SILENT SPRING INSTITUTE

RESEARCHING THE ENVIRONMENT AND WOMEN'S HEALTH

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Carcinogenic Flame Retardants Measured in People

Study Fact Sheet: Northern California Household Exposure Study, Flame Retardants in Urine

Dodson, R.E., N. Van den Eede, A. Covaci, L.J. Perovich, J.G. Brody, R.A. Rudel. 2014. Urinary Biomonitoring of Phosphate Flame Retardants: Levels in California Adults and Recommendations for Future Studies. *Environmental Science & Technology*. In Press. dx.doi.org/10.1021/es503445c

This is the first study to find the carcinogenic flame retardant TCEP in the bodies of Americans. It's also the first study to collectively evaluate urinary levels of several phosphate flame retardant metabolites, like TCEP, which have been largely under the radar. We found all 6 metabolites in urine samples from California residents.

In addition, the researchers discovered a way to test for this class of toxic flame retardants (phosphates), which could open up a new wave of research into a group of pervasive flame retardants that were previously not studied nearly as much as some other flame retardants.

People with the highest metabolite levels of two carcinogenic flame retardants also had the highest levels in their house dust, which had been previously tested. Half of the homes tested had dust levels of at least one of two carcinogenic flame retardants above health guidelines. Based on our results and available literature, we identify targets for poorly studied flame retardant chemicals in future biomonitoring studies.

Background

Consumer products such as furniture, textiles, and electronics often contain chemical flame retardants. These chemicals can come out of the products into house dust and the environment where people are exposed to them. In a recent study, we found a wide range of flame retardant chemicals in dust from California homes and some dust levels were above levels of health concern. Of all the flame retardants, phosphate flame retardants, including two carcinogens, were most abundant and found at the highest concentrations.

To learn more about the health effects of these chemicals, it is helpful to be able to measure them in people's blood, urine, or other tissues. This measurement process is called biomonitoring. Prior to our study, scientists had not established biomonitoring methods for phosphate flame retardants, which we aimed to do through our research.

We measured phosphate flame retardants in homes and residents from California because of previous research showed that levels of flame retardants in California are higher than in other parts of the world.

What is the purpose of the study?
Biomonitoring methods for phosphate flame retardants are just being developed. We aimed to test new methods and to learn about flame retardant exposure levels in a state with high exposure.

What did we do?
We measured 6 metabolites expected to be the major metabolites of commonly found phosphate flame retardants. We also screened urine samples for additional metabolites found in laboratory studies to see if they are also present in people.

We collected urine samples from 16 California adults and dust samples from their homes. The study participants were part of the Northern California Household Exposure Study (http://bit.ly/1t9bek3) that measured many chemicals, including flame retardants, in the dust samples. When we reviewed the results, we were struck by the prevalence of phosphate flame retardants, despite the fact that phosphate flame retardants do not get nearly as much scrutiny as some other flame retardants, such as polybrominted diphenyl ethers (PBDEs). Given the lack of previous research of these chemicals and the relatively high concentrations (in some cases above federal EPA health guidelines), we decided to focus our testing of the urine samples on this class of flame retardants. We evaluated the correspondence between urine levels and dust levels of the chemicals.

What chemicals did we test for and why?
We analyzed urine samples for 6 dialkyl/diaryl phosphates (DAPs). These are the expected major metabolites of 6 phosphate flame retardant chemicals commonly found in house dust. We also screened urine samples for 18 additional potential metabolites to evaluate if additional chemicals should be targeted in future biomonitoring studies.

What did we find?
- All 6 DAP metabolites were found in the urine samples. The major metabolite of a carcinogenic chemical TDCIPP, or chlorinated "tris," was found in almost all of the study participants. This is the first study to detect in Americans' bodies the chemical TCEP, known to cause cancer and problems with neurological functioning and the reproductive system.
- We identified how to measure these chemicals by identifying the biomarkers – what the chemicals break down into after being in people's bodies and can be found in the urine if the chemicals are present. This will hopefully spark additional research into these chemicals that warrant more scrutiny.
- People with the highest levels of two carcinogenic flame retardant chemicals in dust also had the highest levels of the metabolites in urine. This suggests that the home is an important source of exposure to flame retardant chemicals.
- Metabolites in urine and parent compounds in dust co-occur, suggesting common exposure sources for multiple flame retardants. For example, the metabolites DPHP and BDCIPP were correlated with each other in urine and their parent flame retardant chemicals TPHP and TDCIPP were correlated with each other in dust.

- Chlorinated organophosphate flame retardants, including two (TCEP and TDCIPP or chlorinated "Tris") listed as carcinogens under California's Proposition 65, were found at levels up to 0.01% in dust and were higher than EPA health risk guidelines.
- Based on our results as well as research by others, we recommend these 6 DAP metabolites as well as several additional chemicals be targeted in future flame retardant biomonitoring studies.

What are the public health implications of the study?
This study provides the first systematic investigation about the levels in people of an important class of flame retardant chemicals. Some of these flame retardant chemicals have been associated with cancer and neurotoxicity. Half of the homes had dust levels that exceeded health-based guidelines for two carcinogens listed on California's Proposition 65 list.

The flame retardant chemicals in this study are produced in the US at > 1 million pounds/year, and despite these high production volumes, some have not yet been tested for safety. Current practices for putting flame retardants into products are inadequate to protect health.

How can individuals reduce their exposures to flame retardants?
- You can reduce your exposure to chemical flame retardants by selecting furnishings and building materials without chemical flame retardants. There are products made of materials that are flame resistant without harmful chemical additives, such as polyester and wool.
- Ask retailers for flame retardant-free furniture. Furniture labeled as meeting the revised flammability standard (TB117-2013) may or may not contain flame retardants so consumers should ask.
- Make sure furniture made with foam is in good condition and foam is not exposed.
- Since many of these chemicals are found in house dust, keep dust levels low by using a vacuum cleaner with a HEPA filter and wiping surfaces with a wet cloth or mop.
- Wash hands frequently to minimize ingestion of contaminated dust.
- Avoid installing foam padding under carpets, as this can also be a source.
- Additional suggestions to reduce chemical exposures are found at www.silentspring.org/take-action.

How do public policies impact exposures to flame retardants?
Some of these phosphate flame retardants are used in upholstered furniture, which most often meets California's – and the *de facto* national – furniture flammability standard. These findings support a body of evidence that California's TB 117, an open-flame furniture flammability standard, results in exposures to carcinogenic and neurotoxic flame retardant chemicals. The good news is that TB 117 has been improved -- it now is a more realistic smolder standard that can be met without adding flame retardants. Future flammability standard development should consider how standards can promote fire safety without compelling the use of toxic chemicals. It is also important that manufacturers adjust their use of toxic flame retardant chemicals as a result of the new standard. The reality, however, is that they are not required to do so.

Senator Schumer recently introduced the Children and Firefighters Protection Act of 2014 (S.2811). The bill prohibits use of 10 designated flame retardants, including the three chlorinated phosphate flame retardants included in this study, in children's products and upholstered furniture. It also requires that a chronic hazard advisory panel be convened to evaluate the human health effects of all chemical flame retardants used in children's products of upholstered furniture. To learn more, visit Safer Chemicals, Healthy Families (www.saferchemicals.org).

What are the limitations of the study?

As far as we know, this is the first study to measure these 6 phosphate flame retardant metabolites and screen for additional metabolites in US urine samples. We might have learned more in a larger study than the 16 people studied here.

We observed limited correlation between levels in urine and levels in house dust. The lack of a more conclusive link between urine and house dust may be a result of differences in the period of time reflected in each measurement (i.e. urine reflects a shorter exposure period than dust), contribution of other sources of flame retardants (e.g. vehicle and office), limited number of samples, and not analyzing the best metabolite.

Who funded this study?

The California Household Exposure Study was funded by the National Institute of Environmental Health Sciences (5R25ES13258), the New York Community Trust, the Fine Fund, and Art beCAUSE Breast Cancer Foundation.

How can I get more information?

Visit the Silent Spring Institute website at www.silentspring.org.

We measured 6 metabolites expected to be the major metabolites of abundant flame retardant chemicals in house dust.

Dialkyl/diaryl phosphate metabolite in urine	**Parent flame retardant in dust**
bis(2-chloroethyl) phosphate (BCEP)	tris(2-chloroethyl) phosphate (TCEP)
bis(1-chloro-2-propyl) phosphate (BCIPP)	tris(1-chloro-2-propyl) phosphate (TCIPP)
bis(1,3-dichloro-2-propyl) phosphate (BDCIPP)	tris(1,3-dichloro-2-propyl) phosphate (TDCIPP)
diphenyl phosphate (DPHP)	triphenyl phosphate (TPHP), ethylhexyl diphenyl phosphate (EHDPP)
dibutyl phosphate (DBP)	tri-n-butyl phosphate (TNBP)
tris(2-butoxyethyl) phosphate (BBOEP)	tris(2-butoxyethyl) phosphate (TBOEP)

Chemical Table: Northern California Household Exposure Study, Flame Retardants in Urine

Parent Chemical in Dust	How is it used?	How much is used in the US?[i] Is it Regulated?	Health Concerns[ii]
Chlorinated phosphate flame retardants			
tris-(2-chloroethyl)-phosphate (TCEP)	Used in polyurethane foam, plastics, polyester resins, and textiles; Banned from children's products in NY in 2011	• At least half a million pounds produced per year • Substance of Very High Concern in Europe	• Carcinogen • Evidence of effects on the brain in humans • Can cause reproductive harm
tris-(1-chloro-2-propyl)-phosphate (TCIPP)	Used in polyurethane foam	• 10-50 million pounds produced per year	• Chemically similar to TCEP • Lack of health studies
tris-(1,3-dichloro-2-propyl)phosphate (TDCIPP) *Known as chlorinated "Tris"*	Used in polyurethane foam, plastics, and textiles; Removed from children's sleepwear in late 1970s in the US	• 10-50 million pounds produced per year	• Carcinogen • Evidence of hormonal effects in humans • Affects brain function
Non-chlorinated phosphate flame retardants			
triphenyl phosphate (TPHP)	Used in polyurethane foam and in many flame retardant mixtures, including Firemaster 550.	• 10-50 million pounds produced per year	• Evidence of hormonal effects in humans • Lack of health studies
tri-n-butyl-phosphate (TNBP)	Also used for plasticizing and as lubricants in hydraulic fluids	• 1-10 million pounds produced per year	• Carcinogen • Lack of health studies
tri-(2-butoxyethyl)-phosphate (TBOEP)	Also used in floor wax, lacquers, and rubber stoppers	• 1-10 million pounds produced per year	• Affects brain function • Lack of health studies

[i] Per 2006 EPA data
[ii] In animal studies unless otherwise noted

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