CONCLUSION REPORT ON CHALLENGE 1.1 'BETTER DATA'

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Summary

Reliable exposure data are essential for priority setting and efficient regulation of carcinogens. This Challenge aimed to review the available sources for occupational exposure data on chemical carcinogens in Europe, and to identify ways to improve their accessibility and use in priority setting and regulation. The study included a survey for research organisations and database owners to collect information on the available data and views on increasing their usability, and a case study to examine how occupational exposure data are currently utilised in regulatory impact assessment under the Carcinogens, Mutagens and Reprotoxic substances Directive (CMRD).

The survey identified several recent and ongoing joint European and national research projects that provide data on occupational exposure to chemical carcinogens, as well as national exposure measurement databases and registers on workers exposed to carcinogens that could provide valuable information on the current exposure levels and number of exposed workers in Europe. EU-OSHA and JRC are currently mapping the possibility to add a new module for occupational exposure data in the IPCheM platform which could be used to improve the accessibility of these data.

Although a common exposure measurement database received support in the survey, there were also concerns related, e.g., to the resources needed to format the data in the required format, comparability of data collected by different actors, data ownership and data protection. A common platform for sharing general information (metadata) on the research projects and databases was supported as a less resource-demanding way to increase awareness on the available data. Since a majority of the available exposure data lie in the national databases, improving their accessibility was identified as of great importance. Examples were identified on web-based tools and data compilations, and on published (substance-based) overviews, which could improve the usability of these data.

The case study on recent regulatory impact assessments under CMRD highlighted the deviating strategies and sources for exposure data in the assessments, and an evident need for harmonisation and guidelines to ensure that all relevant data would be utilised in the assessments and to increase coherence and equality between different assessments.

Recommendations

European Commission via the Advisory Committee is encouraged to develop guidelines for the assessment of exposure levels and number of exposed workers in the regulatory impact assessments under CMRD, including the primary data sources to be used and guidelines for the literature search and for reporting the data retrieval. This would increase the quality, coherence and transparency of the assessments.

Member States are asked to aid the regulatory work by supplying up-to-date exposure measurement data, and data on the number of exposed workers, if available, from the national databases in the stakeholder consultations. Member States are also asked to consider the need to increase the competence of labour inspectors in the field of exposure assessment and chemical safety in order to better support workplaces, in particular smaller companies, in assessing and controlling exposure to carcinogens.

Database owners and research organisations are asked to pay attention on the accessibility of their exposure data, and to recognise the value the data would have in priority setting and regulation of carcinogens, and thereby in tackling occupational cancers, if made easily accessible (e.g., through publications, web-based tools, or common databases such as the IPCheM). Also, the high quality of the exposure data, and sufficient contextual information, are necessary for further utilisation of the data. The organisations are encouraged to focus their research and measurement campaigns in smaller companies and fields that are currently under-represented in the national exposure measurement databases (e.g., service field).

Funding organisations are asked to acknowledge the increased impact the funded exposure research would have if the data produced were made easily available, and accept this work (e.g., the delivery of the data into a freely accessible database) as a part of the funding, or even demand efforts for data accessibility as a condition for funding.

EU-OSHA and JRC are supported in their plans to add a new module for occupational exposure data in the IPCheM, and encouraged to continue their work with the data owners to have a representative fraction of the recent European exposure measurement data included. This work could also support harmonizing the approaches for collecting and reporting measurement data, improving the comparability of the data produced by different actors. EU-OSHA is also encouraged to map the possibilities to provide a common platform for sharing general information (metadata) on the research projects and available databases.

Introduction

The Roadmap on Carcinogens Challenge 1.1 'Better data' aimed to advance the use of existing occupational exposure data in the regulation of chemical carcinogens in the Europe. The main objectives were:

- to identify recent and ongoing research projects and publications that provide information on occupational exposure to chemical carcinogens in the Europe (**A1**),
- to identify databases containing occupational exposure measurement data on chemical carcinogens in the Europe (**A1**),
- to explore the data sources and type of data used for exposure assessment in the regulatory context (**A4**), and
- to explore the possibilities to improve accessibility and use of existing occupational exposure data in the regulatory context (**A2, A3, A4**).

The information provided in this report is based on an online survey addressed to organisations involved in occupational exposure research or maintaining exposure measurement databases that was carried out in April-May 2022 (further described in Appendix 2), subsequent discussions with the database owners, and a complementing search for exposure data sources considering EU-OSHA (2014), RIVM (2014), EC (2016a), Peters et al. (2022) and Occupational Exposure Tools (net). In order to study the sources and type of exposure data currently used for regulatory impact assessments, and the potential for improvements, a case study examining three recent regulatory impact assessments of occupational carcinogens was also carried out.

Recent and ongoing research projects

Four recent or ongoing joint European research projects were identified as primary relevance for providing information on occupational carcinogen exposure: the European Human Biomonitoring Initiative (HBM4EU), the Partnership for the Assessment of Risk from Chemicals (PARC), the Exposome Project for Health and Occupational Research (EPHOR), and the Worker Survey on Exposure to Cancer Risk Factors (WES). These projects and their potential contribution are discussed in the following sections.

European Human Biomonitoring Initiative (HBM4EU)

The Horizon 2020 project HBM4EU (2017–2022) was coordinating and advancing human biomonitoring in Europe. The main aim was to generate policy-relevant data on the exposure to hazardous chemicals. The specific objectives of the project included:

- harmonizing procedures for human biomonitoring across European countries, to provide policy makers with comparable data on human internal exposure to chemicals;
- linking data on internal exposure to chemicals to aggregate external exposure and identifying exposure pathways and upstream sources;
- generating scientific evidence on the causal links between human exposure to chemicals and negative health outcomes; and
- adapting chemical risk assessment methodologies to use human biomonitoring data and account for the contribution of multiple external exposure pathways to the total chemical body burden.

In relation to occupational carcinogen exposure, two occupational surveys, the HBM4EU chromates study and the HBM4EU E-waste study were performed providing new data on exposure to specific carcinogens at workplace. Third occupational survey performed within the HBM4EU was related to diisocyanates exposure, which – although not classified as cat 1 carcinogens – are important occupational contaminants causing occupational asthma.

The HBM4EU chromates study produced data on **occupational exposure to hexavalent chromium** in electroplating, in other surface treatment activities, and in welding of stainless steels, by collecting samples from companies in nine European countries. Also, exposure to nickel compounds in these activities were evaluated as part of the study but these data are not yet published (but will be further evaluated as part of PARC project, see below). Scientific publications on the HBM4EU chromates study published/in press at the time of writing include:

- Santonen T, Alimonti A, Bocca B, et al. (2019). *Setting up a collaborative European human biological monitoring study on occupational exposure to hexavalent chromium*. Environ. Res 177: 108583.
- Galea KS, Porras SP, Viegas S, et al. (2021). *HBM4EU chromates study—Reflection and lessons learnt from designing and undertaking a collaborative European biomonitoring study on occupational exposure to hexavalent chromium*. Int J Hyg Environ Health 234: 113725.
- Santonen T, Porras SP, Bocca B, et al. (2022). *HBM4EU chromates study—Overall results and recommendations for the biomonitoring of occupational exposure to hexavalent chromium*. Environ Res 204 Pt A: 111984.
- Viegas S, Martins C, Bocca B, et al. (2022). *HBM4EU Chromates Study: Determinants of Exposure to Hexavalent Chromium in Plating, Welding and Other Occupational Settings*. Int J Environ Res Public Health 19: 3683.
- Kozlowska L, Santonen T, Duca RC, et al. (2022). *HBM4EU Chromates study: Urinary metabolomics study of workers exposed to hexavalent chromium*. Metabolites 12(4): 362.
- Ndaw S, Leso V, Bousoumah R, et al. (2022). *HBM4EU chromates study - Usefulness of measurement of blood chromium levels in the assessment of occupational Cr(VI) exposure*. Environ Res 214(Pt 1): 113758.
- Tavares A, Aimonen K, Ndaw S, et al. (2022). *HBM4EU Chromates Study—Genotoxicity and Oxidative Stress Biomarkers in Workers Exposed to Hexavalent Chromium*. Toxics 10: 483.
- Leese E, Jones K, Bocca B, et al. *HBM4EU Chromates Study – The Measurement of Hexavalent and Trivalent Chromium in Exhaled Breath Condensate Samples from Occupationally Exposed Workers Across Europe*. Toxicology letters, submitted.

- Santonen T, Louro H, Bocca B, et al. *The HBM4EU chromates study – outcomes and impacts on EU policies and occupational health practices*. IJHEH, submitted.

The HBM4EU E-waste study evaluated the **exposure to hazardous metals (Cr(VI), Hg, Pb and Cd) as well as phthalates and flame retardants** in the recycling of electrical waste. The study was conducted in eight European countries. The initial results of this study have been published as a deliverable report (Santonen et al. 2022), scientific publications being still under preparation.

In addition to these new sampling campaigns statistical analyses of existing data and systematic reviews have been published within the HBM4EU. These include for example following publications focusing on Cr(VI) and PAHs:

- Verdonck J, Duca RC, Galea KS, Iavicoli I, Poels K, Töreyin ZN, Vanoirbeek J, Godderis L (2021). Systematic review of biomonitoring data on occupational exposure to hexavalent chromium. Int J Hyg Environ Health 236: 113799.
- Mahiout S, Kiilunen M, Vermeire T, Viegas S, Woutersen M, Santonen T (2022). Occupational exposure to Cr(VI) in Finland in 1980-2016 and related lung cancer risk assessment. Regul Toxicol Pharmacol 136: 105276.
- Louro H, Gomes BC, Saber AT, Iamiceli AL, Göen T, Jones K, Katsonouri A, Neophytou CM, Vogel U, Ventura C, Oberemm A, Duca RC, Fernandez MF, Olea N, Santonen T, Viegas S, Silva MJ (2022). The Use of Human Biomonitoring to Assess Occupational Exposure to PAHs in Europe: A Comprehensive Review. Toxics 10(8): 480.

In addition to carcinogens, systematic reviews on occupational exposure biomonitoring data were produced also on phthalates, bisphenols and diisocyanates.

The project also produced data on general population background exposure to different compounds. These general population data have been collected in the EU HBM Dashboard and will be also made accessible via the human biomonitoring module on Information Platform for Chemical Monitoring IPCHEM. Similarly, the data from occupational studies will be made available according to the FAIR principles for use in further studies which means that the data or part of it may be transferred to a third party upon appropriate request and in accordance with applicable law.

HBM4EU's impact on priority setting and regulation of carcinogens

- Key conclusions of the HBM4EU chromates study relevant for the regulation of hexavalent chromium (Cr(VI)) were as follows:
    - For welding, air levels are achievable below the upcoming EU Binding Occupational Exposure Limit Value (BOELV) of 5 µg/m³. Use of local exhaust ventilation and respiratory protective equipment (RPE) seemed to be effective in reducing exposure in welding, although it must be recognised that the use of RPE should be considered as the last resort in the hierarchy of controls.
    - In Cr(VI) surface treatment activities, efficient risk management measures (RMMs) and personal protective equipment are needed to minimise the exposure. Automation of electroplating processes and improved use of RPE is recommended to further reduce exposure.
    - Biomonitoring is a valid method and can be a necessary tool to evaluate the effectiveness of the RMMs in place in Cr(VI) uses.
    - Specific biological guidance values for Cr(VI) in welding do not currently exist. The study provided the necessary data to set specific guidance values for welders.
    - Cr-related activities were associated with the induction of oxidative stress and genotoxic effects, thereby representing a potential risk for workers health. There is still a need to consider further lowering of OELs for Cr(VI) to reduce the identified risks.

- HBM4EU E-waste study observed occupational exposure to lead and cadmium, emphasizing the importance of the update/setting of BOELVs and biological limit values for these substances.

- Review on the available biomonitoring data on occupational exposure to PAHs can support the setting of BOELV for PAHs.

Partnership for the Assessment of Risk from Chemicals (PARC)

The Horizon Europe project PARC (2022–2029) aims to provide new data, methods and innovative tools for chemical risk assessment, and to strengthen related the scientific skills, knowledge sharing and networks. PARC will partly build on the work undertaken in the HBM4EU project. Although environmental and consumer exposure to chemicals is highly emphasised in PARC, occupational exposures are also considered.

Within PARC WP4 on monitoring and exposure, multi-national occupational surveys, similar to the HBM4EU occupational surveys described above, are planned. Altogether four different occupational surveys, providing data on occupational exposure to hazardous chemicals are planned. Two of these have already been agreed, the first one continuing the work done within the HBM4EU E-waste study with the focus in **waste**

management sector, and the second one focusing on exposure to hazardous medicines (including cytotoxic drugs and inhalation anaesthetics) in **health care sector**.

PARC waste management study will continue the work of HBM4EU E-waste study by collecting exposure data on additional waste handling processes and additional chemicals, including carcinogenic metals like Ni and Co. Two further occupational studies will be planned later and since their focus has not been fixed yet, it is possible to impact the planning of these surveys.

PARC WP6 focuses on the development of **new risk assessment approaches**. This includes also approaches for the assessment of aggregated exposure from multiple sources, and the assessment of combined exposure to multiple chemicals. The risk assessments performed within PARC WP6 cover also occupational scenarios and may provide input for the regulatory priority setting. PARC WP5 focuses on hazard assessment and may bring additional information for the **identification of carcinogens**, since both testing of genotoxic and non-genotoxic carcinogenic mechanisms of different substances is included.

PARC's impact on priority setting and regulation of carcinogens

- PARC waste management study is likely to bring information on the exposure to chemical carcinogens in waste management sector.
- PARC health care study will bring information on the current exposure of health care personnel to hazardous medicinal products, including carcinogenic cytotoxic drugs. It will also inform on the possibilities to monitor exposure and the effectivity of the current risk management measures in place in hospitals.
- The risk assessments performed within PARC WP6 may provide input for the regulatory priority setting of carcinogens. Similarly, also WP5 may bring additional information for the identification of carcinogens and priority setting.

Exposome Project for Health and Occupational Research (EPHOR)

The Horizon 2020 project EPHOR (2020–2024), aims to develop a working-life exposome toolbox that can be utilised by scientists, occupational health practitioners, and policy makers. The working-life exposome is defined as the measure of the entire occupational and related non-occupational exposures of an individual. The project will yield improved knowledge on how multiple exposures within the working-life exposome are related to the occurrence of common diseases, and provide innovative methods for collection, storage and interpretation of these data (Pronk et a. 2022).

The EPHOR project will combine large-scale pooling of existing exposure data (the EPHOR mega cohort) with the collection of new external and internal exposure and mechanistic data at the individual level in two case studies. The EPHOR mega cohort will be constructed based on multiple population, industry and occupational cohort studies available in the Europe. The mega cohort will allow for systematically linking occupational risk factors to specific diseases, including cancers.

The project will develop a set of **harmonised job-exposure matrices (EuroJEM)**. The first version (EuroJEM1.0) includes harmonized exposure estimates for **respirable crystalline silica, wood dust, nickel (compounds), diesel engine exhaust, and UV radiation**. At a later stage, also other carcinogens may be included. The EuroJEM will contain estimates on exposure prevalence, and in a later stage, also (quantitative) exposure estimates per occupation. Partners in the EPHOR project will jointly own the EuroJEM (EuroJEM Board), and its administration will be at Karolinska Institute, Sweden. EuroJEM1.0 is expected to be in use by the end of 2022.

The two case studies under EPHOR will focus on **working-life exposures in relation to respiratory health and night shift work**, and will collect extensive external exposure information with sensors, passive sampling and apps, as well as internal markers of exposure and early disease at the individual level (biomonitoring).

The **EPHOR Toolbox** (WE-EXPOSE, draft version online: https://www.we-expose.eu/) will contain the developed tools and methods and will enable scientists to use and enhance the data, methods and models in exposome research. Policymakers and occupational health practitioners can use the toolbox for the development of evidence-based and cost-effective preventive policies and actions.

EPHOR's impact on priority setting and regulation of carcinogens

- EPHOR will provide information on the prevalence of occupational exposure for the carcinogens included in the EuroJEM, and in a later stage, also estimates of exposure levels. EuroJEM1.0 includes respirable crystalline silica, wood dust, nickel (compounds) and diesel engine exhaust.

- Harmonized EuroJEM can be used in registry based retrospective cohort studies across the Europe for enhancing information of multiple simultaneous occupational exposures causing cancer and other diseases.

- WE-EXPOSE toolbox is aimed to contain methods for collection, storage, and interpretation of working life exposome data, which provides policy makers models for better assessing the economic and societal impact of working life exposures.

Worker Survey on Exposure to Cancer Risk Factors (WES)

The EU-OSHA-driven WES survey, planned for the years 2021–2023, aims to provide information the number and characteristics of the workers exposed to a range of cancer risk factors, including **asbestos, benzene, hexavalent chromium, diesel engine exhaust, nickel compounds, crystalline silica, wood dust, and UV radiation**. Information on workers' multiple exposures will be collected. The survey is carried out by telephone interviews in six European countries (Germany, Ireland, Spain, France, Hungary and Finland), and may later be broadened to cover all Member States. The interviews started in September 2022 after a pilot phase.

The Australian Occupational Integrated Database Exposure Assessment System (OccIDEAS) is used in the project for assessing exposures based on the work task descriptions obtained in the interviews. The results from the questionnaire collected by the surveying company are processed by the OccIDEAS algorithm to yield a semi-quantitative estimate of exposures and their levels. A study-specific instance of OccIDEAS was made for Europe, and the researchers choose relevant agents, questions and modules for the WES study. Rules for the agents in the WES study are categorized into semi-quantitative exposure levels which are based on evidence from the literature and/or expert judgement. There are also specific rules to determine the overall exposure levels for a participant carrying out several work tasks.

WES's impact on priority setting and regulation of carcinogens

- WES aims to better identify the most prevalent occupational cancer risk factors and exposure situations, will provide information on the number and characteristics of the exposed workers, and comparable information on both intentionally used and process-generated carcinogens.
- A main aim of the survey is to better target awareness-raising campaigns and preventive measures and to contribute to evidence-based policymaking.
- The survey seeks to provide information that could contribute to updating EU legislation, where appropriate, to improve the protection against dangerous substances and fight occupational cancer, as regards the preparation of possible future amendment proposals of the Carcinogens, Mutagens and Reprotoxic substances Directive (CMRD).
- In addition, the survey is expected to contribute to the OSH actions of Europe's Beating Cancer Plan and to support one of the key objectives of the EU Strategic Framework on Health and Safety at Work 2021-2027 on improving prevention of work-related diseases, in particular cancer.

National projects

In addition to the above mentioned four joint research projects, the organisation responding our survey reported 20 recent or ongoing national research projects providing measurement data on occupational carcinogen exposure (either airborne concentrations or biomonitoring data) (Appendix 1, Table A1-1). These projects address occupational exposure e.g., to **asbestos, diesel engine exhaust, other combustion products, carcinogenic metals, formaldehyde, crystalline silica, and wood dust**. In addition, the respondents reported 11 recent or ongoing research projects addressing occupational carcinogen exposure without providing new exposure data (Appendix 1, Table A1-2). These projects include registry-based studies on occupational cancer, and studies addressing e.g., trends in working conditions, use of epidemiological data on general population for questions in occupational health, and updating risk management measure libraries.

Research registers

For improving awareness on the ongoing research, as well as harmonisation of the data collection and data reporting practises, research registers resembling those in use for clinical trials would be useful also for occupational exposure research. The Network on the Coordination and Harmonisation of European Occupational Cohorts (OMEGA-NET)

is maintaining an inventory for occupational cohorts in Europe and globally (OccupationalCohorts.net), which contains information e.g., on the type of exposure data collected for the cohorts (Kogevinas et al. 2020). For biomonitoring studies, a HBM Global Registry Framework has been proposed (Zare Jeddi et al. 2021). The feasibility and options for developing such a registry framework is proposed to be further studied and promoted under the PARC project.

Exposure databases and related publications

Exposure measurement databases

Table 1 lists national occupational exposure measurement databases available in the Europe (non-exhaustive list). COLHIC data, aggregated per industry/activity, are available through a freely accessible webtool, Solvex. Aggregated data from the FIOH databases (currently only years 2016–2019) can be accessed through FIOH's Work-life knowledge service. According to their response, also MEGA, EXPO, and SIREP would in principle be able to provide aggregated data for specific carcinogenic substances per industry/activity to be used for EU level regulatory processes and priority setting. For MEGA, a permission from the German accident insurances would be needed for the data transfer. Both MEGA and SIREP noted the potential differences in the classification (coding) of occupational activities which needs to be taken into consideration in the data retrieval. SIREP also highlighted the fact that not all sectors and work activities are equally represented in the database, and that small companies are usually underrepresented. This is expected to be a limitation for most of the databases.

In addition to the databases listed in Table 1, Andrija Štampar Teaching Institute of Public Health (Croatia) informed on the plans Croatia has in building up a national exposure measurement database, aiming to include data from both public and private measurement providers. Also, the Institute of Medicine of Gothenburg University (Sweden), the Laboratory of Hygiene and Occupational Diseases of Riga Stradins University (Latvia), and the Institute of Occupational Medicine (IOM) (UK) indicated availability of exposure measurement data on occupational carcinogens. In addition, the Asbestos Removal Exposure Assessment Tool (AREAT) developed by TNO (the Netherlands) contains exposure measurement data related to asbestos removal.

Table 1. European national occupational exposure measurement databases (non-exhaustive).

Database (Country)	Years covered	Administrator	Further information
MEGA (Germany)	1972-current	Institute for Occupational Safety and Health (IFA)	IFA - Databases on hazardous substances: Exposure database MEGA substance-based overviews regularly

			published at IFA/IAG Database publications (see Table 1A-3)
COLCHIC (France)	1987-current	The French National Research and Safety Institute for the Prevention of Occupational accidents and Diseases (INRS)	aggregated data accessible through Solvex - Publications and tools - INRS
SCOLA (France)	2007-current	The French National Research and Safety Institute for the Prevention of Occupational accidents and Diseases (INRS)	overviews published yearly at Chemical risks. Publications, tools, links... - Risks - INRS
SIREP (Italy)	1996-current	National Institute for Insurance against Accidents at Work (INAIL)	scientific articles regularly published (see Table 1A-3)
EXPO (Norway)	1971-current	National Institute of Occupational Health in Norway (STAMI)	About EXPO and EXPO Online - STAMI
Register of Occupational Hygiene Measurements (Finland)	1950-current	Finnish Institute of Occupational Health (FIOH)	aggregated data for years 2016–19 accessible through Work environment exposure measurements | Work-life knowledge service
Biomonitoring Database (Finland)	1960-current	Finnish Institute of Occupational Health (FIOH)	aggregated data for years 2016–19 accessible through Work environment exposure measurements | Work-life knowledge service
PRECUBE (the Netherlands)	1989-current	KU Leuven	
HSE National Exposure Database (NEDB) (UK)	1986-current	Health and Safety Executive (HSE)	
HSE Biological Monitoring Database (BMDB) (UK)	1996-current	Health and Safety Executive (HSE)	

National registers on workers exposed to carcinogens

The directive 2004/37/EC on carcinogens, mutagens or reprotoxic substances at work requires the employer to keep a list of the workers engaged in the activities where exposure to carcinogenic, mutagenic or reprotoxic substances may cause risk to worker's health or safety. With regard to carcinogens and mutagens, this list shall be kept for at least 40 years following the end of exposure, in accordance with national law or practice. In several EU countries, the information on exposed workers are conserved in national registers (Table 2).

Table 2. National registers on workers occupationally exposed to carcinogens (non-exhaustive).

Register	Country	Administrator	Further information
Records of workers exposed to carcinogens and mutagens at work	Croatia	Croatian Institute for Occupational Health and Safety (HZZZSR)	Evidencije izloženosti – HZJZ (hzzzsr.hr)
Records of workers exposed to cytostatic drugs	Croatia	Croatian Institute for Occupational Health and Safety (HZZZSR)	
Register on workers exposed to carcinogens (ASA Register)	Finland	Finnish Institute of Occupational Health (FIOH)	ASA-rekisteri | Työterveyslaitos (ttl.fi) aggregated data for years 2010–19 accessible through Occupational exposure to carcinogenic substances | Work-life knowledge service
Central exposure database of workers exposed to carcinogens (ZED database)*	Germany	German Social Accident Insurance (DGUV)	Datenbank zur zentralen Erfassung gegenüber krebserzeugenden Stoffen exponierter Beschäftigter (ZED) (dguv.de)
Central register of data on exposure to carcinogenic or mutagenic substances, mixtures, agents or technological processes	Poland	Nofer Institute of Occupational Medicine (NIOM)	Central Register of Data on Exposure to Carcinogenic or Mutagenic Chemical Substances, Mixtures,

			Agents or Technological Process (lodz.pl)
Italian information system on occupational exposure to carcinogens (SIREP)	Italy	National Institute for Insurance against Accidents at Work (INAIL)	The Italian information system on occupational exposure to carcinogens (SIREP) (nih.gov)
ASTR register (automatic system of risk classification)	Slovak Republic	Public Health Authority of the Slovak Republic	
Registry of activities involving carcinogens/mutagens	Hungary	The Ministry of Technology and Industry, Department of Occupational Safety with regional labour inspectorates	Rákkeltővel végzett tevékenység bejelentése (ommf.gov.hu)
Register of work categorization (IS KaPr)	Czech Republic	Institute of Health Information and Statistics of the Czech Republic	Registr kategorizace prací - ÚZIS ČR (uzis.cz)

* There are also two related registers in Germany on workers entitled to occupational health care due to their exposure to carcinogens or mutagens, the ODIN Register and the GVS Register.

Job-exposure matrices

In addition to exposure measurement databases and registers of exposed workers, there are also several job-exposure matrices (JEM) available in the Europe that contain information on the prevalence of exposures to chemical carcinogens across industries, and typically also (semi-quantitative) estimates on exposure levels. JEMs are primarily used for exposure assessment in retrospective epidemiological studies, and may therefore suit better for exploring trends in exposures than providing information on the current exposures. As an example of the relatively recently updated JEMs, Matgéné (France) and SYN-JEM (the Netherlands), as well as the EuroJEM under development in the EPHOR project, reach until 2010.

JEMs containing information on multiple chemical carcinogens include:

- SWEJEM; Karolinska Institute, Sweden
- Matgéné; Santé Publique France, France

- ALOHA+ JEM; Utrecht University, the Netherlands
- DOM-JEM; Utrecht University, the Netherlands
- FINJEM; Finnish Institute of Occupational Health (FIOH), Finland
- NOCCA-JEM; Danish Cancer Society Research Center, Denmark; further information:
- MatEmESp; University Pompeu Fabra (UPF); Spain; further information:

JEMs focusing on specific carcinogens include:

- SYN-JEM (asbestos, crystalline silica, chromium, nickel and their compounds, benzo(a)pyrene); Utrecht University, the Netherlands
- Asbestos JEM; Department of Public Health, Erasmus Medical Center, the Netherlands
- BEN-JEM (benzene); Utrecht University, the Netherlands
- DEE-JEM (diesel engine exhaust); Utrecht University, the Netherlands
- Diesel JEM, Karolinska Institute, Sweden
- Wood dust JEM; Aarhus University, Denmark
- Norwegian Silicon Carbide JEM; University Hospital Northern Norway; Norway

Recent publications on occupational carcinogen exposure

Recent publications that provide exposure measurement data on chemical carcinogens, primarily extracted from the above mentioned exposure databases or presenting results of research projects, are presented in Appendix 1, Table A1-3. These publications address a variety of carcinogenic agents, including **1,3-butadiene, aromatic amines, arsenic, asbestos, benzene, beryllium, cobalt, crystalline silica, diesel engine exhaust, formaldehyde, hexavalent chromium, nickel compounds, PAHs, and wood dust**. Table A1-4 in Appendix 1 lists recent publications addressing occupational carcinogen exposure without providing new exposure measurement data.

Improving accessibility of the available exposure data

To increase the impact of research projects and data compilations on the priority setting and regulation on carcinogens it would be important to ease the access of regulators to the available data. Currently, the European Agency for Safety and Health at Work (EU-OSHA) and the Commission's Joint Research Centre (JRC) are exploring the possibility to include a module for sharing occupational exposure measurement data in the Information Platform for Chemical Monitoring IPCheM (airborne concentrations; a module for human biomonitoring data is already included). They have also had preliminary discussions with some of the national database owners on the possibilities to deliver data from the national registers to IPCheM.

To explore the views of the data owners, our survey contained a question addressing the feasibility of different options for sharing the exposure data produced in research projects and surveys, also considering the time and effort needed for entering the data. Three options were given:

- a common European exposure measurement database where measurement data with contextual information would be added,
- a common European platform where general information on ongoing projects and available databases would be added, and
- other (please specify).

A common European exposure measurement database and a common European platform for sharing general information on ongoing projects and available databases received nearly equal support (Figure 1), with seven of the responding organisations choosing the first option, six choosing the second option, and seven choosing both of these options. The two respondents proposing other options supported a global database for human biomonitoring data.

Although a common European exposure measurement database received support from the responding organisations, several respondents pointed out that formatting the measurement and contextual data into the required format, if not included as an integral part of the project work, is most probably too time/resource consuming to be a generally feasible option. One of the database owners suggested including these activities within a specific European project, involving the database owners that are willing to deliver data from their databases into a common database.

The data protection (GDPR regulation) related requirements were seen as an additional complicating factor, and one of the respondents even proposed changes in the data protection legislation to better enable sharing and utilizing exposure measurement data. An important issue pointed out by two of the respondents was the widely deviating ways of collecting and reporting exposure measurement data by the different databases and countries. The lack of clear rules and guidance for collecting and reporting exposure measurement data makes the comparison of data from different data sources very difficult. Harmonizing the approaches was seen as a necessary first step required for creating a common exposure measurement database.

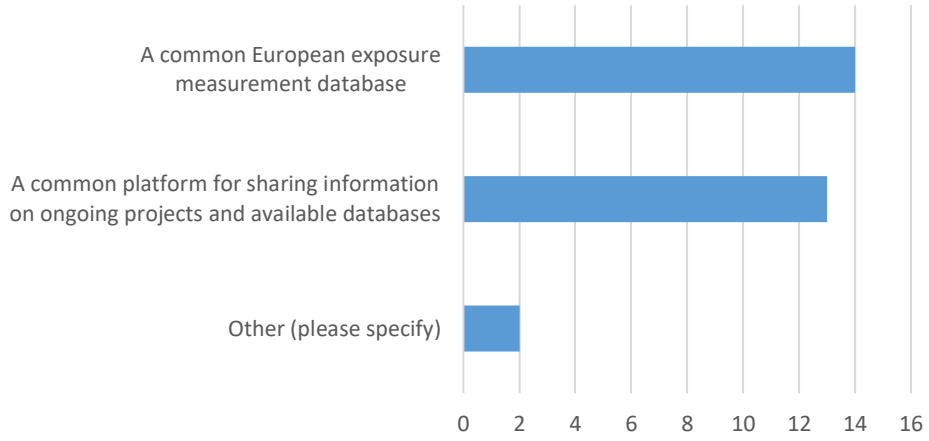

Figure 1. Distribution of responses to the question "Which of the following your institute/organisation finds as feasible means for sharing the exposure data produced in your research projects and surveys, also considering the time/effort needed for you to enter the data" (multiple choices).

Case study on the sources of exposure data for regulatory impact assessment

A case study was carried out to examine the sources of occupational exposure data used for regulatory impact assessment. Three compounds with a relative recent regulatory impact assessment, either under the Carcinogens, Mutagens and Reprotoxins Directive (CMRD) (2004/37/EC) or the REACH Regulation (1907/2006/EC), were selected for the case study: respirable crystalline silica (RCS), cobalt and its compounds, and benzene. These compounds were selected to cover both organic and inorganic compounds, metals and non-metals, and intentionally applied and process-generated agents. All of these compounds are expected to be further discussed in the context of CMRD in the coming years.

Respirable crystalline silica

An impact assessment related to setting a BOELV for RCS under the CMRD (2004/37/EC) was carried out in 2016 (EC 2016b), based on the work by Cherrie et al. (2011). The prevalence of RCS exposure by industry was estimated based on data from CAREX Finland (2007), CAREX Spain (2004) and CAREX Italy (2000–2003) (average of the three countries) and statistical information on European workforce (Eurostat; 2007), also considering data from CAREX EU (1993). CAREX is an information system for occupational exposure to carcinogens that contains estimates of exposure prevalence and numbers of exposed workers (Kauppinen et al. 2000; EU-OSHA 2014). CAREX EU includes estimates for 55 industries in 15 Member States but is unfortunately not updated since mid-1990s. There are more recent national versions of CAREX available e.g., in Canada (CAREX Canada).

The intensity of exposure by industry was assessed based on published scientific literature, information retrieved from the industry, and estimates of the Finnish job-exposure matrix FINJEM. The assessment also considered temporal changes in the exposure levels arising from general improvements of work environments and processes, without the impact of the intended changes in CMRD, based on RCS-specific literature and the general review by Creely et al. (2007). The literature search was not described in further detail.

Benzene

In the process of updating the benzene BOELV under the CMRD (2004/37/EC), an impact assessment was carried out in 2019 (EC 2019). For assessing the current levels of occupational exposure, the study used the reviews of ECHA (2018a) and IARC (2018) as the primary sources of exposure data, supplemented by a further literature review and company data obtained from a stakeholder consultation and from a parallel industry-led impact assessment by Triskelion (2019). The literature search was not described in further detail. It appears from the report that exposure data were also extracted from the French exposure databases COLCHIC and SCOLA for years 2014–2018. Also, Chemical Safety Reports (CSRs) containing mainly modelled exposure data were reviewed but not considered further as measurement data were available from other sources.

COLCHIC and SCOLA seem to be the only exposure measurement databases where data were extracted directly for the purposes of the assessment. In addition, the study cited the publication of Scarselli et al. (2011), which summarizes exposure measurement data for benzene in the Italian SIREP database for years 1996–2007, and two publications that summarize data from the German MEGA database for years 1998–2002 and 2009 (DGUV 2007; BGIA 2009).

The method for deriving the final exposure estimates per industry sector was not described in detail. It seems from the report that the dataset assessed (by expert-judgment) to be the most comprehensive and presentative was used to derive the exposure estimate for each industry sector, rather than aggregating all the available data per industry.

Number of exposed workers was estimated based on industry estimates received in the stakeholder consultation and the Triskelion (2019) study, and the statistical data of Eurostat (2016). Estimates of exposed workers from CAREX EU (1993/1997), CAREX Canada (2016), Finnish ASA register (2014), Italian SIREP database (Scarselli et al. 2011), and French SUMER survey (Surveillance Médicale des Expositions des salariés aux Risques professionnels) (Vinck & Memmi 2013), were also cited but their data were not used for the final assessment.

Cobalt and its compounds

An impact assessment on five cobalt salts was carried out in relation to a restriction proposal under the REACH Regulation (1907/2006/EC) in 2018 (ECHA 2018b). Assessment of current exposure levels by industry sector was based on exposure estimates provided in the registration dossier (i.e., CSRs) of the compounds (considering measured breaching zone concentrations, duration of activities, and the potential use of respiratory protection). The report pointed out that there was no verification on the exposure levels presented in the CSRs, and for certain the activities the number of measurement data were low and/or modelling data were used instead of measurement data.

Literature data on occupational exposure to cobalt salts were found to be scarce. Several Members States (incl. Norway) (FI, SE, NO, SL, FR, GE) provided exposure measurement data on cobalt during the stakeholder consultation. As these data were on cobalt in general, and not specifically on the five cobalt salts, they were not used as such for the assessment of exposure levels. It was, however, checked that the exposure estimates provided in the CSRs did not significantly deviate from the general data on cobalt provided by the Member States. Estimates on the number of exposed workers per industry sector were received from the industry. The report noted that these estimates were based on limited data and could not be verified.

In their opinion on the cobalt salt restriction, the ECHA Risk Assessment Committee (RAC) pointed out the need to set a BOELV for cobalt and its compounds under the CMRD (2004/37/EC) (ECHA 2020). A draft version of the background documentation for a BOELV on cobalt and inorganic cobalt compounds was published in 2022 (ECHA 2022), and the Commission decided to drop the cobalt salt restriction. An impact assessment on cobalt BOELV was not available at the time of writing. The occupational exposure data reviewed in the draft BOELV background documentation included the data provided in the CSRs of cobalt and cobalt compounds, the data provided by the Members States during the stakeholder consultation for the restriction process, the publication of Scarselli et al. (2020), summarising measurement data on cobalt in the Italian SIREP database for years 1996–2006, two publications of FIOH (2019; 2021), summarizing measurement data on cobalt in the Finnish Register of Occupational Hygiene Measurements for 2008–2019 and in the Biomonitoring Database for 1979–2018 and 2012–2019, and a few scientific publications on occupational exposure to cobalt. Methodological information on the literature search was not provided.

Comparison of utilised data with available data

Table 3 summarizes the data used for the assessment of exposure levels and number of exposed workers by industry sector in the impact assessments of RCS, benzene, and cobalt and its compounds.

The impact assessment of RCS did not consider the large European national exposure measurement databases which could be a relevant source of additional data on current exposure levels (Table 1). More than 48 000 exposure measurement datapoints for RCS for the latest years were identified in a sample of five European databases (Table 4). There are also several relatively recent publications summarising the available data on RCS in SCOLA (2016–2020), FIOH database (2006–2017), MEGA (2005–2016) and SIREP (1996–2012) (INRS 20201; Tuomi et al. 2018; IFA/DGUV 2022; Scarselli et al. 2014; see Table A1-3).

The impact assessment of benzene utilised data extracted from COLCHIC and SCOLA, and publications summarising the data in SIREP (1996–2007) (Scarselli et al. 2011) and MEGA (1998–2002 and 2009) (DGUV 2007; BGIA 2009). There would, however, be additional, and more recent, exposure measurement data available in the national databases that could be considered in the future assessments. More than 10 000 datapoints for workplace air measurements of benzene for the latest years were identified in the sample databases (Table 4).

The impact assessment of cobalt salts was relying on industry data, although the uncertainties related to the data were recognised. The forthcoming impact assessment on cobalt BOELV is encouraged to consider all the data presented in the draft BOELV background documentation and to inquire additional data from the national databases. More than 5000 datapoints for workplace air measurements of cobalt were identified in the sample databases for the latest years (Table 4).

The estimates on the number of exposed workers in the reviewed impact assessments were primarily based on data retrieved from industry, complemented with statistical information on the European workforce from Eurostat. Data from the national registers on workers exposed to carcinogens (Table 2), and potentially also JEM data, might be usable to complement and verify the industry-retrieved data. Also, the ongoing WES project is expected to provide information on the prevalence of the current occupational exposure to RCS and benzene in Europe, as well as to other carcinogens. RCS will also be addressed in the EPHOR project.

As a general note, the strategies and data sources used for the exposure assessment in the reviewed impact assessments were not systematically described, and deviated between the assessments. It would be useful to have guidelines presenting the primary data sources to be used for the assessment of exposure levels and the number of exposed workers per industry, also including guidelines for the review of open literature (e.g., search terms and reference databases to be used). A common approach would

increase coherence and equality between the impact assessments and diminish assessor-related discrepancies. To allow for evaluation of the assessments, it would be important to describe the methods used for the data retrieval and exposure assessment in sufficient detail in the assessment documents.

Table 3. Data sources used for assessment of exposure levels and number of exposed workers in the regulatory impact assessments of respirable crystalline silica, benzene and cobalt.

	Respirable crystalline silica	**Benzene**	**Cobalt***
Exposure levels	• scientific literature • industry data • FINJEM	• industry data • data extracted from COLCHIC and SCOLA • publications summarising SIREP and MEGA data • scientific literature	• industry data • (measurement data provided by the Member States**) • (publications summarising SIREP and FIOH data) • (scientific literature)
Number of exposed workers	• CAREX • Eurostat	• industry data • Eurostat	• industry data

* Data utilised for the impact assessment of the cobalt salt restriction listed without parenthesis. Additional data included in the draft BOELV background documentation for cobalt and inorganic cobalt compounds listed in parenthesis. ** France (2007–2017); Slovakia (specific process), Germany (technical rules, "other" sources). In the restriction report, also data from Finland (2004–2007), Norway (1990–1997), and Sweden are mentioned.

Table 4. Approximate number of samples (measurement data points) for respirable crystalline silica (RCS), benzene and cobalt in a sample of European exposure measurement databases for the latest years.

Database	Years	Number of measurement data points			Reference
		RCS	Benzene	Cobalt	
SIREP	2017–21	7000	9000	2500	database management (personal communication)
MEGA	2017–21	5000	1000	2600*	database management (personal communication)
COLCHIC	2017–21	1200	250	220	Solvex webtool
SCOLA	2016–20	35000	na	na	INRS 2021
FIOH	2016–19	500	100**	230***	FIOH 2021
Total		48700	10350	5550	

* Cobalt in inhalable dust; additionally, 2300 respirable dust samples (2017–21). ** Additionally, 700 biomonitoring samples (S-phenylmercapturic acid in urine) (2018–22). *** Additionally, 1500 biomonitoring samples (cobalt in urine) (2016–19).

Discussion and future perspectives

Data on occupational carcinogen exposure are produced in several recent and ongoing European research projects. For example, the HBM4EU project provided data on occupational carcinogen exposure e.g., in electroplating, welding and E-waste management, and the PARC project is expected to provide corresponding data for waste management and health care sector. There are also several recent and ongoing national research projects addressing occupational carcinogen exposure in Europe. These studies usually make their results available by publishing aggregated data in research reports and scientific articles accessible through biomedical reference databases.

Although the research projects produce valuable data, the selection of carcinogens included in the studies, as well as the number of measurement data points, are usually small in comparison with the data available in the national exposure measurement

databases. Therefore, improving accessibility of the large number of up-to-date exposure measurement data in the national databases would be of great importance for priority setting and regulation of carcinogens.

In order to increase the accessibility of occupational exposure measurement data, EU-OSHA and JRC are mapping the possibility to add a new module for occupational exposure data (airborne concentrations) in the IPCheM, and to include some of the data from the national databases in this new database. We strongly support this initiative; having a common freely accessible occupational exposure database, even if limited in the detailedness of the data in comparison with the national databases, would aid to gain an overview on the current levels of occupational carcinogen exposure in the Europe. This would be valuable both for priority setting and for regulatory impact assessment. It would also be beneficial to have the new database under IPCheM, an already established data portal with continued support and maintenance.

Although a common European exposure measurement database received support in our survey, several respondents also considered that formatting the measurement and contextual data into the required format is likely to be too time/resource consuming to make a common database to be a generally feasible option for sharing exposure data. To increase its feasibility, delivering the data should be included, and the work funded, as an integral part of the research projects producing new exposure measurement data (as is currently the case with EU funded research projects yielding new human biomonitoring data which are required to be delivered to IPCheM). This would require the funding sources to recognise and acknowledge the increased impact the funded exposure research would have if the measurement data produced were included in a widely recognised and applied database, and to accept this work as a part of the project funding, or even demand the delivery of the data as a condition for funding. Also, a part of the database owners indicated the need for separate funding to be able to carry out the work needed for delivering the data from the national databases. Apart from the question on resources, the respondents also identified other challenges which need to be tackled, including the questions on data ownership and data protection, and the deviating ways of collecting and reporting the data (e.g., varying measurement strategies, methods, and coding systems used for occupational activities).

Since delivering measurement data to IPCheM, or another common database, is not a feasible option for all the research projects and national databases, at least in a short term, it is worth to consider also other means of improving the accessibility of the available data. A common platform for sharing general information (metadata) on the research projects and available databases would increase awareness on the available data. This option received also support in our survey. Also, the initiatives for more formal research registers/inventories in the field of exposure research, such as the OccupationalCohorts.net (Kogevinas et al. 2021) and the HBM Global Registry Framework (Zare Jeddi et al. 2021), are strongly supported.

Since a majority of the available data lie in the national databases, improving their accessibility would be of great importance. This could be done e.g., by webtools that allow for retrieving aggregated data, such as the Solvex webtool for COLCHIC data, or by regularly publishing (substance-based) overviews of the data, as is done for MEGA, SCOLA, and to some extent also for SIREP and FIOH databases. The freely accessible and downloadable data compilation in the FIOH's Work-life knowledge service is an example of improving data accessibly by sharing aggregated data in an easy-to-use visual format (Figure 2).

Our case study highlighted the deviating strategies and sources for exposure data in the regulatory impact assessments. There is an evident need for harmonisation and guidelines to ensure that all relevant data would be utilised in the assessments, and to increase coherence and equality between different assessments. The recent impact assessments largely rely on industry data for the assessment of exposure levels and number of exposed workers. Although industry-owned data received in stakeholder consultations are a valuable data source, it would be important to compare and complement these data which data from public data sources, such as the national databases. It should also be noted that the industry, although in most cases well-intentioned, may have vested interests as it comes to changes in regulation that may cause additional costs or investment needs. The Member States are encouraged to aid the regulatory work by supplying up-to-date exposure data, and data on the number of exposed workers, if available, from the national databases in the stakeholder consultations.

The survey respondents also noted a shift of carcinogen exposure from larger industrial companies to smaller companies, often in the service sector. This shift, relating mainly to outsourcing of specific activities, should be taken into consideration when planning new research projects and measurement campaigns. As indicated above, a majority of the exposure measurement data available in the national databases are currently based on measurements in larger companies. Also, increasing the competence of labour inspectors in the field of exposure assessment and chemical safety was seen as an important measure since they are in contact also with the smaller companies and could thereby provide valuable support.

Although the focus of present study was on advancing the achievability and use of exposure measurement data, the important role exposure modelling has in complementing the available measurement data should also be recognised and the need for further development of exposure models and tools considered as one of the primary focus areas in future exposure research (see e.g., Schlüter et al. 2022).

The respondents also expressed a wish for a more global view on occupational cancer prevention in general, with joint research efforts and global funding to tackle cancer due to occupational exposures. Even within the Europe, there was experiences on administrative obstacles in the collaboration between the EU and non-EU countries.

Figure 2. Example of visualization of FIOH measurement data in the Work-life knowledge service. The aggregated data are also downloadable from the website.

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Appendix 1: Reported (national) research projects and publications

Table A1-1. Recent/ongoing (national) research projects providing measurement data on inhalation exposure (airborne concentrations) or biomonitoring data on occupational carcinogen exposure.

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
MAPA Asbest	asbestos	ongoing		TNO	The Netherlands	Dutch ministry of social affairs and work
Development of safety of asbestos removal work and related measurement practices	asbestos	2019	https://www.julkari.fi/handle/10024/138158	Finnish Institute of Occupational Health	Finland	Finnish Work Environment Fund
Perceived and measured hazards in Finnish museum work environment	asbestos, arsenic, crystalline silica, PCBs, PAHs, formaldehyde, cadmium, lindane, DDT	2023	https://www.ttl.fi/en/research/projects/perceived-and-measured-hazards-finnish-museum-work-environments-muha	Finnish Institute of Occupational Health	Finland	Finnish Work Environment Fund

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
Particles and noise in sustainable mining environment	asbestos, diesel exhaust (elemental carbon), PAHs, arsenic, cobalt	2016	https://www.julkari.fi/handle/10024/130135	Finnish Institute of Occupational Health	Finland	Business Finland
Transport Personnel Health Collaboration (TRAPHEAC)	carcinogens relevant for professional driving	2026	The project aims at assessing the impact of technological innovation in PT on the bus drivers' health in two countries with different socioeconomic and geopolitical contexts: Belarus and Switzerland, by focusing on the common health outcomes, cardiovascular diseases (CVD) and cancers.	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland	to be confirmed
Work-related exposure to harmful substances in circular economy	cobalt, nickel compounds, cadmium, beryllium, aflatoxins, PCBs	2023	https://www.ttl.fi/en/research/projects/work-related-exposure-harmful-substances-circular-economy-hakita	Finnish Institute of Occupational Health	Finland	Finnish Work Environment Fund

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
Exposure to and management of quartz dust in construction work	crystalline silica	2022 (ongoing)	https://www.ttl.fi/en/research/projects/exposure-and-management-quartz-construction	Finnish Institute of Occupational Health	Finland	Finnish Work Environment Fund, Finnish Construction Trade Union, Confederation of Finnish Construction Industries RT
Stofvrij werken [Dust-free working]	crystalline silica	2016	https://stofvrijwerken.tno.nl/	TNO	The Netherlands	ZonMW
Building an EC-JEM	diesel exhaust (elemental carbon)	2020		Karolinska Institutet	Sweden	FORTE
Swiss workers occupational exposure to endocrine disruptors	DEHP	2024		Unisanté	Switzerland	

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
BIOTRACK: Health Effects of Occupational Exposure to Combustion Particles - a Study on Volunteers Performing as Train Conductors	diesel exhaust (particles)	2019	https://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-019-0306-4; https://pubmed.ncbi.nlm.nih.gov/30917278/	National Research Centre for the Working Environment	Denmark	Danish Centre for Nanosafety II
GenFA - Occupational exposure to formaldehyde. Genotoxic damage and susceptibility evaluation in pathology anatomy laboratory workers	formaldehyde	2013		National Health Institute	Portugal	Fundação para a Ciência e a Tecnologia
BIOJET: Occupational exposure and markers of genetic damage, systemic inflammation and lung function: a Danish cross-sectional study among air force personnel.	jet engine particles, jet fuel, PAHs	2020	PMID: 34504215 https://pubmed.ncbi.nlm.nih.gov/34504215/	National Research Centre for the Working Environment	Denmark	Danish Centre for Nanosafety II

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
MGU (Messsystem Gefährdungsermittlung der Unfallversicherungsträger)	multiple	ongoing	https://www.dguv.de/medien/ifa/de/pub/grl/pdf/2010_002.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany	
BioFirEx - A panel of (bio)markers for the surveillance of firefighter's health and safety	multiple (e.g., PAHs, particles)	2023	https://www.isep.ipp.pt/PAGE/VIEWPAGE/BioFirExPaginaPrincipal	National Health Institute	Portugal	Fundação para a Ciência e a Tecnologia (FCT), Ministério da Ciência, Tecnologia e Ensino Superior (MCTES) and national funds

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
OxiGenoCOM: oil mists, from exposure determinants to early effects markers	oil mists (PAHs, metals)	ongoing		Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland	
BIOBRAND: A Biomonitoring Study of Firefighters and Recruits Under Education as Smoke Divers	PAHs, combustion particles	2017	PMID: 28877717 PMID: 29045708 PMID: 29761929 https://ipchem.jrc.ec.europa.eu/#showmetadata/BIOBRANDPART1	National Research Centre for the Working Environment	Denmark	Danish Working Environment Research Foundation

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
CERASAFE - Production and use of nanomaterials in the ceramic industry	several nanoparticles (harvested in occupational settings)	2019	https://www.nanosafetycluster.eu/nsc-overview/nsc-structure/steering-group/cerasafe/	National Health Institute	Portugal	FP7 ERA-NET Programme on Nanosafety Safe Implementation of Innovative Nanoscience and Nanotechnology (SIINN)
Second-hand smoking in bars and restaurants from Lisbon area: effects on workers' health	tobacco smoke	2013 (some work still ongoing)		National Health Institute	Portugal	Calouste Gulbenkian Foundation and Ministry of Health

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
Wood dust and new binding limit values – can the provision of information have an impact on exposure and working conditions?	wood dust	2022 (ongoing)	https://www.ttl.fi/en/research/projects/wood-dust-and-new-binding-limit-values-can-provision-information-have-impact-exposure-and-working	Finnish Institute of Occupational Health	Finland	Finnish Work Environment Fund, Industrial Union, participating companies

Table A1-2. Recent/ongoing (national) research projects addressing occupational carcinogen exposure without providing new exposure measurement data.

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
Glyphosate rationalisation strategy and health risk assessment	glyphosate	2021	https://eojn.nn.hr/SPIN/application/ipn/DocumentManagement/DokumentPodaciFrm.aspx?id=4338087 (public procurement data)	Andrija Štampar Teaching Institute of Public Health	Croatia	Ministry of agriculture
Nesting occupational epidemiology into Swiss public health studies	metals	ongoing	https://www.unisante.ch/fr/formation-recherche/recherche/projets-etudes/nesting-occupational-epidemiology-swiss-public-health	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland	SECO, Swiss School of public health
Belgian Occupational Cancer database (BOCCA)	multiple	2024	https://www.komoptegenkanker.be/projecten/belgian-occupational-cancer-bocca-database-om-werkgerelateerde-kankers-op-te-sporen-en-te-voorkomen	KU Leuven, Centre for Environment and Health	Belgium	KOTK

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
Inventory of carcinogen exposure at the workplace	multiple	2014 and 2015	https://www.rivm.nl/bibliotheek/rapporten/2015-0107.pdf; https://www.rivm.nl/bibliotheek/rapporten/2014-0083.pdf	RIVM	The Netherlands	Ministry of SZW
Cost Action Dimopex	multiple (biomarkers of genotoxicity/cancer)	2020	https://www.cost.eu/actions/CA15129/	Center for Primary Care and Public Health, University of Lausanne (Unisanté)	Switzerland	EU
Towards monitoring cancer risk according to occupation in Romanian Switzerland	multiple	ongoing		Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland	Swiss national cohort, Swiss cancer league

Project title	Carcinogen(s) addressed	Year of completion	Website/link to further information (if available)	Organisation	Country	Funding source(s)
A sustainable new working life-trends, health effects and governance	multiple	2023	https://ki.se/en/imm/a-sustainable-new-working-life-sustainable-work	Institute of Environmental Medicine, Karolinska Institutet	Sweden	FORTE
ECEL library of risk management measures	multiple	2021	https://diamonds.tno.nl/info/46	TNO	The Netherlands	CEFIC
BROWSE	pesticides, multiple	2014	https://cordis.europa.eu/project/id/265307/reporting	TNO	The Netherlands	EU
B16 (validation of dermal exposure estimates)	pesticides, multiple	2016	http://cefic-lri.org/projects/b16-tno-external-validation-of-tier-1-workers-dermal-exposure-estimates-in-ecetoc-tra/	TNO	The Netherlands	CEFIC LRI
Reanalysis of TiO2 human data (RealyTi)	titanium dioxide	ongoing		Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland	

Table A1-3. Recent publications providing measurement data on inhalation exposure (airborne concentrations) or biomonitoring data on occupational carcinogen exposure.

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
MEGA-Auswertungen zur Exposition gegenüber 1,3-Butadie	1,3-butadiene	2014	https://www.dguv.de/medien/ifa/de/gestis/mega/1_3_butadien.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Appraisal of levels and patterns of occupational exposure to 1,3-butadiene	1,3-butadiene	2017	https://pubmed.ncbi.nlm.nih.gov/28489219/	Italian Workers' Compensation Authority	Italy
MEGA evaluations on exposure to 2-butanone oxime	2-butanone oxime	2013	https://www.dguv.de/medien/ifa/en/fac/reach/mega_auswertungen/butanonoxim_en.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
DGUV Information 213-714 Manuelles Kolbenlöten mit bleihaltigen Lotlegierungen in der Elektro- und Elektronikindustrie	acetic aldehyde, formaldehyde	2018	https://publikationen.dguv.de/widgets/pdf/download/article/553	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
MEGA evaluations for the preparation of REACH exposure scenarios for aniline	aniline	2013	https://www.dguv.de/medien/ifa/en/fac/reach/mega_auswertungen/anilin_en.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
MEGA-Auswertungen zur Erstellung von REACH-Expositionsszenarien für Diantimontrioxid sowie Antimon und seine Verbindungen außer Antimonwasserstoff	antimony, antimony trioxide	2017	https://www.dguv.de/medien/ifa/de/fac/reach/mega_auswertungen/antimon.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Evaluating Antineoplastic Agents and Occupational Exposures Among Italian Workers Using SIREP Surveillance System	antineoplastic agents	2019	https://pubmed.ncbi.nlm.nih.gov/31348426/	Italian Workers' Compensation Authority	Italy
BK-Report 1/2019: Aromatische Amine - Eine Arbeitshilfe in Berufskrankheiten-Feststellungsverfahren	aromatic amines	2019	https://www.dguv.de/ifa/publikationen/reports-download/reports-2019/bk-report-1-2019/index.jsp	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
MEGA-Auswertungen zur Expositionssituation gegenüber Arsenverbindungen (außer Arsin) in der einatembaren Staubfraktion an	arsenic	2017	https://www.dguv.de/medien/ifa/de/fac/reach/mega_auswertungen/arsen.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Arbeitsplätzen in Deutschland					
Metal exposure of workers during recycling of electronic waste: a cross-sectional study in sheltered workshops in Germany	arsenic, beryllium, cadmium, hexavalent chromium, cobalt, nickel compounds	2021	https://doi.org/10.1007/s00420-021-01651-9	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Occupational asbestos exposure after the ban: a job exposure matrix developed in Italy	asbestos	2020	https://pubmed.ncbi.nlm.nih.gov/32747928/	Italian Workers' Compensation Authority	Italy
Occupational exposure in the removal and disposal of asbestos-containing materials in Italy	asbestos	2016	https://pubmed.ncbi.nlm.nih.gov/26970752/	Italian Workers' Compensation Authority	Italy
A scoping review of technologies and their applicability for exposome-based risk assessment in the oil and gas industry	benzene	2021	https://academic.oup.com/annweh/article/65/9/1011/6314667?login=true	Cyprus University of Technology	Cyprus
Benzol - Messungen in verschiedenen	benzene	2015	https://www.dguv.de/medien/ifa/de/pu	Institute for Occupational Safety and Health of the	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Arbeitsbereichen mit Bezug zur Toleranz- und Akzeptanzkonzentration nach TRGS 910			b/grl/pdf/2015_134.pdf	German Social Accident Insurance (IFA)	
BK-Report 1/2022: Ermittlung der Benzo[a]pyren-Dosis (BaP-Jahre)	benzo(a)pyrene	2022	https://www.dguv.de/ifa/publikationen/reports-download/reports-2022/bk-report-1-2022/index.jsp	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Beryllium im Urin als Indikator einer beruflichen Berylliumbelastung	beryllium	2018	https://www.dguv.de/medien/ifa/de/pub/grl/pdf/2018_043.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
MEGA-Auswertungen zur Expositionssituation gegenüber Beryllium und seine Verbindungen ind er einatembaren Staubfraktion an Arbeitsplätzenin Deutschland	beryllium	2017	https://www.dguv.de/medien/ifa/de/fac/reach/mega_auswertungen/beryllium_und_seine_verbindungen.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Estimating cobalt exposure in respirable dust from cobalt in inhalable dust	cobalt	2022	https://pubmed.ncbi.nlm.nih.gov/35378420/	Institute for Occupational Safety and Health of the	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
				German Social Accident Insurance (IFA)	
Kobolttialtistuminen Suomessa 1979-2018: Biomonitoroinnin tilasto [Cobalt exposure in Finland 1979-2018: Biomonitoring statistics]	cobalt	2019	https://www.julkari.fi/handle/10024/138342	Finnish Institute of Occupational Health	Finland
Assessment of exposure to cobalt and its compounds in Italian industrial settings	cobalt	2020	https://pubmed.ncbi.nlm.nih.gov/32096770/	Italian Workers' Compensation Authority	Italy
Evaluation of workplace exposure to respirable crystalline silica in Italy	crystalline silica	2014	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4164880/	Italian Workers' Compensation Authority	Italy
Pölyntorjunta betoniteollisuudessa [Controllling dust exposure in concrete industry]	crystalline silica	2012	https://www.julkari.fi/handle/10024/134929	Finnish Institute of Occupational Health	Finland
Quarzexpositionen am Arbeitsplatz: Arbeitsbedingte Exposition gegenüber Quarz (Siliziumdioxid kristallin) in der alveolengängigen Staubfraktion	crystalline silica	2022	https://publikationen.dguv.de/forschung/ifa/ifa-report/4601/ifa-report-03/2022-quarzexpositionen-	German Social Accident Insurance (DGUV)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
			am-arbeitsplatz-arbeitsbedingte-exposition-gegenueber-quarz		
Exposure to quartz in Finnish workplaces declined during the first six years after the signing of the NEPSI agreement, but evened out between 2013 and 2017	crystalline silica	2018	https://pubmed.ncbi.nlm.nih.gov/29751545/	Finnish Institute of Occupational Health	Finland
Occupational exposure to respirable dust, respirable crystalline silica and diesel engine exhaust emissions in the London tunnelling environment	crystalline silica; diesel exhaust	2015	https://academic.oup.com/annweh/article/60/2/263/2196138?login=true	IOM	UK
A historical job-exposure matrix for occu-pational exposure to diesel exhaust using elemental carbon as an indicator of expo-sure	diesel exhaust	2020	https://pubmed-ncbi-nlm-nih-gov.proxy.kib.ki.se/31368419/	Karolinska Institutet	Sweden
MGU-Messprogramm 9178 "Abgase von Dieselmotoren"	diesel exhaust	2020	https://www.dguv.de/medien/ifa/de/pu	Institute for Occupational Safety and Health of the	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
am Arbeitsplatz - Teil 2: Ergebnisse			b/grl/pdf/grl_2020_003.pdf	German Social Accident Insurance (IFA)	
Exposition gegenüber Dieselmotor-Emissionen (DME, Kohlenstoff elementar) und Dieselmotor-Emissionen (DME, Gesamtkohlenstoff) in der Transport- und Verkehrswirtschaft sowie der Abfallwirtschaft	diesel exhaust	2013	https://www.dguv.de/medien/ifa/de/gestis/mega/dme_auswertung.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Health effects of exposure to diesel exhaust in diesel-powered trains	diesel exhaust (particles)	2019	https://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-019-0306-4	National Research Centre for the Working Environment	Denmark
Occupational exposures to disinfectants and pre-diabetes status among active nurses in Cyprus	disinfection products	2019	https://www.jstor.org/stable/26787327	Cyprus University of Technology	Cyprus
Carbonfasern und carbonfaserverstärkte Kunststoffe (CFK) Teil 1: Charakterisierung,	fibres	2019	https://www.dguv.de/medien/ifa/de/pub/grl/pdf/2019_124.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Exposition, Bewertung und Schutzmaßnahmen					
BK-Report 1/2013: Faserjahre	fibres	2013	https://www.dguv.de/ifa/publikationen/reports-download/reports-2013/bk-report-1-2013/index.jsp	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
National Estimates of Exposure to Formaldehyde in Italian Workplaces	formaldehyde	2017	https://academic.oup.com/annweh/article/61/1/33/2762730?login=true	Italian Workers' Compensation Authority	Italy
Occupational exposure to formaldehyde and early biomarkers of cancer risk, immunotoxicity and susceptibility	formaldehyde	2020	https://doi.org/10.1016/j.jhazmat.2019.121179	National Health Institute	Portugal
Increased levels of chromosomal aberrations and DNA damage in a group of workers exposed to formaldehyde	formaldehyde	2015	https://doi.org/10.1093/mutage/gev002	National Health Institute	Portugal
Ergebnisse von Formaldehydmessungen -	formaldehyde	2020	DGUV Fachgespräch	Institute for Occupational Safety and Health of the	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Verfahrenstechnische und organisatorische Optimierungsmöglichkeiten			"Reduzierung der Formaldehydbelastung", Oktober 2016	German Social Accident Insurance (IFA)	
Expositionsermittlungen in Pathologien von 2016 bis 2019 - Schwerpunkt Formaldehyd	formaldehyde	2020	https://www.dguv.de/medien/ifa/de/gestis/mega/grdl-80-2020.9-s.-349-360-wegscheider-et-al-expositionsermittlungen-in-pathologien-von-2016-bis-2019-schwerpunkt-formaldehyd.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Comparison of formaldehyde exposure measurements stored in French and German databases	formaldehyde	2015	https://www.dguv.de/medien/ifa/de/pub/grl/pdf/2015_066.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
MEGA-Auswertungen zur Erstellung von REACH-Expositionsszenarien für Formaldehyd	formaldehyde	2013	https://www.dguv.de/medien/ifa/de/fac/reach/mega_auswertungen/formaldehyd.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Genotoxic effects of occupational exposure to lead and influence of polymorphisms in genes involved in lead toxicokinetics and in DNA repair	heavy metals (e.g., lead)	2012	https://doi.org/10.1016/j.envint.2012.03.001	National Health Institute	Portugal
Determinants of exposure to hexavalent chromium in plating, welding and other occupational settings	hexavalent chromium	2022	https://doi.org/10.3390/ijerph19063683	National Health Institute	Portugal
Airborne exposure to inhalable hexavalent chromium in welders and other occupations: Estimates from the German MEGA database	hexavalent chromium	2015	https://pubmed.ncbi.nlm.nih.gov/25979374/	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Systematic review of biomonitoring data on occupational exposure to hexavalent chromium	hexavalent chromium	2021	https://www.sciencedirect.com/science/article/abs/pii/S1438463921001140?via%3Dihub	KU Leuven, Centre for Environment and Health	Belgium
DGUV Information 213-716: Galvanotechnik und	hexavalent chromium,	2021	https://publikationen.dguv.de/widgets/	Institute for Occupational Safety and Health of the	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Eloxieren - Empfehlungen Gefährdungsermittlung der Unfallversicherungsträger (EGU) nach der Gefahrstoffverordnung	nickel compounds		pdf/download/article/554	German Social Accident Insurance (IFA)	
Levels and predictors of airborne and internal exposure to chromium and nickel among welders - Results of the WELDOX study	hexavalent chromium, nickel compounds	2013	https://pubmed.ncbi.nlm.nih.gov/22926021/	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Analysis of inflammatory markers and metals in nasal lavage fluid of welders	hexavalent chromium, nickel compounds, welding fumes	2016	https://pubmed.ncbi.nlm.nih.gov/27924706/	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Reduction in welding fume and metal exposure of stainless steel welders: an example from the WELDOX study	hexavalent chromium, nickel compounds, welding fumes	2014	https://pubmed.ncbi.nlm.nih.gov/23719851/	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
MEGA-Auswertungen zur Exposition gegenüber den	isocyanates	2021	https://www.dguv.de/medien/ifa/de/ge	Institute for Occupational Safety and Health of the	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Diisocyanaten HDI, IPDI, MDI und TDI sowie dem Gesamt-NCO-Gehalt (TRIG) an deutschen Arbeitsplätzen			stis/mega/isocyanate-onlinebericht-final.pdf	German Social Accident Insurance (IFA)	
MEGA-Auswertungen zur Erstellung von REACH-Expositionsszenarien für 2,4-Diisocyanattoluol (2,4-TDI) und 2,6-Diisocyanattoluol (2,6-TDI)	isocyanates	2013	https://www.dguv.de/medien/ifa/de/fac/reach/mega_auswertungen/24_tdi_26_tdi.pdf	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Occupational exposure and markers of genetic damage, systemic inflammation and lung function: a Danish cross-sectional study among air force personnel	jet engine particles, jet engine fuel, PAHs	2021	https://www.nature.com/articles/s41598-021-97382-5	National Research Centre for the Working Environment	Denmark
Early Effect Markers and Exposure Determinants of Metalworking Fluids Among Metal Industry Workers: Protocol for a Field Study	metal working fluids	2019	https://pubmed.ncbi.nlm.nih.gov/31376276/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Biomonitoring of several toxic metal (loid) s in different biological matrices	metals (e.g., arsenic, cadmium)	2014	https://doi.org/10.1007/s10653-013-9562-7	National Health Institute	Portugal

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
from environmentally and occupationally exposed populations from Panasqueira mine area, Portugal					
Gender differences in occupational exposure to carcinogens among Italian workers	multiple	2018	https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-5332-x	Italian Workers' Compensation Authority	Italy
Work environment exposure measurements (2016-2019)	multiple	2022	https://www.tyoelamatieto.fi/en/dashboards/lims-exp	Finnish Institute of Occupational Health	Finland
Työympäristön altistumismittaukset 2008-2019 [Work environment exposure measurements 2008-2019]	multiple	2021	https://www.julkari.fi/handle/10024/143799	Finnish Institute of Occupational Health	Finland
Extraction base de données Scola: Rapport d'activité pour la période 2016 à 2020	multiple (e.g., ceramic fibres, cadmium, crystalline silica,	2021		The French National Research and Safety Institute for the Prevention of Occupational accidents and Diseases (INRS)	France

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
	hexavalent chromium)				
Comparing the Advanced REACH Tool's (ART) Estimates With Switzerland's Occupational Exposure Data	multiple (e.g., wood/stone dust)	2017	https://pubmed.ncbi.nlm.nih.gov/29028254/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
From nano to micrometer size particles – A characterization of airborne cement particles during construction activities	nanoparticles, titanium dioxide	2020	https://doi.org/10.1016/j.jhazmat.2020.122838	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
BK-Report 1/2021: Nickel und seine Verbindungen	nickel compounds	2021	https://publikationen.dguv.de/versicherungleistungen/berufskrankheiten/4417/nickel-und-seine-verbindungen-bk-report-1/2021	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Estimating nickel exposure in respirable dust from nickel in inhalable dust	nickel compounds	2021	https://doi.org/10.1016/j.ijheh.2021.113838	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Modelling of occupational exposure to inhalable nickel compounds	nickel compounds	2017	https://pubmed.ncbi.nlm.nih.gov/28098161/	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Nickel compounds in the workplaces: Occupations and activities involving high-risk exposures in Italy	nickel compounds	2018	https://pubmed.ncbi.nlm.nih.gov/30352130/	Italian Workers' Compensation Authority	Italy
Työntekijäkohtaisen altistumisen arviointi ja vähentäminen nikkelityössä [Occupational exposure in production of nickel and copper]	nickel compounds, arsenic	2019	https://www.julkari.fi/handle/10024/138095	Finnish Institute of Occupational Health	Finland
Assessment of polycyclic aromatic hydrocarbon exposure, lung function, systemic inflammation, and genotoxicity in peripheral blood mononuclear cells from firefighters before and after a work shift	PAHs	2018	https://pubmed.ncbi.nlm.nih.gov/29761929/	National Research Centre for the Working Environment	Denmark

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Assessment of work-related exposure to polycyclic aromatic hydrocarbons in Italy	PAHs	2013	https://pubmed.ncbi.nlm.nih.gov/23450729/	Italian Workers' Compensation Authority	Italy
BK-Report 1/2022: Ermittlung der Benzo[a]pyren-Dosis (BaP-Jahre)	PAHs	2022	https://www.dguv.de/ifa/publikationen/reports-download/reports-2022/bk-report-1-2022/index.jsp	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Association between polycyclic aromatic hydrocarbon exposure and peripheral blood mononuclear cell DNA damage in human volunteers during fire extinction exercises	PAHs, olther combustion products	2018	https://academic.oup.com/mutage/article/33/1/105/4553087?login=true	National Research Centre for the Working Environment	Denmark
Firefighters exposure to fire emissions: Impact on levels of biomarkers of exposure to polycyclic aromatic hydrocarbons and genotoxic/oxidative-effects	PAHs, olther combustion products	2020	https://doi.org/10.1016/j.jhazmat.2019.121179	National Health Institute	Portugal

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Particle and metal exposure in Parisian subway: Relationship between exposure biomarkers in air, exhaled breath condensate, and urine	particles (ultafine), metals	2021	https://pubmed.ncbi.nlm.nih.gov/34482160/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Application of the Bayesian spline method to analyze real-time measurements of ultrafine particle concentration in the Parisian subway	particles (ultrafine)	2021	https://www.sciencedirect.com/science/article/pii/S0160412021003986	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
DNA damage and susceptibility assessment in industrial workers exposed to styrene	styrene	2013	https://doi.org/10.1080/15287394.2012.688488	National Health Institute	Portugal
MEGA-Auswertungen zur Erstellung von REACH-Expositionsszenarien für Tetrahydrofuran	tetrahydrofuran	2013	https://publikationen.dguv.de/widgets/pdf/download/article/2840	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
Lung cancer mortality in the French cohort of titanium dioxide workers: some aetiological insights	titanium dioxide	2020	https://oem.bmj.com/content/77/11/795	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Total prohibition of smoking but not partial restriction effectively reduced exposure to tobacco smoke among restaurant workers in Finland	tobacco smoke (nicotine)	2013	https://pubmed.ncbi.nlm.nih.gov/24326912/	Finnish Institute of Occupational Health	Finland
Environmental tobacco smoke in occupational settings: Effect and susceptibility biomarkers in workers from Lisbon restaurants and bars	tobacco smoke, second-hand smoking	2021	https://doi.org/10.3389/fpubh.2021.674142	National Health Institute	Portugal
Polyneuropathie oder Enzephalopathie durch organische Lösungsmittel oder deren Gemische	trichloroethylene, tetrachloroethylene, methylene chloride	2018	https://publikationen.dguv.de/versicherungleistungen/berufskrankheiten/3463/bk-1317-polyneuropathie-oder-enzephalopathie-durch-organische-loesungsmittel-oder-deren-gemische-b	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Modelling of exposure to respirable and inhalable welding fumes at German workplaces	welding fumes	2019	https://pubmed.ncbi.nlm.nih.gov/30625071/	Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)	Germany
The impact of vinyl chloride exposure on the health of Italian workers: an evaluation from SIREP compliance data	vinyl chloride	2021	https://doi.org/10.1080/19338244.2021.1900045	Italian Workers' Compensation Authority	Italy
Workers exposed to wood dust have an increased micronucleus frequency in nasal and buccal cells: results from a pilot study	wood dust	2014	https://pubmed.ncbi.nlm.nih.gov/24603450/	Center for Primary Care and Public Health, University of Lausanne (Unisanté)	Switzerland
Estimating number of workers potentially at risk of exposure to hardwood dust in certain industrial sectors in Italy using a national register	wood dust	2014	https://pubmed.ncbi.nlm.nih.gov/25431980/	Italian Workers' Compensation Authority	Italy

Table A1-4. Recent publications addressing occupational carcinogen exposure without providing exposure measurement data.

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Global Gene Expression Response in Peripheral Blood Cells of Petroleum Workers Exposed to Sub-Ppm Benzene Levels	benzene	2018	https://pubmed.ncbi.nlm.nih.gov/30373255/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Skin Absorption of Bisphenol A and Its Alternatives in Thermal Paper, Annals of Work Exposures and Health	bisphenols	2021	https://doi.org/10.1093/annweh/wxaa095	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Influence of experimental parameters on in vitro human skin permeation of Bisphenol A	bisphenols	2021	https://pubmed.ncbi.nlm.nih.gov/33662515/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Time trends in occupational exposure to chemicals in Sweden: proportion exposed, distribution across demographic and labor market strata, and exposure levels	crystalline silica, welding fumes, wood dust, diesel exhaust, chlorinated solvents	2022	https://pubmed.ncbi.nlm.nih.gov/35696552/	Institute of Environmental Medicine, Karolinska Institutet	Sweden

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Ethanolamines permeate slowly across human skin ex vivo, but cause severe skin irritation at low concentrations	ethanol amines	2019	https://pubmed.ncbi.nlm.nih.gov/31435711/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Respiratory Disease Occupational Biomonitoring Collaborative Project (ROBoCoP): A longitudinal pilot study and implementation research in the Parisian transport company	multiple	2021	https://pubmed.ncbi.nlm.nih.gov/34167564/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Occupational exposure to carcinogenic substances (2010-2019)	multiple	2021	https://www.tyoelamatieto.fi/en/dashboards/exposure-to-carcinogens	Finnish Institute of Occupational Health	Finland
ART, Stoffenmanager, and TRA: A Systematic Comparison of Exposure Estimates Using the TREXMO Translation System	multiple	2017	https://pubmed.ncbi.nlm.nih.gov/29267947/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
TREXMO plus: an advanced self-learning model for occupational exposure assessment.	multiple	2020	https://pubmed.ncbi.nlm.nih.gov/32015431/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Sex-specific risks and trends in lung cancer mortality across occupations and economic activities in Switzerland (1990-2014)	multiple	2020	https://pubmed.ncbi.nlm.nih.gov/32371421/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Biological monitoring of workers exposed to carcinogens using the buccal micronucleus approach: A systematic review and meta-analysis	multiple	2019	https://pubmed.ncbi.nlm.nih.gov/31416572/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Age related micronuclei frequency ranges in buccal and nasal cells in a healthy population	multiple	2020	https://pubmed.ncbi.nlm.nih.gov/31634720/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Characterization of nanoparticles in aerosolized photocatalytic and regular cement	nanoparticles, titanium dioxide	2019	https://www.tandfonline.com/doi/full/10.1080/02786826.2019.1578334	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Polycyclic aromatic hydrocarbons (PAHs) skin permeation rates change with simultaneous exposures to solar ultraviolet radiation (UV-S)	PAHs	2018	https://pubmed.ncbi.nlm.nih.gov/29410274/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland

Publication title	Carcinogen(s) addressed	Year of publication	Website (URL) (if available)	Organisation	Country
Occupational exposure to plant protection products and health effects in Switzerland: what do we know and what do we need to do?	plant protection products	2018	https://pubmed.ncbi.nlm.nih.gov/29698541/	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Carcinogenicity of quinoline, styrene, and styrene-7, 8-oxide	styrene	2018	https://pubmed.ncbi.nlm.nih.gov/29680246/	National Health Institute	Portugal
Airborne nano-TiO2 particles: An innate or environmentally-induced toxicity?	titanium dioxide	2017	https://doi.org/10.1016/j.jphotochem.2017.04.022	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland
Increase in oxidative stress levels following welding fume inhalation: a controlled human exposure study	welding fumes	2016	https://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-016-0143-7	Unisanté, Dept of Occupational and Environmental Health (DSTE)	Switzerland

Appendix 2: Survey on occupational exposure data on chemical carcinogens

An online survey aiming to collect information on recent and ongoing research projects, databases and publications was carried out in April-May 2022. The survey was intended to organisations involved in occupational exposure research or maintaining exposure databases, and was distributed through Roadmap on Carcinogens newsletter and webpage, the mailing list of PEROSH, the mailing list of EU-OSHA's national focal points, and to partners involved in the occupational exposure related activities of the PARC project and certain OECD working groups. The respondents were also asked to distribute the survey to relevant partner organisations. An outline of the survey is presented below.

The survey received responses from 22 organisations in 15 European countries (Austria, Belgium, Croatia, Cyprus, Denmark, Finland, France, Germany, Luxembourg, Portugal, Spain, Sweden, Switzerland, The Netherlands, United Kingdom). In addition, potential data owners from nine additional countries (Czech Republic, Estonia, Hungary, Italy, Latvia, Norway, Poland, Slovak Republic, Romania) were separately contacted.

Finnish Institute of Occupational Health

Survey on occupational exposure data on chemical carcinogens

Reliable exposure data are essential for priority setting and efficient regulation of carcinogens.

This survey aims to collect information on recent and ongoing research projects, databases and publications related to occupational exposure to chemical carcinogens in the Europe, and to map the possibilities for more systematic compilation of these data. The survey is conducted under the Roadmap on Carcinogens Challenge 1.1. Roadmap on Carcinogens is a voluntary action scheme of European organisations to raise awareness and exchange good practices on occupational carcinogen exposure.

The survey is intended to organisations involved in occupational exposure research or maintaining exposure databases. Please feel free to distribute the survey to relevant organisations in your network. The survey will be open **until 6.5.2022**.

In case you have any questions, please do not hesitate to contact us (Piia Taxell, piia.taxell@ttl.fi).

Privacy statement:

The survey may be responded without direct personal data. However, information on organisation and projects is collected. Name and email address of the respondent is collected for those respondents who consent to be contacted to follow up their answers if necessary. This information is kept at the Finnish institute of Occupational Health until the end of 2023, and is not distributed further. The results of the survey will be published on the Roadmap on Carcinogens website. Personal data of the respondents will not be published. The respondents have the right at any time to access and rectify, erasure, or restrict processing of the personal data, or to withdraw the consent. For further information, please read the privacy notice of the Finnish Institute of Occupational Health.

General information *

Institute/organisation: _____

Country: _____

Can we contact you to follow up your answers, if necessary? *

◯ Yes ◯ No

Q1. Has your institute/organisation coordinated or participated in national or multinational research projects producing data on occupational exposure to chemical carcinogens in the past ten years, or are you planning such projects?

If yes, please indicate the projects below (except the EU funded projects HBM4EU, EPHOR or PARC).

☐ Yes, the EU funded projects HBM4EU, EPHOR and/or PARC (no further information needed)

☐ Yes, other national/multinational projects (please indicate the projects below)

☐ No

Project 1

Project title:	
Website/link to further information:	
Year of completion (estimate for ongoing/starting projects):	
Funding source(s):	
Carcinogen(s) addressed (if multiple, separate with a comma):	

Project 1: Type of data produced:

- ☐ measurement data on inhalation exposure/airborne concentrations
- ☐ biomonitoring data
- ☐ measurement data on skin or surface contamination
- ☐ exposure modelling data
- ☐ job-exposure matrices
- ☐ estimates of exposed workforce
- ☐ other (please specify)

Would you like to add another project?

◯ Yes ◯ No

Q2. Does your institute/organisation maintain database(s) containing occupational exposure measurement data on chemical carcinogens or information on exposed workforce (incl. job-exposure matrices)?

If yes, please indicate the databases below.

◯ Yes

◯ No

Database 1

Database title:	
Website/link to further information:	
Years covered:	
Carcinogen(s) included (if multiple, separate with a comma):	

Database 1: Type of data

- [ ] measurement data on inhalation exposure/airborne concentrations
- [ ] biomonitoring data
- [ ] measurement data on skin or surface contamination
- [ ] job-exposure matrices
- [ ] number of exposed workers in the country/region or specific field(s)
- [ ] other (please specify)

Would you like to add another database?

◯ Yes ◯ No

Q3. Has your institute/organisation published data on occupational exposure to chemical carcinogens in the past ten years (e.g., summarizing data of your databases or research projects)?

If yes, please indicate the publications below.

◯ Yes

◯ No

Publication 1

Publication title:

Year of publication:

Website (URL):

Carcinogen(s) addressed:

Publication 1: Type of data

- [ ] measurement data on inhalation exposure/airborne concentrations
- [ ] biomonitoring data
- [ ] measurement data on skin or surface contamination
- [ ] job-exposure matrices
- [ ] number of exposed workers in the country/region or specific field(s)
- [ ] other (please specify)

Would you like to add another publication?

- ◯ Yes
- ◯ No

Q4. To increase the impact of research projects and data compilations in the priority setting and efficient regulation on carcinogens it would be important to ease the access of regulators to the available data. Which of the following your institute/organisation finds as feasible means for sharing the exposure data produced in your research projects and surveys, also considering the time/effort needed for you to enter the data:

- ☐ a common European exposure measurement database where measurement data with contextual information would be added
- ☐ a common European platform where general information on ongoing projects and available databases would be added
- ☐ other (please specify) _____

Q5. Would like to share anything else related to the subject of the survey, or to give feedback? (optional)