HBM4EU science and policy for a healthy future

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HBM4EU

POLICY BRIEF

JUNE 2022

European Human Biomonitoring Initiative

PAHs

This policy brief summarizes the adverse human health effects of Polycyclic Aromatic Hydrocarbons (PAHs), their main exposure pathways for humans, and how Human biomonitoring of PAHs could be of value in the development of EU policy.

KEY MESSAGES

- Exposure to PAHs, both acute and chronic, can result in or contribute to a range of adverse health effects.
- The contribution of PAHs to cancer is of particular concern, especially for exposed workers.
- Current exposure levels are related to an excessive lifetime cancer risk (ELCR).
- Workers dealing with asphalt and soil remediation are particularly exposed to PAHs.
- The general population is exposed to PAHs via food, ambient air pollution, smoking and consumer products. Dietary exposure accounts for 90% of exposure to PAHs.
- Within Europe, Eastern and Western regions show the highest, and similar levels of exposure based on PAH metabolites measured in urine, followed by Southern Europe, with Northern Europe having the lowest exposure levels observed.
- Many data gaps remain concerning integrated PAH exposure assessment, which can be investigated by additional HBM analyses coupled with analyses of environmental matrices.
- European citizens are concerned about environmental chemical pollutants such as PAHs 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

In order to further support current and future HBM studies, HBM4EU has produced a variety of publicly available groundwork materials for a harmonised approach to study planning and implementation in Europe. Within HBM4EU, biomarkers of exposure to PAHs were measured in adults aged 20 to 39 years, to obtain a comprehensive overview of their exposure through inhaled air and diet. A total of 13 PAH markers were included in QA/QC and assessed in the HBM4EU Aligned Studies[1]. The levels of exposure to PAHs were found to vary between countries and between the general population and various occupation-exposed groups. For example, exposure reconstruction from occupational human biomonitoring data of soil remediation workers on a former creosote wood impregnation site polluted with creosote oil in Finland showed the highest exposures, about seven times higher than the next occupation (coke plant workers) and ten or more times higher than bus drivers and waste incinerator workers.

In the general population (adults 20-39 years old), exposure to pyrene varies across European Regions: P50 and P95 of urinary 1-PYR concentrations are in the range of 0.03-0.24 µg/g creatinine and 0.10-1.02 µg/g creatinine across studies. Western and Eastern European populations have the highest average exposure, followed by Southern and Northern Europe. The recommended method to monitor PAH exposure via HBM is through their metabolites in urine samples, which are easy to collect and process with enough volume for standardized analytical methods.

A PBPK model has been developed for pyrene, where exposure reconstruction is based on the observed 1-OH-pyrene urinary levels. Based on this data and the exposure reconstruction methodology, the average daily intake of pyrene for the general population was estimated at 0.05 µg/kg_bw/d, with values ranging from 0.01 µg/kg_bw/d in non-smoking population to 0.24 µg/kg_bw/d in smokers. The dominant route is dietary intake, followed by inhalation.

In addition, HBM4EU performed a cancer risk assessment in relation to exposure to PAHs and found that for the general population, exposure to four particularly hazardous PAHs through diet may already be increasing lifetime cancer risk for various groups of consumers beyond the indicative tolerable risk level for the general population proposed by the EC (2016).

Genotoxicity biomarkers have been shown to be suitable effect biomarkers for PAHs: the measurement of chromosomal aberrations, sister chromatid exchange, DNA damage (comet assay), and the formation of 8-oxo-deoxyguanosine and micronuclei, specifically in relation to exposure to mixtures containing benzo[a]pyrene. No promising new biomarkers of effect could be identified at this time.

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

EXPOSURE AND HEALTH EFFECTS

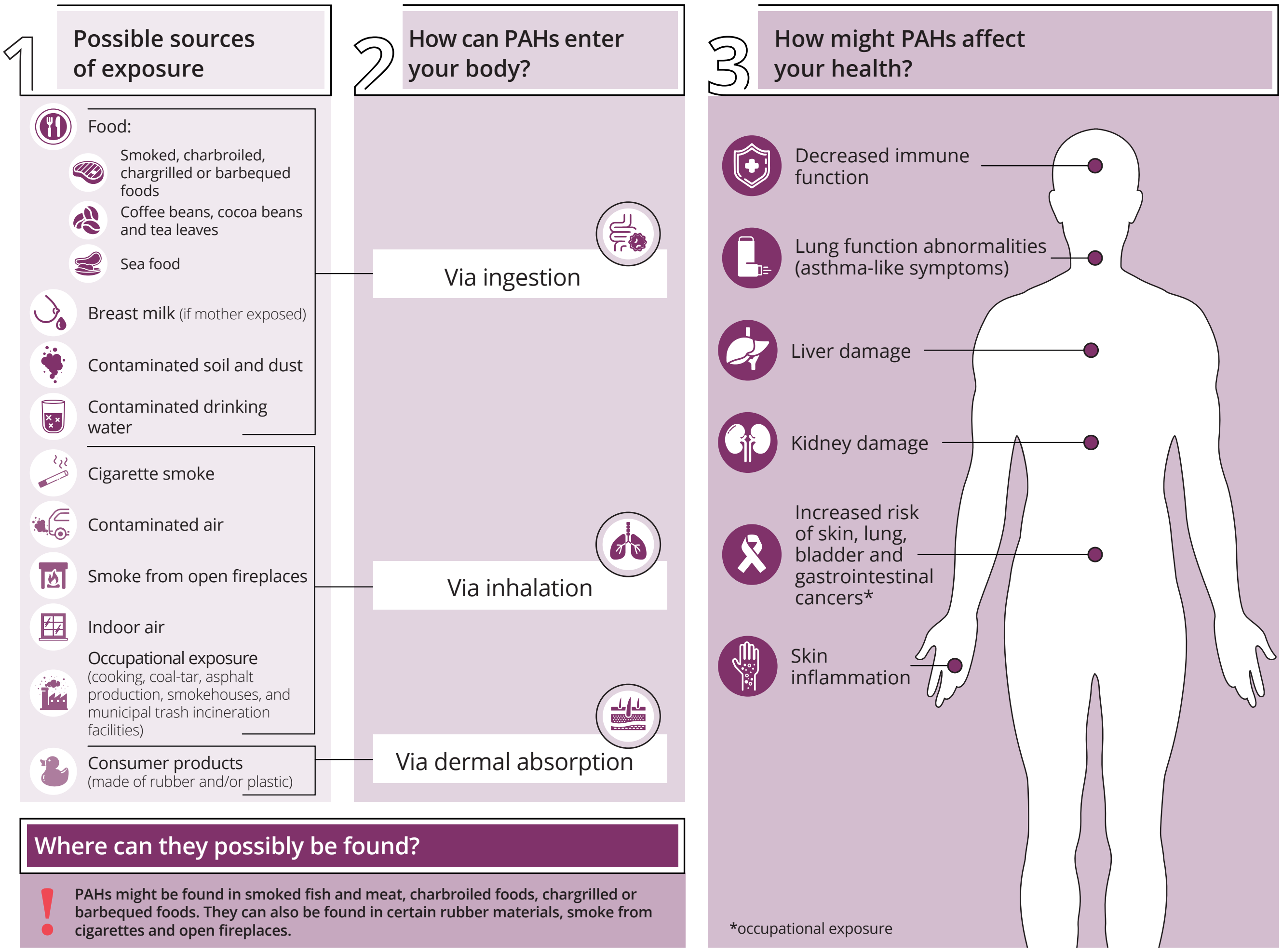
The main sources, pathways of human exposure and health effects of PAHs are shown in Figure 1.

For the general population, the main routes of exposure to PAHs are diet and the environment. PAHs can also be found in plastics and rubber products, primarily as result of additives from production and manufacturing. Two additives are the main PAH sources through this process: carbon black and extender oils. Workers in a variety of industries are exposed to higher levels of PAHs than the general population. These include the production of carbon black, coal-tar pitch and asphalt, aluminum and coke, petroleum refineries, exhaust fumes from motor vehicles and from dermal contact with synthetic turf.

Various PAHs are carcinogenic and/or mutagenic which means they can cause or contribute to the development of cancer, and they are also reproductive toxicants.

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.

Figure 1. Overview of exposure sources, pathways and health effects associated with PAHs



INPUT TO POLICY PROCESSES AND RELEVANT POLICY MEASURES

HBM4EU results have contributed to consultations for the Chemicals' Strategy for Sustainability and are available in the HBM4EU Science to Policy section.

Several policy measures have been introduced in the EU to reduce exposure to PAHs. These include measures under REACH and other policy instruments, in particular restrictions under REACH for extruder oils in the production of tires or parts of tires. PAHs in food are restricted through Section 6 (Polycyclic aromatic hydrocarbons) of the Annex of the Food Contaminants Regulation 1881/2006. They are also restricted in rubber and in plastic parts of some consumer goods, while eight carcinogenic PAHs are restricted for use in childcare articles and toys. Anthracene oil and coal tar pitch are also subject to authorisation under REACH. Furthermore, air pollutants including PAHs, are regulated under the Ambient Air Quality Directive and the National Emission Ceilings Directive.

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 is the current exposure of the EU population to PAHs?

HBM4EU has delivered unprecedented information on several PAH metabolites found in adults in ten countries in Europe. Some of these metabolite levels are comparable to levels measured in the USA and Canada. Still, further HBM data are necessary from more countries/regions in Europe[2].

The most recent values obtained in the HBM4EU Aligned Studies show that the levels of internal exposure in the adult European population are similar to those from previous studies published in the literature. The resulting excessive lifetime cancer risk (ELCR) mean values ranged from $3.9x10^{-6}$ to $3.2x10^{-5}$. Considering the indicative acceptable risk level of 10^{-6} for the general population proposed by the EC, the ELCR results obtained by HBM4EU would indicate concern in four of the ten countries included in the aligned studies (Luxembourg, France, Czech Republic and Poland); the ELCR in these countries is in the 10-5 range, i.e. up to ten times higher than the acceptable limit value.

2 What is the current exposure of different occupational groups?

The exposure levels are still high in some occupational settings. The highest intake estimates from the sectors included in HBM4EU were identified in soil remediation workers, followed by asphalt workers and workers in the aluminum and rubber industry. The lowest intake levels were identified in waste incinerator workers. There is a need for developing new occupational studies, applying a set of exposure biomarkers, including a specific biomarker for BaP exposure, which would allow a better risk estimation for exposed workers.

3 Is there an association between air quality and human exposure to PAHs?

There is, but the inhalation contribution to PAHs exposure is minor (about 10%) compared with dietary exposure (contributing to almost 90% of daily intake). The contribution of inhalation is higher where significant sources of inhalation exposure exist, such as industrial hotspots, heavily trafficked roads, biomass emissions, as well as smoking. Smokers have consistently higher exposure levels to pyrene. Most studies on PAHs estimate exposure based on external measurements rather than human biomonitoring.

4 Does exposure differ between countries? Why?

Exposure differs between countries in Europe. Based on data coming from the HBM4EU Aligned Studies and the HBM4EU data repository, the median daily intake of pyrene in adults was higher in Luxembourg and Poland, followed by Croatia, the Czech Republic, France, Germany and Switzerland. Regarding data from earlier studies, Israel and Sweden present the highest median intake level, followed by Belgium, Germany and the Czech Republic. The differences in exposure levels among the various countries are mostly explained by differences in dietary intake as shown by exposure modelling. This may be linked to differentiated soil contamination and different dietary patterns (frequency of eating smoked food) and to a smaller extent to differences in air pollution levels.

2 The HBM4EU dashboard has 18 datasets with PAHs exposure data integrated and in IPCHEM metadata for 40 datasets with PAHs data are available.

5 Can we see a decline in exposure to the eight PAHs restricted under REACH?

We do not have enough evidence to say that yet. Restrictions from REACH are expected to affect the contribution of exposure related mainly to consumer products. It is also likely that the restriction of use will result in a reduction in the overall tonnage that will be reflected in soil levels; these will be reflected in turn in the food chain and the dietary intake. However, to identify a potential decline, a trend analysis is needed, which in turn requires the completion of the statistical analysis of existing data. HBM data supply the basis for analyses in comparison with subsequent rounds of measurement.

6 Can HBM4EU data inform the development of legislation specifically targeting exposure to PAHs through ambient air?

Yes, HBM data can inform about efficacy of measures in areas with high levels of air pollution. HBM4EU work on exposure reconstruction of PAHs from HBM data has indicated that most of exposure to PAHs comes from dietary sources rather than ambient air pollution, which is only contributing about 10% of the overall exposure. However, coupled use of HBM data-based exposure reconstruction and bottom-up assessment of source contribution, allows us to identify the relative contribution of the various sources to PAH exposure. Such a comprehensive modelling framework can properly identify differences in HBM data attributable to different sources. To answer this question comprehensively, HBM data should be linked with monitoring data from air and/or food. Stratification of available HBM data that will allow intake estimates to account for spatial variability (to capture air pollution differences) and/or seasonal variability (to capture the seasonal differences in air pollution) are needed.

KNOWLEDGE GAPS

We need to link HBM data with simultaneously collected data from food and air monitoring. These would allow us to better understand the relative contribution from the different exposure routes and major sources to the internal concentrations.

A crucial knowledge gap regarding PAHs concerns the robust estimation of the respective burden of disease and of the costs of exposure to these substances. In this regard, in addition to enhancing the exposure estimates, efforts should be made to better understand the immunotoxic effects of PAHs and to enhance the data necessary to unravel the adverse outcome pathways (AOPs) associated with PAHs carcinogenicity, immunotoxicity, pro-inflammatory and reproductive toxicity effects.

Challenges faced in using HBM data to assess exposure to PAHs are summarized in Figure 2. Determining the overall exposure of PAHs needs to be understood since the exposure to multiple sources can contribute to varying amounts. A further issue is the limited amount of data available for the whole population and subgroups across the EU.

Figure 2. Key data gaps and challenges

CHALLENGE 1: Integrated exposure assessment	**CHALLENGE 2:** Available exposure studies	**CHALLENGE 3:** Analysis of PAHs
Data on multiple sources of exposure	EU wide data	More sensitive biomarkers of BaP
Data on multiple routes of exposure	Age groups	Lower the limit of analytical detection of PAH metabolites
Coupled HBM data	Occupational groups	

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