HBM4EU science and policy for a healthy future

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HBM4EU

POLICY BRIEF

JUNE 2022

European Human Biomonitoring Initiative

Chromium VI

This policy brief summarises HBM4EU's results, adverse human health effects of hexavalent chromium – Cr(VI), its main exposure pathways for humans, and how human biomonitoring (HBM) could be of value in the development of EU policies.

The primary health concern associated with Cr(VI) is carcinogenicity, and exposure occurs mainly in occupational settings.

KEY MESSAGES

- Occupational exposure to Cr(VI) presents a high risk. A HBM exposure study in the surface coating and stainless-steel welding sectors indicated that workers in the chrome plating sector had elevated Cr levels in urine, red blood cells (RBC), and exhaled breath condensate (EBC). In addition, effect marker analyses suggested that these exposure levels, although being mostly below the current occupational limit values, are not fully without health risks.
- For the general population, sources of Cr(VI) are mainly environmental via the ingestion of contaminated soil or food, and the inhalation of ambient air. Exposure may also come from smoking tobacco and from consumer products (it may be present in some rust-proofing paints and in preserved wood).
- Overall, the knowledge on the levels of Cr(VI) in the European population is limited and further data are required to increase the understanding of the current risks.
- A range of policy measures are in place to control the use of hexavalent chromium and to protect both workers and the general population from exposure to Cr(VI).
- A multicentre study using HBM in the assessment of occupational exposure and associated health risks in occupational settings provides a model that can greatly improve risk assessment and management in workplaces. The data generated can be used to support the update of the national limit values for Cr(VI) and the national enforcement programs.

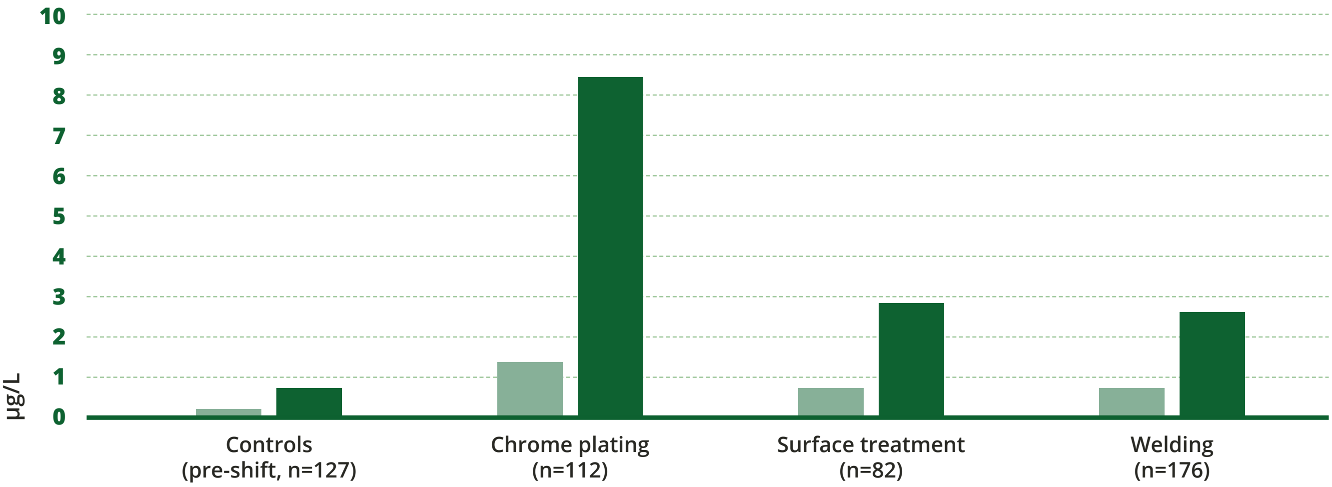
BACKGROUND: HBM4EU

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

A targeted occupational study in the surface treatment and stainless-steel welding sectors was undertaken in 2018, with samples taken in France, The Netherlands, Finland, Belgium, Poland, Portugal, UK, Italy and Luxembourg. This study included ca. 40 companies and a total of 602 workers comprising 203 controls (not occupationally exposed to Cr(VI)) and 399 workers exposed to Cr(VI) in several occupational activities. Different HBM matrices, such as exhaled breath condensate (EBC) and red blood cell (RBC), as well as Cr in urine were used. Among the sectors covered by the study, workers in the Cr plating sector had the highest urinary Cr levels (Figure 1).

Figure 1. Urinary total Cr(VI) levels in controls (pre-shift, blue) and exposed workers (post-shift, yellow)



In the air measurements, inhalable Cr(VI) levels were in most cases below the exposure limit value of 5 µg/m³ in welding and chrome plating, whereas in other surface treatments, levels were above the transient exposure limit value of 10 µg/m³. More frequent use of respiratory protective equipment (RPE) may explain why other surface treatment workers showed lower exposure in biomonitoring studies. Effect marker analyses suggest that even these exposure levels may not be fully safe. Overall, HBM data, together with air and dermal monitoring data, helped to identify the role of different routes of Cr(VI) exposure in occupational settings.

In addition, the information provided by the different (bio) markers can be complementary to assessing occupational exposure and risks. The results of the multicentre HBM study can be used to improve the management of occupational exposure to Cr(VI) in workplaces and associated health risks.

The high number of participating companies, covering the spectrum of small to large companies, and the inclusion of several countries from different parts of Europe, will enhance the power of the study and the usability of the data in regulatory risk assessment and decision making in the EU. Last but not least, HBM4EU has produced a variety of publicly available groundwork material for a harmonised approach to study planning and implementation in the EU in order to further support current and future HBM studies.

Chromium was also monitored in the HBM4EU E-waste Study on workers involved in the processing of different types of electronic waste. Urinary-Cr (U-Cr) levels observed in these workers were close to those observed in control workers.

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

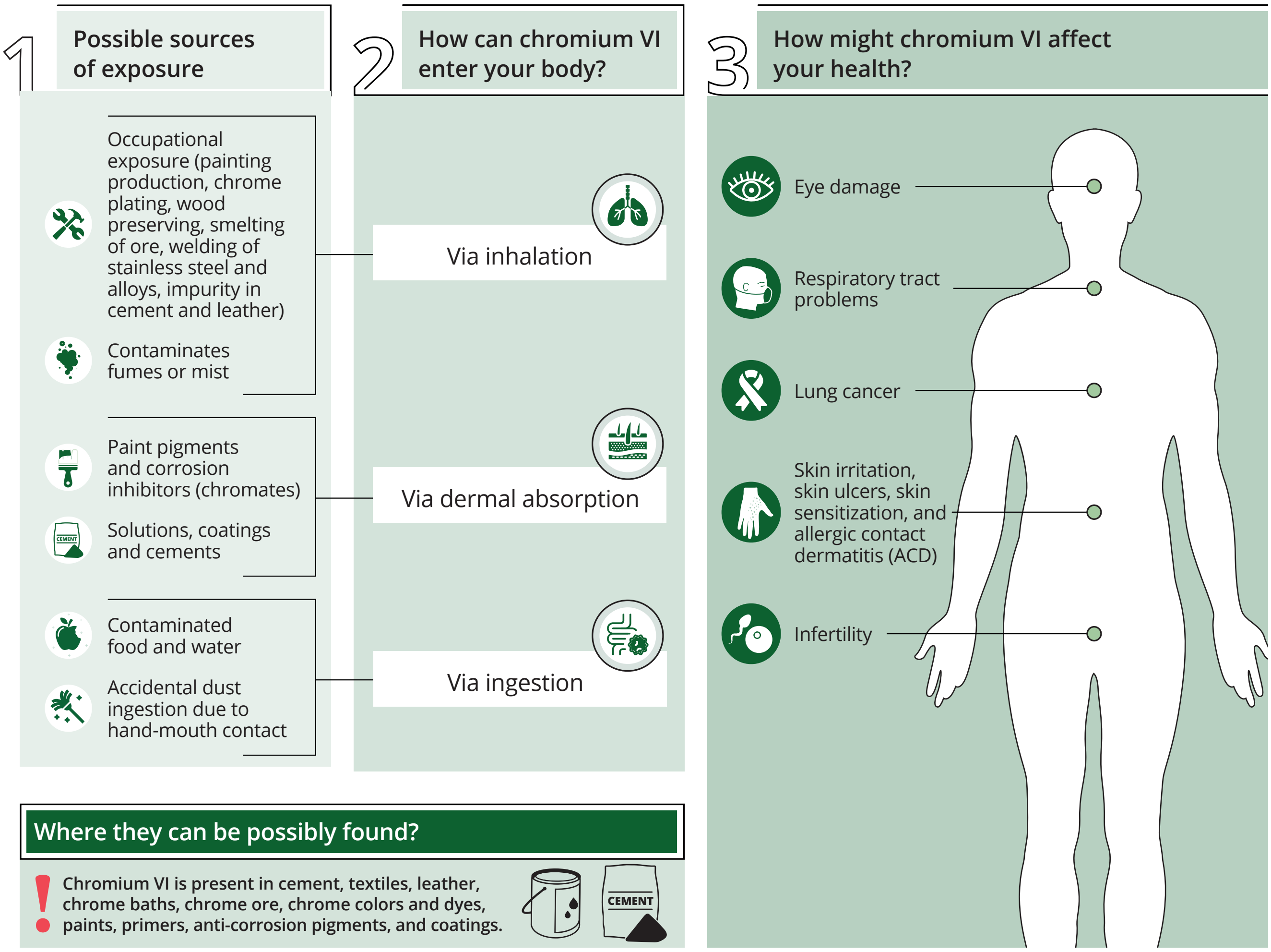
EXPOSURE & HEALTH EFFECTS

The primary health concern associated with Cr(VI) is carcinogenicity. It is classified as a Carc. 1B substance (ECHA) by inhalation exposure, a carcinogen Group 1 by IARC and a genotoxic carcinogen listed under the Carcinogens and Mutagens Directive. Hexavalent chromium is associated with increased lung cancer risk among workers in certain industries and also nasal and sinus cancers. Cr(VI) is also classified as a skin sensitising substance. Single exposures to Cr(VI) can lead to irritation of the nasal lining and the upper respiratory tract, skin damage (burns and ulceration), skin irritation and eye damage from splashes. Exposure to Cr(VI) can also result in kidney damage and infertility. The most significant exposure to Cr(VI) occurs at work where the most common exposure route is inhalation. Occupational exposure can occur in a variety of sectors as the uses of hexavalent chromium include chemical synthesis, manufacturing of pigments and dyes, metal plating, refractory production and the use as corrosion inhibitors.

For the general population, sources of Cr(VI) are mainly environmental via ingestion of Cr-contaminated soil or food, and inhalation of ambient air. Exposure in the general population may also come from smoking tobacco and from consumer products (rust-proofing paints and preserved wood). Chromium is unlikely to be present in drinking water in significant quantities with data for the Drinking Water Directive indicating over 99.9% compliance (for total chromium).

An overview of main sources of exposure (environmental, occupational, consumer), exposure pathways (oral, inhalation, dermal) and health effects is provided in Figure 2.

Figure 2. Overview of exposure sources, pathways and health effects of Chromium VI



INPUT TO POLICY PROCESSES AND RELEVANT POLICY MEASURES

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

The use of Cr(VI) compounds requires authorisation under REACH (e.g. ammonium dichromate, potassium dichromate). Additionally, Cr(VI) is restricted under REACH in cement and leather. The use of chromated copper arsenic wood preservative is also banned in the EU. Chromium (VI) is restricted under the EU Cosmetics Directive 76/768/EEC and is prohibited from use in cosmetics in Germany. Chromium is also regulated under the Food Contact Materials Regulations. Chromium concentrations are also subject to maximum concentrations in water with a new lower limit of 25 µg Cr/L for total Cr introduced under the revised Drinking Water Directive, though this limit only applies from 2036. Migration limits for Cr(VI) are specified under the Toy Safety Directive (2009/48/EC). Occupational exposure to Cr(VI) is subject to an 8-hour workplace OELV of 0.005 mg/m^3 under the CMD (Directive 2004/37/EC).

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 (last 5 years) exposure of the European population to Cr(VI)?

The lack of studies on environmental exposure to Cr(VI) was evident in all EU countries, due to the very low exposure levels of the general population.

Six countries reported occupational biomonitoring data on Cr, but most data comes from the use of total chromium measurements. Since this is not specific for Cr(VI), it was decided to use new Cr(VI) specific biomarkers and to expand the scattered EU data on Cr(VI) (see below).

2 What is the level of exposure, environmentally and occupationally relevant to Cr(VI) in the EU population?

Within the targeted occupational study, workers from different occupational settings, as chrome platers, surface treatment workers and welders, have been analysed to test differences in Cr(VI) levels respect to controls and depending on the task, using HBM matrices (urine, RBC, EBC) and industrial hygiene samples (inhalable and respirable air, dermal wipes).

All analysed biomarkers of exposure demonstrate that workers from all occupational settings have higher exposure to Cr and Cr(VI) when compared with control groups. Strong correlations were observed between urinary Cr levels and atmospheric concentration of Cr(VI) in platers and welders, supporting the use of urinary Cr as a primary method for the biomonitoring of Cr(VI) exposure at workplaces (Santonen et al. 2022).

In addition, workers show higher Cr(VI) levels in post-shift than in pre-shift urinary samples. Moreover, all the occupational settings show higher values of Cr in dermal wipes samples during and at the end of shifts suggesting that hand contamination increases during the day.

3 Does the exposure to Cr(VI) differ significantly between countries and population groups? What are the main reasons for differences in exposure?

In all countries participating in the occupational study, the results of the targeted occupational study show higher exposure to Cr(VI) among workers in industries using Cr(VI) with respect to controls.

The chromium plating sector shows the highest biomarkers exposure levels. The lower biomarker values in surface treatment workers, when compared to chrome platers, may reflect the use of RPE.

4 Is there a significant time trend of Cr(VI) levels in existing population studies?

In 2021, Verdonck et al. (2021) reported a decreasing time trend of urine Cr concentrations in workers, based on an unpublished biomonitoring dataset (comprising of urinary levels of 3799 workers from different industries in Belgium collected between 1998 and 2018). Similar decreasing trend has been reported from Finland from biomonitoring measurements collected between 1980 and 2016 (Mahiout et al., 2022, *submitted*).

Data are insufficient to evaluate time-trends on an EU-wide scale.

5 What are the groups at risk?

The results obtained under the Cr(VI) Occupational Study reveal significant differences between subgroups of workers by industrial sector (Tables 10-12, D8.9).

In general, based on the biomonitoring data, chrome plating workers are exposed to higher levels than surface treatment workers and welders.

6 Are the overall exposure levels (in different population groups) above any health-relevant assessment levels (HBM guidance values, TDI)?

Data from Cr(VI) occupational study highlight that in the industrial hygiene measurements, the 90th percentile (P90) of inhalable Cr(VI) levels is below the binding occupational limit value of 5 $\mu g/m^3$ in welding and chrome plating, whereas in surface treatment the P90 is above the transient BOELV of 10 $\mu g/m^3$. Biomonitoring data supports the air measurement data showing that the exposure in most cases remains below these levels. However, our effect marker data suggests that even these levels may not be fully safe since increases in genotoxicity markers were observed both in platers and welders.

7 Has the regulation under REACH had a favourable impact like a reduction of GM/median concentrations?

Results obtained under the Cr(VI) Occupational Study, even with several regulatory frameworks in place (REACH and OSH), show that exposure to Cr(VI) in plating still occurs and at higher levels than in the other investigated sectors.

Although the chemical form of the chromates used and the effect of wearing RPE are likely to have an impact, available results also suggest that other exposure routes (ingestion due to hand-to-mouth contact) may also play a role in the total exposure.

In order to conclude whether new regulations have had a favourable impact on Cr(VI) exposure, further research is needed. However, a rich dataset has been collected in the HBM4EU Occupational Study, which can be used as a baseline for future research applying the same methodology.

8 What are the current HBM methods for Cr(VI)?

Within HBM4EU, new and more specific methods for biomonitoring of Cr(VI) were tested, and harmonised methodology for the collection of biological samples (urine, RBC and EBC) and environmental industrial hygiene samples (as dermal wipes and air) have been developed.

Cr(VI) in exhaled breath condensate (Cr EBC) has been proposed as a new biomarker. There are currently few data on the relationship between the levels in the EBC and in atmospheric air. Being in early stages, the use of EBC data has analytical and consistency issues making it difficult to compare.

The HBM4EU Chromate Study demonstrated a high correlation between chromium urinary levels and air Cr(VI) or dermal total Cr exposure. Urinary chromium proved to be valuable as a first approach for the assessment of total internal exposure. Our data can be used to set biomonitoring guidance values for U-Cr corresponding to air limit values for Cr(VI) (Viegas et al., 2022). Our data supports several other studies carried out in occupational settings that have reported measurements of urinary Cr and their correlations with Cr(VI) air concentrations in Cr plating activities (ANSES, 2017). In addition, we provided correlations between urinary chromium and Cr(VI) air concentrations that can be used for setting HBM guidance values for welders. Correlations between urinary chromium and Cr(VI) in EBC and Cr in RBC were low, probably due to differences in kinetics, indicating that these biomonitoring approaches may not be interchangeable but rather complementary.

9 Which are the appropriate biomarkers for Cr(VI)?

Even though urinary total Cr is a non-specific biomarker, it has shown its value as the first approach to assess the total internal exposure to Cr(VI) as mentioned above. The biomarkers RBC and EBC were the most specific to Cr(VI) and can be used to provide complementary data.

The biomarkers more specific to Cr(VI) exposures are the RBC-Cr(VI) and EBC-Cr. Both are indeed significantly elevated in workers compared to controls.

Concerning biomarkers of effect, the HBM4EU Chromate Study included the collection and analysis of samples for several effect biomarkers. Effect markers analysed in the chromate study (see D8.5) were reticulocyte micronuclei (MN), MN in peripheral blood lymphocyte (in collaboration with WP14), comet assay in leukocytes, global methylation analysis (and specific epigenetic markers), telomer length in blood, metabolomics studies (urine), oxidative stress biomarkers in urine. The data suggests that effect biomarkers can be successfully applied in occupational settings to identify the potential concern for early effects.

KNOWLEDGE GAPS

The HBM4EU Chromate Study provided relevant data on occupational Cr(VI) exposure to support the regulatory risk assessment and decision-making in the EU. In addition, the usefulness of new and specific different biomarkers (RBC and EBC) for the assessment of Cr(VI) exposure were evaluated, and specific methods have been developed for detecting Cr(VI) additionally to total chromium.

Follow up research needs to be conducted to conclude whether new regulations have had a favourable impact on the Cr(VI) exposure.

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