HBM4EU science and policy for a healthy future

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HBM4EU

POLICY BRIEF

JUNE 2022

European Human Biomonitoring Initiative

Flame Retardants

This policy brief summarizes the adverse human health effects of flame retardants (FRs), their main exposure pathways for humans, and how human biomonitoring (HBM) could be of value in the development of EU policies.

KEY MESSAGES

- Exposure to flame retardants may result in, or contribute to, a range of adverse health effects.
- The contribution of flame retardants to endocrine disruption is of particular concern, especially in children.
- The general population is exposed to flame retardants via building materials and consumer products, such as electronics, textiles, furnishings, automobiles, insulation, etc.
- We do not have a comprehensive overview of the population's exposure to flame retardants.
- Increases in the levels of older flame retardants in breast milk of European population have ceased for flame retardants that were restricted in the early 2000s, indicating the efficacy of policy actions on reducing human exposures to flame retardants.
- Interlaboratory validation exercises identified good capacity within Europe for HBM of older flame retardants, but a lack of capacity for currently used FRs.
- European citizens are concerned about industrial chemicals such as flame retardants and largely support the use of HBM for risk assessment and policy, though awareness is still low.

BACKGROUND: HBM4EU

The European Human Biomonitoring Initiative, HBM4EU, running from 2017 to June 2022, is a joint effort of 28 countries, the European Environment Agency and the European Commission, and co-funded under Horizon 2020. The main aim of the initiative is to coordinate and advance human biomonitoring in Europe. HBM4EU has provided a wealth of improved evidence of the actual exposure of citizens to chemicals and their possible health effects. Human biomonitoring allows us to measure our exposure to chemicals by measuring either the substances themselves, their metabolites or markers of subsequent health effects in body fluids or tissues. Information on human exposure can be linked to data on sources and epidemiological surveys to inform research, prevention, and policy with the objective of addressing knowledge gaps and promoting innovative approaches. If you would like to read more about the project itself, please visit the HBM4EU website.

HBM4EU RESULTS

HBM4EU has produced a variety of publicly available groundwork material for a harmonised approach to study planning and implementation in Europe in order to further support current and future HBM studies. The main outputs from the HBM4EU to date include the following:

Given the lack of comprehensive biomonitoring data for flame retardants in the European population, new data was necessary to better understand European population exposure and regional variations.

To ensure comparability across newly generated biomonitoring data, four rounds of interlaboratory validation exercises were carried out. The intercomparison exercises identified a significant core network of comparable European laboratories for HBM of halogenated flame retardants (PBDEs, HBCDD, Dechlorane Plus). On the other hand, the data revealed a critically low analytical capacity for HBM of currently used flame retardants (e.g., TBBPA, DBDPE, 2,4,6-TBP, and the OPFR biomarkers) in Europe.

Relying on the laboratories that were successful in intercomparison exercises, biological samples (serum and urine) from European children from six countries were screened for levels of flame retardants. Highly lipophilic FRs, particularly those with higher persistence (such as the PBDEs and HBCDD) were detected in human blood serum (data collected from the HBM4EU Aligned Studies)[1]. Despite restrictions on the new use of PBDEs, these chemicals were present in serum from 62% of the children. Currently used organophosphate ester-based flame retardants (OPFRs) are metabolized in the body; metabolites of OPFRs were detected in urine of 99% of the children.

Based on children's urine levels of the metabolites of selected OPFRs (TDCIPP, TCIPP and TCEP), the contribution of dietary intake was estimated. Dietary contributions to the total intake of these OPFRs for children is substantial, indicating that OPFRs in food products are a major source of these FRs for children. Given the wider availability of data for PBDEs and HBCDD, these two flame retardants were selected to evaluate temporal and geographic trends. Literature review and meta-analysis to reconstruct temporal trends in breast milk concentrations identified significantly increasing concentrations in European breast milk from 1980-2010, after which point the rapid increase ceased, entering a plateau phase. This shift in the time trends coincided with the introduction of restrictions on HBCDD in Europe, suggesting the effectiveness of policy actions on human exposure. Similarly for PBDEs, policy drives geographic and time trends of exposure. The meta-analysis identified 10-100x higher concentrations in breast milk from USA compared to Europe, reflecting higher flame retardancy standards resulting in greater use of PBDEs in USA. Europe, as well as North America, showed decreasing concentrations of the PBDEs for which early restrictions were introduced, but no apparent decrease in BDE-209, the last PBDE to be restricted, again suggesting the clear link between policy actions and HBM levels.

A risk assessment was done (Deliverable 5.11) on tris(2-chloroethyl) phosphate (TCEP) -- an OPFR, for the general population
as this was the most urgent FR to address, given the evidence of hazard and limited regulation. The risk assessment identified low risk according to one EU hazard threshold and possible risk based on US EPA threshold; uncertainty in both the hazard and exposures to TCEP leads to uncertainty in the risk assessment.

Another aim of HBM4EU is to establish exposure-health relationships. A comprehensive literature search showed that toxicological data was either incomplete or critically lacking for many flame retardants in use. Ten FRs have substantial hazard information; nine FRs have evidence of toxicological concern; 20 FRs lack mammalian toxicology data and 22 FRs have only limited toxicity data. Molecular targets, health outcomes and potential adverse outcomes pathways (AOPs) were identified for 9 priority FRs of concern. Many flame retardants share endocrine disruptive activities, in particular the inhibition of androgen receptor, emphasizing the risks of combined effects when people are exposed to mixtures of flame retardants.

Identification of biomarkers of effect for BFRs and OPEs was also investigated. A more complete scientific understanding is available for BFRs, with 58 molecular/biochemical markers identified, while only 23 for OPFRs, reflecting the less complete understanding of the effects of OPE exposure. Ten biomarkers were then proposed for possible use in human biomonitoring reflecting the concerns related to the impact of flame retardants on the endocrine systems (e.g. thyroid-stimulating hormone, estradiol, testosterone).

HBM4EU also laid the foundations for a European HBM Network to monitor human exposure to priority chemicals, including flame retardants.

1 The HBM4EU Aligned Studies are a survey aimed at collecting HBM samples and data as harmonised as possible from (national) studies to derive current internal exposure data representative for the European population/citizens across a geographic spread.

EXPOSURE AND HEALTH EFFECTS

Flame retardants are often used in consumer products like electronics, textiles and furnishings, automobiles and other vehicles, and building materials including insulation, flooring, appliances and ducting. However, the information on EU and/or global production of FRs is extremely limited and often not publicly available.

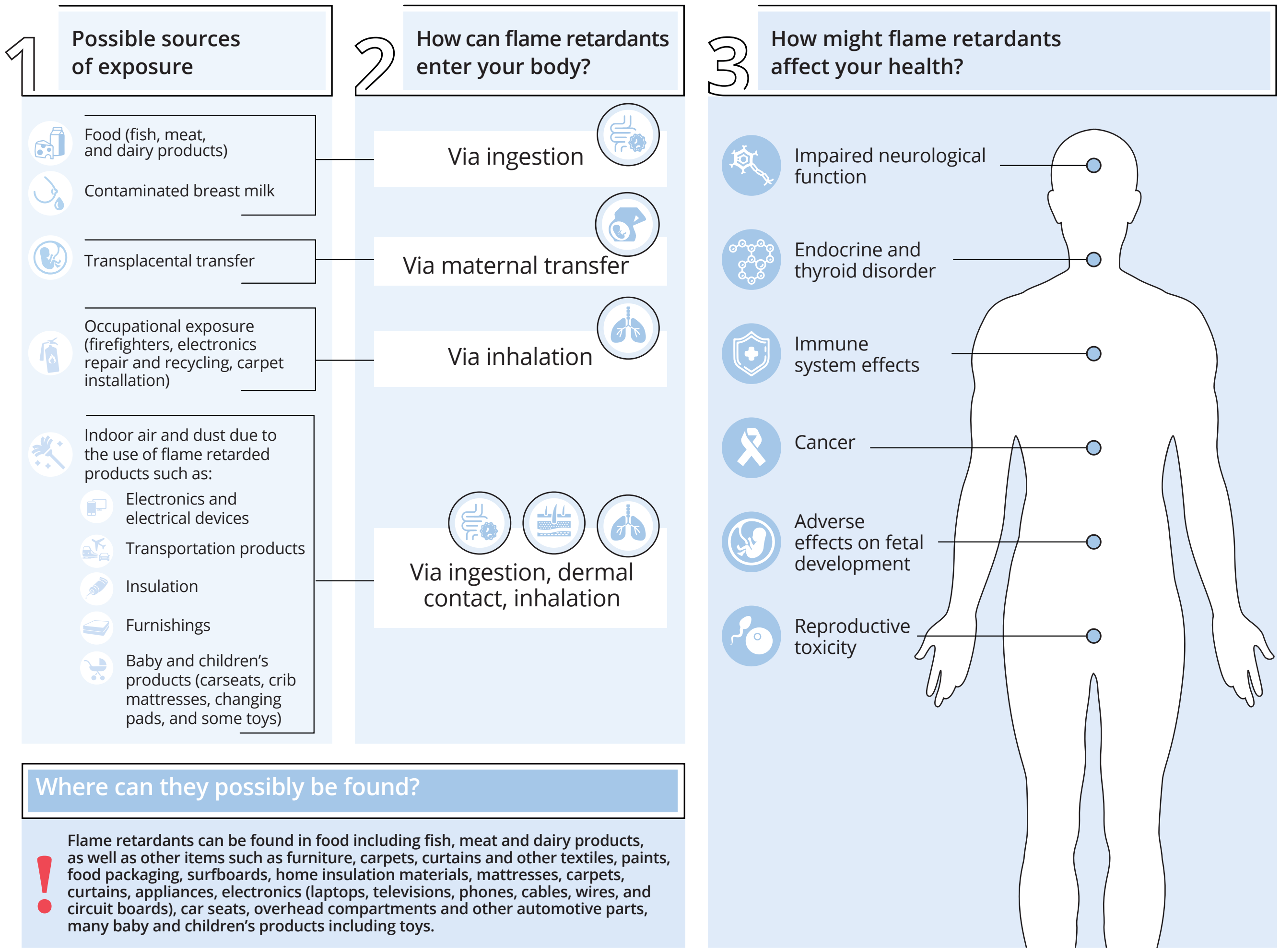
In occupational settings, exposure to flame retardants can occur in professions related to highly flame retarded products, particularly e-waste processing. Workers in these settings are typically exposed to both legacy and current-use flame retardants at higher levels than the general population due to emissions of gaseous and particulate flame retardants during the dismantling of electrical and electronic waste.

For the general population, exposure to flame retardants PBDEs and HBCDDs has been identified to have a range of adverse health effects, including potential endocrine, immune, reproductive, fetal and child development, and neurological and carcinogenic effects. Numerous replacement FRs are also suspected of similar health concerns, but most have not been adequately evaluated yet. Some FRs have endocrine disruptive effects, and several FRs are suspected to cause or contribute to cancer and are thus categorized as potential or possible carcinogens by regulatory agencies in Europe and elsewhere.

The main health concerns of flame retardants come from chronic or long-term exposures. These exposures occur on a regular, repeated basis due to the contact with flame retarded products, accidental ingestion of indoor dust contaminated with flame retardants, and dietary exposure. Young children typically have higher exposure due to transplacental transfer, flame retardants in breast milk, and specific behaviour. Children accidentally ingest indoor dust which has high levels of FRs, and are exposed due to the mouthing of objects and hand-to-mouth transfer.

The main sources, pathways of human exposure and health effects of flame retardants are shown in Figure 1.

Figure 1. Overview of exposure sources, pathways and health effects of flame retardants



INPUT TO POLICY PROCESSES AND RELEVANT POLICY MEASURES

HBM4EU results have contributed to consultations for the Chemicals' Strategy for Sustainability, the Zero-Pollution Action Plan and ECHA. These are available in the HBM4EU Science to Policy section.

Some FRs are restricted within the EU as well as at the international level. PBDEs, HBB, and HBCDD compounds are restricted under the Stockholm Convention on Persistent Organic Pollutants (POPs) and therefore now have very limited use. Dechlorane Plus was recommended for risk management evaluation by the Persistent Organic Pollutants Review Committee. Many replacement/alternative FRs are registered under REACH, but there are currently no regulations for a number of FR compounds.

For the majority of FRs there are no established safety limits, health-based reference values or guidance values, and limited knowledge of usage volumes due to manufacturer confidentiality.

Of the list of 62 FRs identified by HBM4EU, one is registered under REACH under the 10,000-100,000 t/y tonnage band, 7 are at 1,000-10,000 t/y and 9 are at 100-1,000 t/y. Three FRs are not registered under REACH but listed under CoRAP based on (among others) high aggregated tonnage and wide dispersive use. Twenty eight of the 62 FRs are not registered under REACH.

EFSA is working on an update of the EFSA scientific opinions on brominated flame retardants, taking into account new occurrence data and any newly available scientific information.

POLICY QUESTIONS

The answers below are summarised. For more details, please consult the substance report available on the dedicated substance page of the HBM4EU website.

1 What are current HBM levels of legacy/regulated FRs (e.g., PBDEs and HBCDD)? Is the current legislative framework and proposed actions leading to a significant decline in restricted compounds and is this uniform across the EU?

Existing biomonitoring of FRs in the European population suggests an impact of restrictions on PBDEs and HBCDDs on population levels. PBDE levels in breast milk show a decline in selected lower brominated PBDE congeners (BDE 47, 99), whereas higher brominated PBDE congeners (BDE-153, BDE-209) do not yet show a decline, reflecting later restrictions on them. Existing biomonitoring of HBCDD in breast milk in the European population suggests a decline after 2010, however this trend is not yet conclusive due to the scarcity of data. New biomonitoring of PBDEs and HBCD confirms their presence in the serum of European children, however it is not possible with the available data to distinguish if this is legacy exposure from maternal transfer or new exposures from flame retarded products.

2 What is the exposure of the European population to current use FRs? Does it differ by gender, or affect more sensitive sub-groups (e.g., infants and children)?

The European population is widely exposed to flame retardants, and it is clear that this widespread exposure extends to children. However, there is insufficient data to fully address this question. For many current-use FRs, we lack any human biomonitoring data. Exposure modelling identified the highest estimated exposure for infants, though there are high uncertainties and data gaps in FR exposure in infants and children. There is no gender difference in exposure.

3 How does exposure differ by geographic area within Europe? Do countries/regions have different FR exposure levels?

Existing studies on human biomonitoring of breast milk for HBCDDs suggest lower exposures in Northern Europe and higher exposures in Southern Europe. The lower exposures in Northern Europe can be related to the earlier restrictions and lower use of HBCDDs in Northern Europe. PBDE exposures are similar across Europe, though noticeably lower than exposures in North America, where the use of PBDEs was substantially higher. There appear to be geographic differences in current use FR exposures in children, but this is based on limited data, and no cause has yet been identified.

4	**Are there one or more occupationally exposed sub-groups? What occupations are associated with high exposure to FRs?**	Occupations with potentially elevated exposure to FRs include e-waste processers, computer repairers, construction workers, some chemical industry workers, and carpet installers, among others.
5	**Are we exposed to multiple flame retardants at the same time?**	Yes, the evidence suggests that we are typically exposed to a variety of flame retardants and that a mixture of them can usually be found in our blood and other tissues.
6	**Can exposure to FRs be linked with any adverse health effects?**	Yes, a summary of them is available in Figure 1 of this briefing.
7	**Can reference values be established for any FRs?**	There is currently insufficient data to establish reference values.

KNOWLEDGE GAPS

HBM4EU has helped to identify a number of specific data gaps and challenges that must be addressed to give policy makers relevant and strategic data to establish appropriate regulations and improve chemical risk management.

We have identified that OPFRs are widely marketed and used as alternatives to the restricted PBDEs and HBCDDs. There is comprehensive data for a small subset of these OPFRs (notably TCIPP, TCEP, TDCIPP), however for the majority of currently used flame retardants the knowledge and data gaps extend across the spectrum from analytical methods for HBM to toxicity and determinants of exposures and effects. There are inconsistencies in laboratory analyses and limited capabilities within Europe for current-use FRs, particularly OPFRs. Analytical methods vary for different sub-groups of FRs due to differences in chemical structure, and there is a general need for optimising methods. Additional short- and long-term toxicity data are needed, including information on synergistic and additive effects.

The key challenges identified are:

Challenge 1: Data

- Limited HBM data for currently used FRs
- Limited exposure data

Challenge 2: Assessment

- Hazard assessment information
- Lack of laboratories and inconsistencies in performance

Challenge 3: Measurement

- Very large chemical group with diverse chemical structures
- Uncertainties regarding which FRs to prioritize based on use and likelihood of exposure
- Analytical methods require optimisation

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