HBM4EU science and policy for a healthy future

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SCOPING DOCUMENT

(2nd round of prioritization)

Prioritized substance group: Lead

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1. Introduction

Human Biomonitoring for Europe (HBM4EU) has established a strategy for deriving prioritized substance groups that HBM4EU will work on in 2019 and 2020. This stepwise strategy included input from national and EU policy makers and from stakeholders. The substances were nominated and prioritised according to a transparent procedure that is described in Deliverable 4.3 on the Prioritisation strategy and criteria, produced by the French Agency for Food, Environmental and Occupational Health & Safety (ANSES). The detailed description of how this prioritisation strategy was implemented in practice, the inputs received and the methodology applied for selecting substances to include in the second list of prioritised substances is the subject of the Deliverable D4.4 (lead European Environment Agency, EEA).

First, a survey was launched to understand the demands of the National Hubs, EU policy makers and members of the HBM4EU Stakeholder Forum. Subsequently an online survey requested the nomination of substances for research under HBM4EU. A long list of new nominated single substances and substance groups was produced. Substances on the long list were ranked according to the number of nominations received, enabling to reduce the list down to a short list of approximately 25 substances Background documents on the substances on the short list were produced. An expert group of HBM4EU scientists scored and ranked the substances according to their hazardous properties, exposure characteristics; and public concern. The ranked list was discussed at a joint meeting of the HBM4EU Management Board and the EU Policy Board in March 2018, where agreement was reached on the draft 2nd list of HBM4EU priority substances. The Governing Board approved the final list. The Governing Board members were asked to identify a list of candidate institutions and experts for the positions of Chemical Substance Group Leaders for the new substances/groups of substances. The substance group leaders were approved and were asked to produce the scoping documents for the new list of prioritised substances. The process is documented in D4.5 Second list of HBM4EU priority substances and Chemical Substance Group Leaders for 2019-2021.

2. Background information

2.1 Hazardous properties

Lead is a soft, silvery grey metal. It is highly resistant to corrosion, but is soluble in nitric and hot sulphate acids. Solubility in water varies: lead sulphide and lead oxides are purely soluble while nitrate, chlorate and chloride salts are reasonably soluble in cold water. Lead also forms salts with organic acids as lactic and acetic acids, and stable organic compounds such as tetraethyl lead and tetramethyl lead.

Although lead and its organic compounds occur (or used to occur) in various man-made substances like petrol additives (tetraethyl- and tetramethyl lead), or lead-based paints (lead(II) chromate - „chrome yellow", lead (II,IV) oxide – „red lead", lead carbonate – „white lead"), a considerable proportion of human exposure is also resulted from inorganic lead or lead salts (lead pipes and solder in plumbing systems, lead-soldered food cans, batteries, etc.). Independently of their original form the toxicity of lead compounds is determined by their ionic lead content (IARC, 2006), therefore human biomonitoring of lead exposure concentrates on measuring inorganic lead in human biological materials.

2.1.1 Absorption and distribution

Gastrointestinal absorption of ingested lead is influenced by physiological factors (e.g. age, fasting, nutritional calcium and iron status, pregnancy) and the physicochemical characteristics of particles (size, solubility, and lead species). (Jakubowski, 2012).

Deposition and absorption of inhaled lead-containing particles are influenced by their size and solubility. Large particles are transferred by mucociliary transport into the pharynx and then swallowed, with possible absorption from the gastrointestinal tract. Smaller particles can be deposited in the alveolar part of the lungs and almost completely absorbed (Jakubowski, 2012).

Lead in blood is found primarily in the red blood cells (96-99%). The half-life of lead in blood is approximately 30 days in adult male humans but it varies depending on the level of exposure, sex and age. (Jakubowski, 2012). Half life of lead in bones is approximately 10-30 years (EFSA, 2010), but it can be mobilized by certain physiological processes like pregnancy or other factors.

2.1.2 Health effects

2.1.2.1 General overview of health effects

Lead has been classified by the German Research Foundation (MAK Commission) in category 2, to be regarded as human carcinogen. IARC classified lead (in general) as possibly carcinogenic to humans (Group 2B) (IARC, 1987), inorganic lead compounds as ***probably carcinogenic*** to humans (Group 2A) (IARC, 2006) and organic lead compounds were not classifiable as to their carcinogenicity to humans (Group 3) (IARC, 2006).

Epidemiological evidence indicated **cancers** of the stomach, lung, kidney, and brain in workers exposed to inorganic lead, but not in all studies.

Genetic susceptibility to lead exposure related to ALAD gene polymorphism has been indicated by some but not all studies (IARC, 2014).

Lead exposure ***may damage fertility***, may damage the unborn child (reduced foetal growth and disturbed maturation, pre-term delivery) and may cause harm to breast-fed children.

Lead can easily cross the placental barrier, therefore can readily enter the bloodstream of the foetus. Since Pb can also pass the blood brain barrier, neurological development is of great concern when prenatal exposure to lead occurs (Baeyens et al., 2014). There is also a potential link between blood lead level and increase of blood pressure in pregnant women at low level exposure (Wells et al., 2011)

A systematic review evaluating the evidence on the associations between lead exposure and cardiovascular endpoints in human populations concluded that the evidence is sufficient to infer a causal relationship of lead exposure with ***hypertension*** (Navas-Acien et al., 2007).

Lead is known to affect several enzymatic reactions critical in haem synthesis resulting in ***anaemia***. (EHC, 1995)

Lead is associated with a wide range of toxicity in children These toxic effects extend from acute, clinically obvious, symptomatic poisoning at high levels of exposure down to subclinical (but still very damaging) effects at lower levels. Lead poisoning can affect virtually every organ system in the body. The principal organs affected are the **central and peripheral nervous system** and the cardiovascular, gastrointestinal, renal, endocrine, immune and haematological systems. (WHO, 2010).

2.1.2.2 Acute clinical toxicity

Intense, acute, high-dose exposure to lead can cause symptomatic poisoning in children. It is characterized by colic, constipation, fatigue, anaemia and neurological features that can vary from poor concentration to stupor. In the most severe cases, a potentially fatal acute encephalopathy with ataxia, coma and convulsions can occur. In many instances, children who survive acute lead poisoning go on to have permanent and clinically apparent deficits in their neurodevelopmental function (Byers & Lord, 1943, cit in WHO, 2010).

2.1.2.3 Subclinical (chronic) toxicity

The subclinical toxic effects of lead can be very damaging. The premise underlying the concept of subclinical toxicity is that there is a dose-related continuum of toxic effects in which clinically apparent effects have their asymptomatic (but still very real) counterparts (Landrigan, 1989).

Haematological toxicity

Anaemia is the classic clinical manifestation of lead toxicity in erythrocytes. The severity and prevalence of lead-induced anaemia correlate directly with the blood lead concentration. Younger and iron deficient children are at higher risk of lead-induced clinical anaemia. The anaemia induced by lead is caused primarily by impairment of the haem biosynthesis, but an increased rate of erythrocyte destruction may also occur (Schwartz et al., 1990).

Neurotoxicity

Neurodevelopmental effect of lead is the most important hazard of chronic lead exposure from public health point of view. In the central nervous system, lead causes asymptomatic impairment of neurobehavioural function in children at doses insufficient to produce clinical encephalopathy. The dose–response relationship between blood lead levels and loss of IQ was found to be stronger at blood lead levels lower than 10 µg/dl than at higher levels (Lanphear et al., 2000). An international pooled analysis of data from seven cohorts has confirmed these findings (Lanphear et al., 2005)

An increase in blood lead level from less than 1 µg/dl to 10 µg/dl was associated with a six IQ point decrement, which is considerably greater than the decrement associated with an increase in blood lead level from 10 µg/dl to 20 µg/dl. The findings of this pooled analysis – that there are adverse effects below 10 µg/dl and that the effects are steepest at the lowest levels of exposure – have been confirmed by numerous investigators (Emory et al., 1999, 2003; Bellinger & Needleman, 2003; Wasserman et al., 2003; Chiodo, Jacobson & Jacobson, 2004; Despres et al., 2005; Fraser, Muckle & Despres, 2006; Hu et al., 2006; Kordas et al., 2006; Schnaas et al., 2006; Tellez-Rojo et al., 2006; Chiodo et al., 2007; Surkan et al., 2007, all cit. in WHO, 2010).

When a population's exposure to lead is sufficiently widespread to cause a decrease in its mean IQ, there results a substantial increase in the number of children with diminished intelligence and mental retardation. At the same time, there is a substantial reduction in the number of children with truly superior intelligence. The consequences are: (a) a substantial increase in the number of children who do poorly in school, who may require special education and other remedial programmes, and who may not contribute fully to society when they become adults; (b) a reduction in a country's future leadership; and (c) a widening gap in socioeconomic attainment between countries with high and low levels of population exposed to lead (Needleman et al., 1979).

However, adverse effects of chronic lead exposure on cognitive function were observed not only in children. Sufficient evidence exists to conclude that there is an association between lead dose and decrements in cognitive function in adults, too. Overall, while the association between blood lead levels and cognitive function is more pronounced in occupational groups with high current lead exposures, associations between bone lead levels and cognitive function are more evident in studies of older subjects with lower current blood lead levels, particularly in longitudinal studies of cognitive decline. (Shih RA et al., 2007).

2.2 Exposure characteristics

2.2.1 Lead production and consumption

Lead is manufactured and/or imported in the European Economic Area in 1,000,000 – 10,000,000 tons per year (ECHA, 2018). About 50 nations mine lead in quantities ranging from a few hundred tons to more than half a million tons (U.S. Bureau of Mines, 1993). Roughly 20 nations produce only secondary (i.e., recycled) lead. Secondary smelting (recycling) of lead from lead-acid batteries from vehicles and industries has become increasingly important and by the end of the 20th century accounted for almost half of world refined lead production**.** Other uses of lead include pigments and other compounds, rust inhibitors, rolled and extruded products, cable sheathing, alloys, radiation shielding, ceramic glazes, plastic stabilizers, jewellery making, soldering, crystal products, fishing weights, shot and ammunition, electronic waste, use in water pipes, and fuel additives **(**The Global Dimensions of Lead Poisoning: An Initial Analysis, 1994). Due to regulation in Europe on the use of lead in dyes and ceramics it is expected that exposure through these applications is decreasing.Global consumption of lead is increasing today, because of increasing demand for energy-efficient vehicles. The largest current use of lead is in storage batteries for cars and other vehicles. (WHO, 2010).

2.2.2 Lead exposure routes

Although some exposure to lead results from direct contact with lead containing products, human exposure more frequently occurs via environmental media such as air, water, and soil. Based on worldwide collection of results of airborne lead concentrations measured before 1994, it was concluded that lead levels in both air and soil were generally higher in urban areas and near industrial sources than in other areas (median values in urban areas were 1.075 µg/m^3, in suburban ones 0.33 µg/m^3 and in rural areas 0.1 µg/m^3). In urban areas, air and soil levels were associated with use of leaded petrol. Lead concentrations in both air and soil increased with traffic density and proximity to roads, as well as with higher lead concentrations in petrol. (The Global Dimensions of Lead Poisoning: An Initial Analysis, 1994).

The ECHA (2018) is mentioning that releases of lead to the environment is likely to occur from:

- outdoor use in long-life materials with low release rate (e.g. metal, wooden and plastic construction and building materials)
- indoor use in long-life materials with low release rate (e.g. flooring, furniture, toys, construction materials, paints, curtains, foot-wear, leather products, paper and cardboard products, electronic equipments)
- indoor use in close systems with minimal release (e.g. cooling liquids in refrigerators, oil-based electric heaters)
- outdoor use in close systems with minimal release (e.g. hydraulic liquids in automotive suspension, lubricants in motor oil and break fluids)

Human exposure to lead from drinking water results primarily from lead leaching from leaded plumbing components, rather than contamination of source waters (i.e., lakes, rivers, and aquifers).

The following sources and products account for most cases of childhood exposure to lead and lead poisoning (WHO, 2010):

- lead from an active industry, such as mining (especially in soils)
- lead-based paints and pigments,
- lead solder in food cans
- ceramic glazes
- drinking-water systems with lead solder and lead pipes
- lead in products, such as herbal and traditional medicines, folk remedies, cosmetics and toys
- lead released by incineration of lead-containing waste
- lead in electronic waste (e-waste)
- lead in the food chain, via contaminated soil
- lead contamination as a legacy of historical contamination from former industrial sites

Human exposure routes:

- **Inhalation**: inhalation of lead particles generated by burning materials containing lead (e.g. during smelting, recycling, stripping leaded paint, and using leaded petrol or leaded aviation fuel)
- **Oral**: ingestion of lead-contaminated dust, water (from leaded pipes), food from lead-glazed or lead-soldered containers, highly consumed food with low/medium lead content (e.g. grains) or food with known elevated lead content (e.g. mussels and lead-shot game meat).

- **Trans placental**: Lead in bone is released into blood during pregnancy and becomes a source of exposure to the developing fetus. Moreover, lead is transmitted by maternal milk to infants.

2.2.3 Availability of HBM data

Surveys measuring blood lead levels in the general population have been conducted in several countries since the early 1980-ies. After phasing out lead from petrol in most of the European countries interest in blood lead levels has been faded for a while. Results of blood lead level surveys conducted during the past two decades among the general population were found to be available in sixteen European countries (see Table 1), most of them covered children population, too. Decreasing trend in blood lead level of children could be observed with lowering lead content of petrol and finally phasing out leaded petrol in various countries. However, e.g. in Sweden it was found that after 2009 the decrease in the blood lead level discontinued (Wennberg et al., 2017) which means that there are still other existing lead exposure sources to be detected and eliminated.

Unfortunately, there are very few data on the present blood lead levels among the general population in the European countries. In an intensive literature search only 7 countries (Belgium, Germany, Denmark, Kosovo, Poland, Slovenia and Sweden) were found from where blood lead levels measured during the past 5 years were available.

Table 2.1: Summary of European blood lead surveys reported in the past 10 years

Country	Study	Population studied	N	Year of sampling	PbB (µg/L)	Reference
Armenia	3 towns adjacent to metal mining and smelting industries	4 – 6 years	159	2013	GM: 60.0 S.D.: ± 30.0	Grigoryan et al. (2016)
Belgium	FLEHS I	newborns	1,072	2002-2006	GM: 13.7; 95% C.I.:12.9-14.6	Schoeters et al. (2017)
		adolescents	1,650	2002-2006	GM: 22.5; 95% C.I.:21.8-23.3	
	FLEHS II	newborns	241	2007-2011	GM: 8.6; 95% C.I.:8.0-9.2	
		adolescents	207	2007-2011	GM: 14.6; 95% C.I.:13.8-15.5	
	FLEHS III	newborns	281	2012-2015	GM: 6.4; 95% C.I.:6.0-6.7	
		adolescents	204	2012-2015	GM: 9.5; 95% C.I.:9.0-10.0	
	Ath (Hainaut province)	2.5- 6 years	98	2009	GM: 16.6; 95% C.I.:14.8-18.2	Fierens et al. (2016)
		7-11 years	74	2009	GM: 14.8; 95% C.I.:13.2-16.6	
		40-60 years men	52	2009	GM: 31.7; 95% C.I.:27.9-36.1	
		40-60 years women	54	2009	GM: 21.4; 95% C.I.:18.1-25.3	
Croatia	Koprivnica	7-14 years	46	2007-2008	GM: 17.9; Range:10.0-42.0	Hruba et al. (2012)
Czech Republic	Prague	7-14 years	8	2007-2008	GM: 15.5; Range:12.0-22.0	Hruba et al. (2012)
	CZ-HBM	18-58 years	4,472	1994-2003 and 2005-2009	GM: 23.0	Cerna et al. (2012)
		8-10 years	3,798		GM: Boys: 22.0; Girls: 19.0	
		breastfeeding primipare	5,667		GM: 14.0	
Denmark	Snart Foraeldre/Milieu	18-40 years women	73	2011-2014	GM: 8.1 (95th% 15.8)	Rosofsky et al. (2017)
Finland	NFBC	31 years males	126	1997	GM: 17.06 S.D.:± 1.84	Abass et al. (2017)
		31 years females	123	1997	GM: 9.06; S.D.: ± 2.20	

Country	Study	Population studied	N	Year of sampling	PbB (µg/L)	Reference
France	ENNS 2006-2007	18-39 years	579	2006-2007	GM: 19; 95%C.I.: 44-62	Falq et al. (2008)
		40-59 years	947		GM: 29; 95%C.I.: 66-85	
		60-75 years	423		GM: 39; 95%C.I.: 86-115	
		Total 18-75 years	1,949		GM: 26; 95%C.I.: 68-77	
	hospital-based	1-6 years	3,831	2008-2009	GM: 14.9 (95% C.I.:14.5-15.4)	Etchevers et al. (2014)
Germany	GerES I	adults	2,731	1985-1986	GM: 61	Schulz et al. (2017)
	GerES II	adults	4,287	1990-1992	GM: 45	
		children	812	1990-1992	GM: 32	
	GerES III	adults	4,822	1997-1999	GM: 32	
	GerES IV	3-14 years	1,790	2003-2006	GM: 17	
	GerES V	3 – 17 years	2,500	2014-2017	not yet available	
Hungary	NKFP (past hot spots)	4 – 15 years	253	2006	GM: 30	Rudnai et al. (2009)
Italy	PROBE	18-65 years	1,423	2008-2011	GM: 19.9 (95% C.I.:19.2-20.5)	Bocca et al (2013)
Kosovo	Mitrovica	5-11 years	166	? 2012-2014	AM: 24 ±19 (Range: 5-163)	Kutllovci-Zogaj et al (2014)
	Shtime (control)	6-12 years	53	? 2012-2014	AM: 23 ±7 (Range: 12-52)	
	Mitrovica	kindergarten	31	? 2012-2014	AM: 38 ±13 (Range: 22-77)	
Poland	Upper Silesia	3-18 years	4,882	1999-2013	? (in Abstract not available)	Pelc et al. (2016)
	REPRO_PL	pregnant women	594	2007-2011	GM: 11.0; Range: 3.0-57.0	Polanska et al (2014)
	Szczecin	2-18 year	78	? 2010-2011	AM: 19.7 ± 13.59	Szkup-Jabłońska et al. (2012)
	Piekary Śląskie (Silesia)	3 – 6 year	678	2013	GM: 24.7 ± 17.5	Kowalska et al (2018)
Slovakia	Banska Bystrica	7-14 years	57	2007-2008	GM: 19.4; Range: 8.0-47.0	Hruba et al. (2012)

Country	Study	Population studied	N	Year of sampling	PbB (µg/L)	Reference
Slovenia	Ljubljana	7-14 years	42	2007-2008	GM: 13.4; Range: 6.9-24.0	Hruba et al. (2012)
	National HBM Programme	6-11 years	174	2011 - 2014	GM: 16.1	Tratnik et al (2013)
		men (20-35 years)	147		GM: 19.6	
		women (20-35 yrs)	127		GM: 17.3	
		women (50-60 yrs)	66		GM: 26.7	
Spain	BIOAMBIENT.ES	18-65 years	1,880	2007-2010	GM: 24 (95% CI:23.0-25.1)	Canas et al (2014)
Sweden	Landskrona	7-14 years	41	2007-2008	GM: 14.0; Range: 6.0-25.0	Hruba et al. (2012)
	MONICA	adult men	619	2004-2014	25-35 yrs:11.1; 50-60 yrs:15.1	Wennberg et al (2017)
		adult women	926		25-35 yrs:9.69; 50-60 yrs:13.1	

2.2.4 Guidance values

Similar guidance values were considered safe for children and adults then CDC introduced an intervention level of **25 µg/dL** for children. After recognizing the special susceptibility of children to lead's toxic effects CDC formulated **10 µg/dL** as the *"value of concern"* for children in 1991 (CDC, 1991), saying that there was enough information identifying harmful effects of lead in children at blood lead levels at least as low as 10 µg/dL. At that time CDC also stated that "as yet ***no threshold has been identified*** for the harmful effects of lead". In 2012 CDC threw away the "value of concern" expression and decided to use a childhood BLL *reference value* of **5 µg/dL** based on the 97.5th percentile of the population BLL in children aged 1-5 to identify *children and environments associated with lead-exposure hazards (CDC, 2012)*

Epidemiological studies have provided a lot of evidence that **there is no safe level of blood led** concentration. In Germany the German HBM Commission concluded that any setting of an "effect threshold" for blood lead levels would be arbitrary and therefore unjustified, therefore it suspended the HBM-I and HBM-II guideline values for blood lead levels in children and adults (Wilhelm et al, 2010), and based on the results of GerES III and IV, in combination with current data from the German Environmental Specimen Bank, the following statistically derived *reference levels* were identified: 4 **µg/dL** for adult men, 3 **µg/dL** for adult women and **3.5 µg/dL** for children (UBA, 2018).

The Panel on Contaminants in the Food Chain (CONTAM Panel) of the European Food Safety Authority (EFSA) identified developmental neurotoxicity in young children and cardiovascular effects and nephrotoxicity in adults as the critical effects for the risk assessment and derived Benchmark Dose Levels (BMDLs) from blood lead levels for these effects: 5 µg/dL in the case of developmental neurotoxicity, 6.3 µg/dL for chronic kidney disease and 15 µg/dL for elevated systolic blood pressure (EFSA, 2010).

There is a need for a harmonized European biological guidance value !

2.3 Policy relevance

2.3.1 Existing regulations

The EU's Drinking Water Directive (98/83/EC) aims at protection of human health from adverse effects of any contamination of water intended for human consumption. It defines the health limit value of lead in drinking water as 10 µg/L.

According to the „Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the quality of water intended for human consumption" the Commission proposes lowering the value to 5 µg/l 10 years after the entry into force of the Directive. During this transitional 10-year period, the current value of 10 µg/l will be maintained.(EU, 2017)

The 2013/39/EU Directive amending directives 2000/60/EC and 2008/1056EC as regards priority substances in the field of water policy, suggests to have lead concentration lowered to a limit of 1.2 µg/L in ***inland surface water***, and 1.3 µg/L in outland surface water.

Directive 2008/50/EC of the European Parliament and of the Council sets a regulatory ***limit value for lead in air*** as 0.5 µg/m^3 per calendar year.

Regulatory ***limit value of lead in soil:*** 50 – 300 mg/kg, in sludge for agriculture: 750 – 1200 mg/kg ("EUR-Lex (86/278/EEC)"

1881/2006/EC set maximum levels for certain contaminants, including ***lead in foodstuffs.***

However, the Panel on Contaminants in the Food Chain (CONTAM Panel) of the European Food Safety Authority (EFSA) concluded that the present PTWI of 25 µg/kg b.w. is no longer appropriate and noted that there was no evidence for a threshold for a number of critical endpoints including developmental neurotoxicity and renal effects in adults. Therefore, a margin of exposure approach was applied to risk characterisation. (EFSA, 2010)

Occupational exposure is regulated by the Chemical Agents Directive 98/24/EC containing both a binding OEL and a Biological Limit Value for inorganic lead and its compounds, this latter being 70 µg/dL.

2.4 Technical aspects

To prevent false-positive results, stringent procedures are necessary to reduce environmental contamination of blood collection devices and supplies. Consequently, venous blood collected using evacuated tubes and needles certified as “lead-free” is considered the most appropriate specimen for blood lead measurements. However, collection of venous blood from paediatric subjects is sometimes difficult; thus, capillary blood from a finger puncture is used widely for screening purposes. Published studies have compared the quality of blood lead results for capillary and venous specimens drawn simultaneously (Schlenker et al., 1994; Schonfeld et al., 1994; Parsons et al., 1997). With stringent precautions, particularly rigorous hand washing, contamination errors can be held to <4% (Parsons et al. 1997). Therefore, although venous blood is preferable for epidemiologic studies of environmental lead exposure, use of capillary blood is acceptable if collected by staff specially trained in the technique using devices certified as “lead-free.” Data should be provided showing an acceptably low rate of contamination errors and low mean bias in the capillary BLLs as collected using the study protocol. (CDC, 2005)

Acceptable analytic methods include graphite furnace AAS (GFAAS, also known as electrothermal AAS), ASV, and ICP-MS. Information on laboratory performance (i.e., accuracy and precision) from external and internal quality control data should be provided.

2.5 Societal concern

Blood lead levels vary widely from country to country and region to region. The highest blood lead levels and the largest burden of disease from exposures to lead are seen in low-income countries – in particular, in areas where there are industrial uses of lead (such as smelters, mines and refineries) and/or where leaded petrol is still used heavily.

Although lead can affect children from every socioeconomic stratum, socially and economically deprived children and children in low-income countries carry the greatest burden of disease due to lead. Poor people are more likely to be exposed to lead and to be at risk of exposure to multiple sources. They are more likely to dwell on marginal land (near landfills and polluted sites), to live in substandard housing with ageing and deteriorating lead-based paint, and to live near industry, sites where waste is burned and heavy traffic. Also, lead smelting is used by marginalized populations to generate resources (WHO,2010).

The economic costs associated with childhood exposure to lead are substantial (Landrigan et al., 2002). The costs of childhood lead poisoning may be divided into *direct* and *indirect* costs. The direct or medical costs include those costs associated with the provision of medical care to children with acute lead poisoning, as well as the costs of treating cardiovascular disease in adults who have developed hypertension following exposure to lead.

Analyses of the indirect (non-medical) costs of lead poisoning have focused mainly on the loss of intelligence that is caused by lead and on the lifelong decrements in economic productivity that result from this loss of intelligence. These costs are sometimes referred to as *lost opportunity costs*. Using a conservative estimate, the decrease in intelligence attributable to each 1 µg/dl increase in blood lead level is 0.25 IQ points, and the decrement in lifetime economic productivity associated with each lost IQ point is 2.4%. (WHO, 2010)

3. Categorization of Substances

Table 3.1: Substances included in the substance group, listed according to availability of toxicology and human biomarker data, in category A, B, C,D,E substances (see general introduction)

Category	Abbreviation/ Acronym	Systematic name	CAS No.	Regulation
A	Pb	Lead, Plumbane	7439-92-1	Regulation (EC) No 2006/1881 (food) EU 2017/738 (toys) 98/83/EC (drinking water) 2013/39/EU (surface water) 2008/50/EC (air) 86/278/EEC (soil) 98/24/EC (occupational exposure)

4. Policy-related questions

1. What is the concentration of lead in the human blood nowadays (after phasing out leaded petrol) in the countries of Europe?
2. Do blood lead levels of both adults and children still indicate permanent existence of lead exposure?
3. What are the sources of still existing lead exposure in different countries of Europe?
4. What kind of exposure sources are the most important for the children of various age groups and the younger or older adult population?
5. Taking the hazard from transplacental lead exposure of the unborn child into consideration, what are the blood lead levels of pregnant women?
6. Taking the presumably low concentration of lead in blood, is it feasible to measure blood lead levels in children from as small amount of blood as it can be gained from capillary samples? What criteria should be applied in order to avoid contamination from outside sources?

5. Research Activities to be undertaken

While completing this table please think of data and gaps concerning toxicology (and exposure [in three dimensions: **location** (differences between the countries), **time** (trends) and **age** (data available for which age group)]. If no HBM method is available or the method has to be harmonized within partner countries, please indicate this too.

Table 5.1: Listing of research activities to be carried out to answer the policy questions

Policy question	Substance	Available knowledge	Knowledge gaps and activities needed
1, 2	Lead	After phasing out leaded petrol, blood lead levels significantly dropped but not at the same extent and not at the same time in different countries.	Collection of information on the time and extent of phasing out lead from petrol in the various countries. Collection, comparison and evaluation of existing data on current blood lead levels and their integration into IPCheM
3,4,5	Lead	Leaded petrol used to have dominant role in blood lead levels. After its phasing out, several possible lead sources earlier thought to be insignificant (e.g. drinking water from leaded pipes, lead-containing products, etc.) may have become important, because **there is no safe level of lead exposure**	In order to eliminate still existing lead sources in countries showing interest in participation, we have to identify their importance in the exposure of different population subgroups (e.g. children 1-3 years, 4-6 yrs, 7-14 yrs and 15-18 yrs, as well as adults (19-40 years; 41-65 years; > 65 years). Special attention should be paid to pregnant women, they should be a separate group in the survey.
6	Lead	It is unquestionable, that blood lead level is the most reliable marker of lead exposure, especially in children. (In adults, bone lead content can also be used to determine lead content accumulated in the organism). Taking venous blood samples from children lacking any clinical symptoms or environment suspicious for lead contamination, only for screening purposes raises ethical concerns. Therefore more practicable way of sampling would be capillary blood collection. In principle it is possible to use not only venous but also capillary blood samples for the determination of blood lead level but there is a risk of contamination which may obscure the very low concentrations.	In order to demonstrate availability of appropriately trained personnel, parallel measurements of blood lead levels should be performed from capillary and venous blood samples in small groups of children. Detailed description of sampling circumstances should be provided..

6. References

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