Designer Tiffany Follin

EXECUTIVE SUMMARY

In California, where until recently state regulations led to near-universal use of flame retardants in upholstered furniture, laboratory tests on a group of volunteers confirm that mothers and their children have been exposed to two particularly toxic chemicals.

The new study by EWG and Duke University researchers shows that the exposures to the two chemicals were higher in California than those found in a similar study in New Jersey. For one chemical, California children had exposures more than twice as high as their Garden State peers.

One of the chemicals is known to cause cancer in animals, and the second is a suspected endocrine-disruptor that may affect the way our bodies control fat metabolism. The testing detected metabolites (breakdown products) of both chemicals in the volunteers' urine.

The EWG-Duke study showed that on average, the California children in the study had been exposed to the carcinogenic flame retardant TDCIPP in amounts that were more than double those detected in the New Jersey children. Younger children were the most highly exposed. Mothers in California also had higher exposures to TDCIPP than their New Jersey counterparts, but differences were not as extreme as in the children.

Mothers and children in the Golden State also had higher levels of a metabolite of the second flame retardant—ip-PDPP, a suspected endocrine disruptor—than those in the New Jersey study. The metabolite, ip-PPP, forms as the body processes the original chemical.

In both the California and New Jersey studies, children generally had higher levels of flame retardant metabolites than their mothers, but in some cases the differences were more extreme in California. In 1-to-5-year-olds in California, metabolites of TDCIPP were on average 15 times higher than the amounts in their mothers. Children of the same ages in New Jersey had amounts of these metabolites about five times higher than those in their mothers. Metabolites of the endocrine disruptor TPHP were almost six times higher in California children than in their mothers, compared to three times higher in New Jersey.

The new study is the first to have tested children and their mothers for a newly discovered metabolite of TCIPP, whose chemical structure closely resembles that of carcinogenic TDCIPP. In laboratory experiments TCIPP damages nerve cells, and it has the potential to affect the developing nervous system.[1,2] All of the 28 mothers and 33 children who participated in the California study had detectable levels of the TCIPP metabolite BCIPHIPP in their urine.

Furniture laced with flame retardants is common throughout the United States, but until 2014 California was the only state with regulations that led to their use in virtually *all* foam cushioning for furniture. This meant that all of the upholstered furniture sold in California before 2014 probably contained flame retardants.

The EWG-Duke researchers conducted the new study shortly after California updated its furniture flammability rules amid concerns that flame retardants could be harming public health and the environment, and growing awareness that the chemicals did not substantially improve furniture fire safety. The EWG-Duke study underscores how the misguided regulations exposed people to harmful chemicals.

These findings come as the U.S. Consumer Product Safety Commission considers implementing a national furniture flammability standard. Health advocates are urging the Commission to adopt a standard that will not result in the increased use of flame retardants. The agency is also weighing a petition to ban a class of toxic chemicals called organohalogens from four types of consumer products: upholstered furniture, children's products, electronics, and mattresses or mattress pads. In 2015, EWG collected more than 10,000 signatures in support of this ban.

DETAILED EWG-DUKE STUDY RESULTS

Testing on couches and baby products shows that some of the most common flame retardants in foam cushioning are a class of chemicals called organophosphates and a mixture of chemicals known as Firemaster® 550. An **EWG-Duke study** published in 2014 found that children living in New Jersey had higher levels of certain metabolites of these substances in their urine than that of their mothers. For a summary of the New Jersey study results, click **here**.

Californians may have even higher exposures to these chemicals because of a decades-old state furniture flammability standard that led to heavy, routine use of flame retardants. This regulation, TB117, was revised in 2013 to give furniture manufacturers the option of not using flame-retardant chemicals. The new standard, TB117-2013, requires manufacturers to pass flammability tests involving smoldering ignition sources instead of an "open flame," which can be done with technology that does not use flame retardants.

TB117-2013 became effective at the beginning of 2014, but most California homes still have furniture that meets the old standard. This means that most, if not all, of their couches, love seats and cushioned chairs still contain large amounts of chemical flame retardants.

To investigate whether regulations that encourage the use of flame retardants also increase potentially harmful chemical exposures in people, EWG and Duke University scientists collected urine samples from mothers and their children living in California, which were then compared with samples collected earlier in New Jersey.

WHAT WE TESTED FOR

1. Metabolites of two very similar chlorinated organophosphate flame retardants.

BDCIPP, or bis(1,3-dichloro-2-propyl) phosphate. It is formed when the body breaks down a flame retardant called tris(1,3-dichloro-2-propyl)phosphate, or TDCIPP.

BCIPHIPP and **BCIPP**, which are both metabolites of TCIPP, or tris(1-chloro-2-propyl)phosphate. BCIPHIPP and BCIPP are called bis(1-chloro-2-propyl)1-hydroxy-2-propyl phosphate, and bis(1-chloro-2-propyl) phosphate, respectively.

2. Metabolites of the chemicals in a widely used flame retardant mixture called Firemaster® 550. Some of these chemicals may also be used in other flame retardants.

DPHP, or diphenyl phosphate. This forms when the body breaks down an organophosphorous flame retardant called triphenyl phosphate, or TPHP. DPHP may also be formed by other organophosphate-based flame retardants and plasticizers.

tb-PPP and **ip-PPP**, organophosphate metabolites similar in structure to DPHP. They are the breakdown products of t-butyl triphenyl phosphate, or tb-PDPP, and isopropyl triphenyl phosphate, or ip-PDPP.

TBBA, or tetrabromobenzoic acid, a metabolite of 2-ethylhexyl-2,3,4,5-tetrabromobenzoate, or EH-TBB.

Laboratory analysis done at Duke University revealed that Californians did in fact have higher levels of some flame retardant metabolites in their urine. BDCIPP, a metabolite of carcinogenic TDCIPP, was detected in every study participant tested, and children's levels were 2.4 times higher in California than in New Jersey. The mothers' levels were also elevated, but not to the same extent as children's. A metabolite of ip-PDPP, also detected in every study participant, was elevated in both mothers and children. Moms in California had levels nearly twice (1.85 times) as high New Jersey mothers.

Children in California had higher levels of certain flame retardant metabolites than their mothers. This trend was also seen in New Jersey, but the differences were more extreme in California. Children's levels of BDCIPP were 15 times higher than their mothers', while in New Jersey they were five times as high. DPHP in California children was six times higher than that in their mothers, compared to just three times higher in New Jersey. In the most shocking case, one California child's level of BDCIPP was 291 times higher than the mother's.

Children's ages and hand-to-mouth activity were strongly associated with higher exposures to some of the flame retardant chemicals. Children with more than six hand-to-mouth contacts per day had BDCIPP and DPHP levels that were 7.9 times and 3.3 times, respectively, higher than those of children with fewer than six contacts. Thumb sucking was associated with higher levels of ip-PPP, and more frequent hand-washing correlated with lower levels of urinary BDCIPP. Younger children were more likely to have higher levels of BDCIPP and DPHP than older ones, probably because they put their hands and objects in their mouths more often. Flame retardants are known to contaminate house dust, which accumulates on floors where children play. BDCIPP levels decreased by 5 percent with every one-month increase in age, while DPHP levels decreased by about 6 percent per month.

The EWG-Duke study also measured a newly discovered metabolite of the flame retardant TCIPP, whose structure is close to that of carcinogenic TDCIPP. TCIPP is used in polyurethane furniture foam but is also common in building insulation. Forms of a metabolite called BCIPHIPP were detected in 100 percent of the participants. The New Jersey study, which looked for a different metabolite of TCIPP called BCIPP, only detected it in 14 percent of mothers and 4 percent of children. These results suggest that BCIPHIPP is a better indicator of exposure to TCIPP.

It is noteworthy that levels of BCIPHIPP were not associated with hand-to-mouth behavior in this study, but other flame retardant metabolites were. A separate, recently published study that tested indoor air showed that TCIPP had the highest breathable levels out of a number of chlorinated flame retardants.[3] Another study found a relationship between urinary levels of BCIPHIPP and the presence of TCIPP special wristbands that collect contaminants found in air.[4] Therefore inhalation may be an important route of exposure for TCIPP.

Overall, the EWG-Duke study results suggest that the greater TDCIPP and ip-PDPP exposure in California may be driven by the flammability regulations that were only recently revised. Higher levels of PBDE metabolites have also been reported in Californians than in people in other states,[5] further supporting the evidence that misguided regulations can lead to excessive and potentially unsafe human exposures.

FLAME RETARDANTS LINKED TO DEVELOPMENTAL TOXICITY, ENDOCRINE DISRUPTION AND CANCER

Independent researchers are slowly uncovering the toxic properties of many flame retardant chemicals that industry has long maintained are safe. Endocrine disruption, cancer and adverse effects on development are at the top of the list.

Experiments with zebra fish embryos, which are often used to study developmental toxicity, have demonstrated the damaging effects of flame retardant chemicals on immature animals. A research group at Oregon State University tested 44 flame retardants, including those found in the EWG-Duke study, and showed that 93 percent caused harmful responses in one or more tests of survival, development and neurobehavioral activity.[6] This indicates that many flame retardant chemicals are biologically active in developing organisms. It also raises serious questions about the consequences of combined exposures to these compounds. Biomonitoring studies show that people typically have several metabolites of these chemicals in their bodies.

Studies have also shown that some of these compounds are toxic to nerve cells. TDCIPP had neurotoxic effects on brain cells that were as great or greater than those caused by the pesticide chlorpyrifos, which is a known neurodevelopmental toxicant. Both TDCIPP and TCIPP altered the way nerve cells mature, suggesting that the developing nervous system may be especially vulnerable to these compounds.[1] The study authors concluded that the changes triggered by TDCIPP and TCIPP have the potential to produce "extensive miswiring" of the developing nervous system.

Follow-up animal studies by the same research group showed that TDCIPP and TCIPP had other neurodevelopment effects.[2] For TDCIPP, the timing of exposure was important: Fish exposed during very early stages of development were much more likely to be harmed. Other flame retardant compounds that have similar structural properties also cause neurotoxicity in developing fish.[7]

In a 2015 study, Duke University scientists found that animals exposed to TDCIPP and TPHP early in development showed behavioral impairments that were still evident in adulthood. The authors estimated that the levels of TDCIPP and TPHP detected in the tissues of the exposed fish could be similar to those documented in humans.[8]

Similarly, experiments with the Firemaster® 550 mixture showed that animals exposed during early development displayed behavioral changes that persisted through adolescence. Lasting behavioral changes were not seen when older animals were exposed, even at higher doses.[9] Exposure to low levels of TDCIPP during development also caused reproductive abnormalities in animals.[10] These studies emphasize that exposure during critical windows of development can have lasting harmful effects.

Research signals that children may be particularly sensitive to these chemicals. This is especially true of compounds that affect biological processes necessary for proper development. Each of the children in this study were exposed to TDCIPP, ip-PDPP, TPHP and TCIPP, and all of these substances have shown adverse effects in experiments studying developmental toxicity.

In addition, exposures to both TDCIPP and TPHP have been associated with decreases in sperm quality and hormone changes in men.[11,12] Animal studies show that TDCIPP alters the activity of genes that regulate hormone signaling important for reproduction and development.[13,14] TPHP stimulates receptors for female sex hormones, and in experiments with cells, both TPHP and TDCIPP block male sex hormone activity.[15] In the same set of experiments, TCIPP stimulated the pregnane X receptor, which helps defend the body against toxic chemicals. These fluctuations in the hormone system could ultimately alter metabolism and reproduction.

In a 2012 study, rats exposed to Firemaster® 550, which contains TPHP and ip-PDPP, became overweight.[16] This led scientists to investigate whether specific components of the mixture were causing metabolic changes and weight gain. Subsequent experiments showed that TPHP and ip-PDPP stimulate a receptor that is important to fat cell development, indicating that it may act as an "obesogen"—increasing susceptibility to weight gain.[17,18] Even in low doses, TPHP disrupts fat metabolism and decreases liver cells' ability to repair damaged DNA.[19]

Cancer risk is yet another concern with flame retardants. TDCIPP causes tumors in animals and is listed in the state of California as a known carcinogen.[20,21] The U.S. Consumer Product Safety Commission classifies it as a probable human carcinogen.[22] Safety data for TCIPP is inadequate and it is not listed as a carcinogen, but it is structurally similar to TDCIPP and shares some toxicological properties, such as neurotoxicity. The National Toxicology Program is in the process of completing a two-year carcinogenicity study in rodents exposed to TCIPP. The Consumer Product Safety Commission requested the study in 2005 because of "anticipated increased use in upholstered furniture and bedding and potential consumer exposures from these uses," and "insufficient toxicity data to assess potential health risks."[23]

CALIFORNIA FLAMMABILITY RULE CREATED *DE FACTO* NATIONAL REGULATION

In 1975, California regulators adopted Technical Bulletin 117, known as TB117. The regulation required that polyurethane foam used in furniture cushioning be able to withstand ignition for 12 seconds when exposed to an open flame. The cheapest and easiest way for furniture manufacturers to meet this requirement was to add flame retardant chemicals to the foam.

The consequences of California's rule were eventually recognized as a public and environmental health threat. The chemicals used to slow ignition were found to be toxic and have long-lasting environmental effects. Widely used flame retardants included a class of compounds, called polybrominated diphenyl ethers or PBDEs, which were phased out in the U.S. as a result of accumulating evidence that they were toxic, persisted in the environment, and accumulated in human bodies and wildlife. PBDEs have been linked to thyroid hormone disruption and other endocrine effects, such as premature breast development in girls.[24,25,26,27] In 2008, **EWG published testing results** that showed toddlers had levels of these chemicals in their blood that were on average three times higher than those in their parents. The PBDE phase-out created demand for alternatives that came with their own health concerns, including cancer risk and hormone disruption.

The use of PBDEs and other hazardous flame retardants was not limited to furniture sold in California, however. Since it was easier for manufacturers to add these chemicals to all their furniture rather than producing special products to meet California's standard, flame retardant use quickly became widespread across the country. Studies done in 2012 and 2011 showed that 85 percent of couches and 80 percent of baby products tested positive for flame retardants.[28,29] Samples used in both studies were collected across the U.S. Today, we know from a plethora of biomonitoring data that people around the globe consistently have detectable levels of flame retardant metabolites in their blood, urine and even breast milk, reflecting widespread exposure.

INDUSTRY BLOCKED EFFORTS TO REDUCE EXPOSURE; HEALTH ADVOCATES FOUGHT BACK

With the spotlight on the environmental and public health risks of flame retardants, the California legislature decided to take action. In 2011, Senate Bill 147 was introduced to change the flammability standard to one based on ignition by smoldering sources, such as cigarettes, instead of an open flame. This made sense because cigarettes are the leading cause of death and injury from furniture fires. The change would have allowed manufacturers to meet flammability standards without flame retardant chemicals. It would also have authorized the chief of the state Bureau of Home Furnishings and Thermal Insulation to exempt polyurethane foam from flammability requirements if it was shown not to pose a fire hazard.[30] A companion bill, AB 2197, was introduced in the state assembly.[31]

In response, industry lobbyists came out in force. Some operated in the guise of an entity called "Citizens for Fire Safety," a now discredited front group that had only three member companies—Albemarle, ICL Industrial Products and Chemtura—which happened to be the biggest American manufacturers of flame retardant chemicals. The executive director of the organization, Grant Gillham, was also an adviser to and lobbyist for the tobacco industry.

The attempts to block the California legislation and other efforts to reduce flame retardant use took a deceptive turn. In 2012, Chicago Tribune reporters Patricia Callahan, Sam Roe and Michael Hawthorne published a **prize-winning investigative series** that uncovered the deceitful tactics the industry had employed to defeat legislation that would shrink the market for flame retardants. In particular, they reported on one industry ally, Dr. David Heimbach, who had testified against the California bill and other legislation by describing infants who had supposedly suffered severe burns because their crib mattresses had not been treated with the chemicals. The Tribune reporters found that those infants never existed. Heimbach conceded that he had made up those cases but justified it by saying that he **"wasn't under oath."** Other groups that opposed flame retardant regulations included the National Association of State Fire Marshals, which had deep financial and political ties to the chemical and tobacco industries.

The Senate bill failed to clear the Business, Professions and Economic Development Committee, and died the year it was introduced. The assembly version was abandoned in 2012.

Nevertheless, public health concerns about flame retardants continued to grow. In the face of legislative inaction and the industry deception uncovered by The Chicago Tribune, California Gov. Jerry Brown ordered the state Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation to revise the flammability standard to take into account modern manufacturing technology that could avoid the use of flame retardants.[32] In 2013, the agency approved a new standard (TB117-2013) that focused on smoldering ignition sources and could be met without applying flame retardants. It took effect January 1, 2014. A few weeks later, Chemtura, one of the largest U.S. flame retardant manufacturers with $2.2 billion in sales in 2013, filed suit to overturn the standard. The Superior Court of California ruled against the company eight months later, keeping TB117-2013 intact.

TB117-2013 does not expressly restrict flame retardants but gives manufacturers the choice of whether or not to use them to meet the smoldering ignition test. Because of pressure from consumers and health advocacy groups such as EWG, the market is now shifting toward retardant-free furniture. Large home furnishing manufacturers and retailers such as Ashley Furniture, Broyhill and Kincaid Furniture no longer offer new products with added flame retardants, but consumers should remain vigilant since old inventory on the market may still contain the chemicals.

Americans now have more choices. A recent survey of 37 companies representing 60 brands conducted by the Center for Environmental Health and the American Home Furnishings Alliance found that all respondents were offering retardant-free furniture. The Center's **website** provides a list of companies that have removed flame retardant chemicals from all their products, allowing consumers to make informed choices.

California has made other progress since implementing of the new fire safety standard. In 2014, the legislature passed Senate Bill 1019, authored by state Sen. Mark Leno, which required upholstered furniture to carry labeling indicating whether it contains flame retardants in the foam, barrier or fabric. This law made it easier for consumers to make better choices at the point of sale.

Health advocacy groups are now pushing for a national labeling requirement. To date, 78 percent of the surveyed furniture makers have adopted flame retardant labeling across the entire American market—a precedent that all manufacturers and retailers should follow.

STRANGE BEDFELLOWS JOINED FORCES TO THWART LABELING OF CHILDREN'S PRODUCTS

Although California lawmakers passed labeling requirements for furniture, they stopped short of requiring it for children's products.

Sen. Leno introduced legislation in 2015 to mandate labeling of children's products, but ran into stiff opposition when surprising organizations joined forces with the chemical industry. The Juvenile Products Manufacturing Association, representing more than 250 manufacturers who make 95 percent of the products marketed to preschoolers, infants and mothers-to-be, opposed the legislation and issued a joint letter with the American Chemistry Council and the Chemical Industry Council of California. The chemical industry orchestrated attempts to add weakening amendments and the bill is now inactive. The Juvenile Products Manufacturing Association issued a press release praising the lobbying campaign and claiming victory.

The same association is also opposing a pending petition urging the U.S. Consumer Product Safety Commission to ban toxic organohalogen flame retardant chemicals in children's items. EWG has collected more than 10,000 signatures supporting the petition.

EWG firmly supports both state and national labeling requirements for flame retardant chemicals. Americans' right to be fully informed when making a purchase must take priority over industry interests.

EWG RECOMMENDATIONS

1. **Shop smart. Purchase furniture that doesn't contain flame retardants. Look for labels that disclose flame retardant content—often noted on the underside. If you can't find a label, ask the retailer.**

2. **Because flame retardants often contaminate dust on floors where children play, parents should use a vacuum with a HEPA filter to help remove smaller dust particles, wet mop floors and always have children wash their hands before eating.**

3. **The Consumer Product Safety Commission should immediately prohibit the use of flame retardants in baby items and children's products. Until their use in kids' products ends, EWG supports local, state and national labeling efforts that help consumers can make informed choices.**

4. **The Commission is also considering a national furniture flammability standard. EWG supports a standard that will not encourage or increase the use of flame retardants.**

5. **Sen. Chuck Schumer, D-N.Y., has reintroduced the Children and Firefighter Protection Act, which would ban 10 toxic flame retardant chemicals, including TDCIPP and TCIPP, from being used in upholstered home furniture and children's products. Metabolites of TDCIPP and TCIPP were detected in all California study participants. The bill would also require the Consumer Product Safety Commission to appoint an advisory panel tasked with evaluating the health risks of other flame retardants and make recommendations that could restrict their use. EWG continues to support this important piece of legislation.**

6. **The California case shows that misguided regulations can increase exposure to harmful chemicals. As the EPA implements the overhauled federal chemical safety law, it must ensure that chemicals are safe before they come to market and reduce the public's exposure to toxic substances.**

REFERENCES

1. L.V. Dishaw et al., Is the PentaBDE Replacement, Tris (1,3-dichloro-2-propyl) Phosphate (TDCPP), a Developmental Neurotoxicant? Studies in PC12 Cells. Toxicology and Applied Pharmacology, 2011.
2. L.V. Dishaw et al., Developmental Exposure to Organophosphate Flame Retardants Elicits Overt Toxicity and Alters Behavior in Early Life Stage Zebrafish (Danio rerio). Toxicological Sciences, December 2014.
3. E.D. Schreder, N. Uding and M.J. La Guardia, Inhalation a Significant Exposure Route for Chlorinated Organophosphate Flame Retardants. Chemosphere, May 2016.
4. S.C. Hammel et al., Measuring Personal Exposure to Organophosphate Flame Retardants Using Silicone Wristbands and Hand Wipes. Environmental Science & Technology, April 19, 2016.
5. A.R. Zota et al., Elevated House Dust and Serum Concentrations of PBDEs in California: Unintended Consequences of Furniture Flammability Standards? Environmental Science & Technology, 2008.
6. P.D. Noyes et al., Advanced Morphological - Behavioral Test Platform Reveals Neurodevelopmental Defects in Embryonic Zebrafish Exposed to Comprehensive Suite of Halogenated and Organophosphate Flame Retardants. Toxicological Sciences, May 2015.
7. L. Sun et al., Developmental Exposure of Zebrafish Larvae to Organophosphate Flame Retardants Causes Neurotoxicity. Neurotoxicology and Teratology, March 24, 2016.
8. A. Oliveri, J. Bailey and E. Levin. Developmental Exposure to Organophosphate Flame Retardants Causes Behavioral Effects in Larval and Adult Zebrafish. Neurotoxicology and Teratology, November-December 2015.
9. J.M. Bailey and E.D. Levin, Neurotoxicity of Firemaster 550® in Zebrafish (Danio rerio): Chronic Developmental and Acute Adolescent Exposures. Neurotoxicology and Teratology, November-December 2015.
10. Q. Wang et al., Developmental Exposure to the Organophosphorus Flame Retardant Tris(1,3-dichloro-2-propyl) Phosphate: Estrogenic Activity, Endocrine Disruption and Reproductive Effects on Zebrafish. Aquatic Toxicology, March 2015.
11. J.D. Meeker and H.M. Stapleton, House Dust Concentrations of Organophosphate Flame Retardants In Relation to Hormone Levels and Semen Quality Parameters. Environmental Health Perspectives, 2010.
12. J.D. Meeker et al., Exploratory Analysis of Urinary Metabolites of Phosphorus-Containing Flame Retardants In Relation to Markers of Male Reproductive Health. Endocrine Disruptors, 2013.
13. C. Liu et al., Effects of Tris(1,3-dichloro-2-propyl) Phosphate and Triphenyl Phosphate on Receptor-Associated mRNA Expression in Zebrafish Embryos/Larvae. Aquatic Toxicology, 2013.
14. X. Liu et al., Effects of TDCPP or TPP on Gene Transcriptions and Hormones of HPG axis, and Their Consequences on Reproduction in Adult Zebrafish (Danio rerio). Aquatic Toxicology, 2013.
15. H. Kojima et al., In Vitro Endocrine Disruption Potential of Organophosphate Flame Retardants Via Human Nuclear Receptors. Toxicology, 2013.
16. H.B. Patisaul et al., Accumulation and Endocrine Disrupting Effects of the Flame Retardant Mixture Firemaster® 550 in Rats: An Exploratory Assessment. Journal of Biochemical and Molecular Toxicology, 2013.
17. S.M. Belcher et al., In Vitro Assessment of Human Nuclear Hormone Receptor Activity and Cytotoxicity of the Flame Retardant Mixture FM 550 and its Triarylphosphate and Brominated Components. Toxicology Letters, 2014.
18. H. Pillai et al., Ligand Binding and Activation of ppar by Firemaster® 550: Effects on Adipogenesis and Osteogenesis in Vitro. Environmental Health Perspectives, 2014.
19. Z. Du et al., TPhP Exposure Disturbs Carbohydrate Metabolism, Lipid Metabolism, and the DNA Damage Repair System in Zebrafish Liver. Scientific Reports, Feb. 22, 2016.
20. OEHHA, Evidence on the Carcinogenicity of Tris(1,3-dichloro-2-propyl) Phosphate. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, 2011.
21. OEHHA, Safe Drinking Water And Toxic Enforcement Act Of 1986. Chemicals Known to the State to Cause Cancer or Reproductive Toxicity. Office Of Environmental Health Hazard Assessment, California Environmental Protection Agency, 2014.
22. M.A.Babich, CPSC Staff Preliminary Risk Assessment of Flame Retardant (FR) Chemicals in Upholstered Furniture Foam. U.S. Consumer Product Safety Commission, 2006.
23. Nomination Summary for Flame Retardants (N20608). National Toxicology Program, 2005. Available at www.ntp.niehs.nih.gov/testing/noms/search/summary/nm-n20608.html
24. A. Chen et al., Prenatal Polybrominated Diphenyl Ether Exposures and Neurodevelopment in U.S. Children through 5 Years of Age: The HOME Study. Environmental Health Perspectives, 2014.
25. J. Chevrier et al., Polybrominated Diphenyl Ether (PBDE) Flame Retardants and Thyroid Hormone During Pregnancy. Environmental Health Perspectives, 2010.
26. H.M. Stapleton et al., Associations Between Polybrominated Diphenyl Ether (PBDE) Flame Retardants, Phenolic Metabolites, and Thyroid Hormones During Pregnancy. Environmental Health Perspectives, 2011.
27. A. Deodati, et al., Serum Levels of Polybrominated Diphenyl Ethers in Girls with Premature Thelarche. Hormone Research in Paediatrics, April 2, 2016.
28. H.M. Stapleton et al., Novel and High Volume Use Flame Retardants in US Couches Reflective of the 2005 PentaBDE Phase Out. Environmental Science & Technology, 2012.
29. H.M. Stapleton et al., Identification of Flame Retardants in Polyurethane Foam Collected from Baby Products. Environmental Science & Technology, 2011.
30. California Senate Bill 147. 2011. Available at www.leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120SB147
31. California Assembly Bill 2197. 2012. Available at www.leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120AB2197
32. Office of the Governor., Governor Brown Directs State Agencies To Revise Flammability Standards. 2012. Available at www.gov.ca.gov/news.php?id=17598