Annals of Work Exposures and Health, 2026, **70**, wxaf074
https://doi.org/10.1093/annweh/wxaf074
Advance access publication date: 24 December 2025
Commentary

An introduction to BASIC Guide: human biomonitoring and surveillance of chemical exposure in occupational settings

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Received: August 22, 2025, Accepted: September 12, 2025

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Abstract

Human biomonitoring (HBM) complements air and surface measurements by integrating exposure from all routes and sources, strengthening occupational exposure assessment and control. In occupational settings, HBM can quantify exposure during routine work and nonroutine activities, evaluate controls, investigate incidents (potential overexposures), and support medical surveillance. To use HBM to its full potential, occupational health and safety professionals (OHPs) should adopt harmonized biomonitoring approaches reflecting best practice. This short communication presents the BASIC Guide series (Human Biomonitoring and Surveillance of Chemical Exposure in Occupational Settings), initiated by the International Society of Exposure Science Human Biomonitoring working group (ISES Europe HBM WG) as an integral part of the HBM Global Network. These chemical-specific practical documents operationalize the OECD (Organisation for Economic Co-operation and

Development) occupational biomonitoring guidance, supporting the consistent implementation of exposure biomonitoring programs. Each BASIC Guide provides clear instructions on biomarker selection, sample handling, analytical methods, quality assurance, and result interpretation and communication. By translating international frameworks into actionable protocols, the BASIC Guides improve reproducibility and regulatory alignment in occupational HBM and enable more defensible exposure assessments worldwide.

Keywords: exposure assessment; exposure surveillance; guidance values; occupational biomonitoring; Occupational Biomonitoring Levels (OBLs); occupational health.

Introduction

Human biomonitoring (HBM), also referred to as biological monitoring, is a pivotal methodology for assessing chemical exposure and investigating potential health risks, particularly in occupational settings (Jones 2020). It is the measurement of chemical agents and/or their metabolites, or markers indicative of biological effects, in organisms and biological media such as tissues, cells, or fluids (Heinemeyer et al. 2022). This approach provides a comprehensive and integrated assessment of the internal levels of a chemical, offering valuable insights especially for substances that can enter the body via multiple exposure pathways, including inhalation, dermal absorption, and ingestion. In occupational settings, HBM serves as a complementary approach to external monitoring techniques such as personal air or surface sampling. It can be implemented during routine operations or strategically deployed during high-risk activities (eg, plant maintenance repair or upgrading (industrial plant turnarounds)) or in emergency scenarios like chemical spills. Moreover, HBM plays a critical role in medical surveillance programs and is central to proactive occupational health and disease prevention strategies (WHLGNI 2025). By capturing variability in absorption, distribution, metabolism, and excretion (Hopf et al. 2024), HBM enables a more individualized and accurate exposure assessment than external monitoring alone. This individualized approach enhances risk characterization and supports decision-making in workplace safety and regulatory compliance.

Differences between actual and estimated chemical exposure are influenced by a wide range of factors, including the physicochemical properties of chemicals, their bioavailability, individual susceptibility, routes of exposure, and the intensity, frequency and duration of exposure. Additional determinants include the availability and proper use of personal protective equipment, the implementation of engineering controls, worker behavior, and the specific nature of work tasks and operational procedures (Jones 2020; Hopf et al. 2024). HBM reflects these factors and may, therefore, play a key role in risk assessment and management of chemicals as currently this is not the case in all countries/sectors (Viegas et al. 2020; Hopf et al. 2024).

The effective application of HBM relies heavily on the expertise of occupational health and safety professionals (OHPs) including occupational physicians, industrial hygienists, occupational and environmental health nurses, and exposure scientists with experience in occupational exposures and safety professionals. These professionals must possess a thorough understanding of the work environment, including sources of exposure, control measures, the chemicals used or generated during industrial processes, and worker behaviors that may influence exposure levels. Additionally, there is a need to enable OHPs to stay up to date on the latest research and practices, best biomarkers of exposure, analytical techniques, and updated health-based guidance values to prevent misinterpretation or inappropriate use of biomonitoring data (Manno et al. 2014). Such fundamental knowledge enables accurate communication of biomonitoring results and appropriate responses to the findings (Jones 2020). Recognizing the need for harmonized, high-quality practices, the Organisation for Economic Co-operation and Development (OECD) developed stepwise occupational biomonitoring guidance (OECD 2022). The guidance promotes harmonized practices across countries and sectors, enabling consistent exposure assessments and supporting workplace risk management. This harmonized, methodological framework is explicitly recommended for adoption by OHPs in the design and implementation of biomonitoring programmes for occupational health risk assessment and management. To support its practical adoption, experts affiliated with both the European chapter of the International Society of Exposure Science, Human Biomonitoring working group (ISES Europe HBM Working Group) and HBM Global Network developed the BASIC Guide (Human Biomonitoring and Surveillance of Chemical Exposure in Occupational Settings). BASIC Guides are concise, chemical-specific biomonitoring protocols and best practices built on an earlier initiative on the Biomonitoring Application Data Sheets (BADS) from the EU Project Biological Monitoring of Exposure to Carcinogenic Substances (BIOMONECS) in 2006 (Scheepers 2009). The BIOMONECS effort led to the development of BADS for 15 chemicals that were published by the National Institute of Public Health and the Environment (RIVM) and the Association of Public Health Services (GGD Nederland) in the Netherlands, intended for use in response to chemical incidents (Eggens et al. 2012). These BADS are in the process of being updated and expanded upon by the ISES Europe HBM working group as part of the HBM Global Network in the format of BASIC Guides. Each chemical-specific BASIC Guide

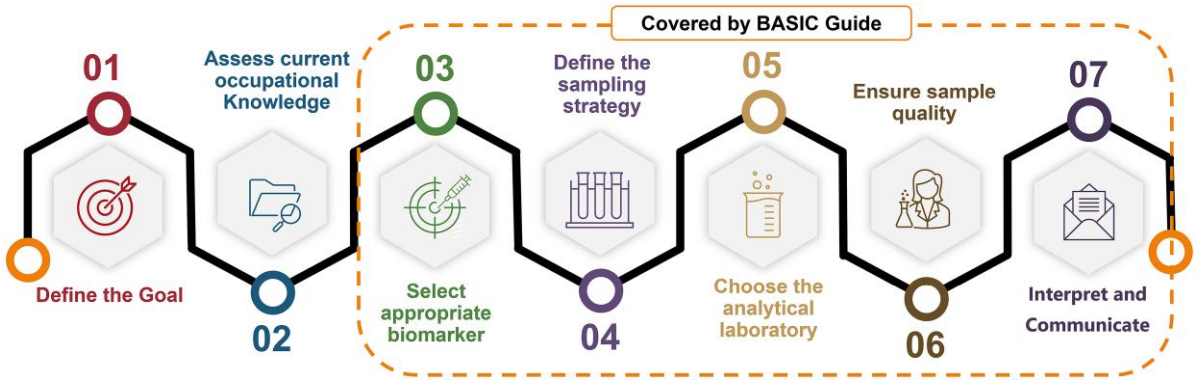

Fig. 1. OECD stepwise approach to set up an occupational biomonitoring program (adopted from Hopf et al. (2024)).

Table 1. Modular structure of the BASIC Guide.

Section	Aim
Biomarker Selection	What to measure
Physico-chemical properties & Kinetics	Why and when it shows up
Matrix & Sample Type	Where to look
Use-Range & Sensitivity	When it is reliable
Sampling Strategy	How to time it
Handling & Storage	How to keep it valid
Analytical Methods & QA/QC	How to measure it robustly
Result Interpretation	How to judge what it means
Result communication	How to explain individual results to the worker and aggregate results to the employer and workers council

focusses on the collection, handling, and analysis of biological samples, covering the entire process from biomarker selection to laboratory analysis and interpretation and communication of results. The BASIC Guide is designed to offer clear, user-friendly guidance for OHPs, thereby supporting the development of efficient, reliable, and scientifically sound biomonitoring programs in workplace settings. This initiative seeks to promote the adoption of harmonized methodologies and standardized practices, enabling meaningful comparisons of exposure data across diverse industries, occupational environments, and geographical regions. By fostering consistency and improving data quality, the BASIC Guide contributes to more robust risk assessments and ultimately enhances health protection measures for workers.

The BASIC Guides (human biomonitoring and surveillance of chemical exposure in occupational settings)

The BASIC Guides operationalize the OECD's harmonized biomonitoring framework (Hopf et al. 2024), offering step-by-step instructions tailored to individual chemicals (Fig. 1). As shown in Table 1, the BASIC Guide highlights appropriate biomarkers for various chemicals, considering physiological and environmental factors that may influence biomarker reliability. It elucidates why certain biomarkers may be less reliable than others (eg, due to sensitivity and specificity issues). Furthermore, the Guide provides instructions for sample collection, including optimal timing, recommended container types, and detailed procedures for handling, storage, and transportation. These measures are designed to mitigate contamination risks and preserve sample integrity, thereby enhancing the accuracy and reliability of analytical outcomes. Additionally, the BASIC Guide emphasizes the importance of selecting accredited laboratories that comply with rigorous quality assurance and quality control standards. Finally, it provides necessary information for correct interpretation and effective communication of the results. Overall, the BASIC Guide serves as a standard protocol for the design and implementation of occupational biomonitoring which directly supports the OECD harmonized biomonitoring initiative (OECD 2022).

Table 2. List of chemical-specific BASIC Guides (human biomonitoring and surveillance of chemical exposure in occupational settings).

Chemical	Abbreviation	CAS number
Benzene	…	71-43-2
Chromium (VI)	Cr(VI)	18540-29-9
Nickel and its compounds (excluding tetracarbonyl nickel)	Ni	
Propylene oxide	PO	75-56-9
1,3 Butadiene	BD	106-99-0
Acrolein	…	107-02-8
Arsenic	As	7440-38-2
Cadmium	Cd	7440-43-9
Cobalt	Co	7440-48-4
Dioxin	TCDD	1746-01-6
Ethylene oxide	EO	75-21-8
Hydrogen cyanide and potassium cyanide	HCN and KCN	74-90-8 and 151-50-8
Hydrogen fluoride	HF	7664-39-3
Lead	Pb	7439-92-1
Mercury	Hg	7439-97-6
Methyl bromide	MeBr	74-83-9
Polycyclic aromatic hydrocarbons	PAHs	Multiple
Styrene	…	100-42-5
Toluene	…	108-88-3
Vanadium	V	7440-62-2
Xylenes	…	1330-20-7 (mixed isomers)
Hydrogen sulfide	H_2S	7783-06-4

Chemical focus and development plan

The BASIC Guide series currently includes 22 high-priority chemicals (Table 2), selected based on occupational relevance, regulatory concern, and existing gaps and needs for HBM best practice and harmonization.

The BASIC Guide is intended to be progressively expanded to encompass additional chemical substances. The initiative actively encourages stakeholder submissions for candidate compounds, particularly those associated with emerging health risks or driven by evolving industrial needs. To date, the BASIC Guide for benzene has been completed and is available on the FAIREHR (Findable, Accessible, Interoperable, Reusable-Environmental Health Registry) platform (Zare Jeddi et al. 2023; Galea Karen et al. 2025), as well as in the Supplementary material in Annex A. Additional BASIC Guides will be published on the FAIREHR platform (https://fairehr.com/BasicGuides) as they are finalized.

Updating, version control, and transparency

Each BASIC Guide includes a visible version number and date. BASIC Guides are reviewed by ISES Europe and HBM Global Network experts to incorporate:

- Scientific advances
- Regulatory updates
- Stakeholder feedback (via FAIREHR Helpdesk)

A version history section will be maintained within each guide. This section will document the date of the change and a brief description of the updates. This ensures transparency and helps users understand the evolution of the guide.

This living approach ensures continuous improvement and responsiveness to user needs.

Dissemination and global adoption

A comprehensive dissemination strategy will drive adoption of the BASIC Guides to ensure widespread use and application. Outreach targets include key international bodies like the World Health Organization (WHO) and the International Labour Organization (ILO), as well as regional and national entities such as the European Agency for Safety and Health at Work (EU-OSHA) and the National Institute for Occupational Safety and Health. Professional associations like the International Occupational Hygiene Association (IOHA), British Occupational Hygiene Society (BOHS), the American Society of Safety Professionals, Society of Occupational Medicine and the Canadian Society of Safety Engineering, along with industry-specific organizations such as the Chemical Industries Association the International Association of Oil & Gas Producers (IOGP), and the European industry association of nonferrous metals producers and recyclers (Eurometaux) and the European Chemical Industry Council (Cefic) will also be key partners in promoting the guides. Through these collaborations, the initiative seeks to incorporate the guides into established biomonitoring programs, thereby promoting a harmonized methodology and equipping OHPs with a reliable, state-of-the-art resource for assessing chemical exposures in workplaces worldwide.

Conclusion

The BASIC Guide initiative operationalizes the OECD occupational biomonitoring framework by translating it into actionable, chemical-specific protocols. Through the standardization of biomarker selection,

sample collection and handling procedures, analytical methodologies, result interpretation and communication, the initiative enables OHPs to conduct chemical exposure assessments with improved quality and cross-context comparability.

With the Benzene BASIC Guide already published online (https://fairehr.com/BasicGuides) and others underway, this globally accessible and evolving resource will improve decision-making, regulatory compliance, and worker health protection across industries.

Acknowledgments

We sincerely thank all the experts from the ISES Europe HBM Working Group and HBM Global Network for their contributions to developing the BASIC Guide series.

Author contributions

All authors contributed to the conception, design, drafting, and review of the BASIC Guides and the manuscript.

Supplementary material

Supplementary material is available at *Annals of Work Exposures and Health* online.

Funding

This project did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Chemical-specific BASIC Guides series will be made available on the FAIREHR (www.fairehr.com) platform.

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