European Agency for Safety and Health at Work

Occupational cancer risk factors in Europe – methodology of the Workers' Exposure Survey

European Agency for Safety and Health at Work

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1 Introduction

The European Agency for Safety and Health at Work (EU-OSHA) has conducted a large worker survey, the *Workers' Exposure Survey on cancer risk factors in Europe (WES),* in six EU Member States: Germany, Ireland, Spain, France, Hungary and Finland.

This survey is the first of its kind in Europe, and it provides information on probable exposure of workers during the last working week to several known cancer risk factors, both chemical and physical. Detailed information on the specific circumstances of exposure across jobs and the preventive and protective measures applied at work (including personal protective equipment) was also collected. A selection of demographic data supports the identification of exposed worker groups.

The main goal of WES is to provide reliable and informative data on workers' exposure that is complementary to the existing data sources in the EU, such as workplace measurements or job-exposure matrices. WES results will provide additional valuable data in the context of future amendment proposals to the carcinogens, mutagens or reprotoxic substances at work directive (CMRD)[1] and thereby contribute to the fight against work-related cancer. Updated information on occupational exposures to selected cancer risk factors, comparable across countries, will also support one of the key objectives of the EU Strategic Framework on Health and Safety at Work 2021-2027 on improving the prevention of work-related diseases, in particular cancer, and will contribute to Europe's Beating Cancer Plan and the EU Roadmap on Carcinogens initiatives.

WES is a cross-sectional survey providing a picture of the probability of workers' exposure to selected cancer risk factors at a given time point, and it should not be used to establish causal relations with current cancer outcomes. WES data should contribute to increasing awareness of cancer risks at the workplace and to a better understanding of where these exposures may occur, enhancing prevention and risk management across the EU.

EU-OSHA has coordinated the overall development and implementation of WES, finalised in 2023.

This report provides more information on the methodology used to implement WES, expanding on the publication 'Occupational cancer risk factors in Europe – summary of the methodology of the Workers' Exposure Survey'.

Section 2 describes the technical work done to adapt the Australian Work Exposures Study (AWES) to the European context, both in terms of the questionnaire and the underlying exposure assessment algorithms included in the Occupational Integrated Database Exposure Assessment System (OccIDEAS) for the selected cancer risk factors.

Section 3 details all the steps related to the translation of the questionnaire in the national languages, testing of the preliminary adapted questionnaire, sampling strategy, the main fieldwork process, and the final data quality control steps and data weighting procedures.

[1] Directive 2004/37/EC. See: https://eur-lex.europa.eu/eli/dir/2004/37

2 Adaptation of the survey and tool to the European context

EU-OSHA has collaborated since the early stages of WES with the original developers of the survey concept in Australia and of the OccIDEAS tool for exposure assessment (Lin Fritschi and Troy Sadkowsky, Data Scientists Ltd, Australia), and has closely coordinated the work of six national expert teams from the EU countries where WES has been conducted, in reviewing the original content of the survey, working on the survey harmonisation and language adaptations of technical terms, and reviewing exposure assessments taking into account the specific European context of work and the existing EU legislation on carcinogens.

2.1 Background to WES

2.1.1 The AWES

WES is based on AWES, a telephone survey developed and conducted in Australia in 2011-2012 that explored the prevalence of occupational exposure in 5,000 workers to 38 known or probable carcinogens as classified by the International Agency for Research on Cancer (IARC) and with evidence of use in the Australian industry at that time.[2,3] More recently, a similar worker survey has been implemented in New Zealand, covering 54 agents including some non-carcinogens.[4]

The original AWES survey questionnaire (and subsequently WES) is operationally divided into job modules and task modules, which include both sets of questions developed to assess potential exposure of workers to the selected cancer risk factors.

Job modules contain questions about what the worker does in a particular job or occupation (e.g. driver, health professional). Task modules are sets of questions that relate to a specific work-related activity or process (e.g. welding or unloading vehicles), which might be carried out or applied in different jobs (for example, welding could be done by farmers, construction workers or foundry workers). Therefore, the same task module is often asked to workers in different occupations. The AWES questionnaires cover the most common jobs in developed economies with more than 50 job modules and 44 sets of questions on tasks (or task modules) that are relevant for several job modules.

The specific duration of the interview changes for each worker interviewed depending on the person's occupation and the specific tasks they conducted during the last working week.

2.1.2 Exposure assessment principle based on OccIDEAS

WES uses an existing software to estimate occupational exposure to cancer risk factors: OccIDEAS.

OccIDEAS is an open-source and web-based application available on the software development platform GitHub at https://github.com/DataScientists/OccIDEAS and is linked from https://occideas.org. OccIDEAS is a Java Spring Boot application that runs on an embedded web server.[5] The data generated for WES using OccIDEAS has been stored in the EU-OSHA server.

The principle relies on the ability of workers to accurately describe what they do and how they work, and it estimates exposure by linking this factual information with the available evidence regarding exposures to cancer risk factors resulting from specific work tasks combined with the use and reuse of expertise

[2] Fernandez, R. C., Driscoll, T. R., Glass, D. C., Vallance, D., Reid, A., Benke, G., & Fritschi, L. (2012). A priority list of occupational carcinogenic agents for preventative action in Australia. *Australia and New Zealand Journal of Public Health, 36*(2), 111-115. https://doi.org/10.1111/j.1753-6405.2011.00849.x

[3] Carey, R. N., Driscoll, T. R., Peters, S., Glass, D. C., Reid, A., Benke, G., & Fritschi, L. (2014). Estimated prevalence of exposure to occupational carcinogens in Australia (2011–2012). *Occupational and Environmental Medicine, 71*(1), 55-62. http://dx.doi.org/10.1136/oemed-2013-101651

[4] WorkSafe New Zealand. (2023). *New Zealand Carcinogens Survey 2021 – Overview*. https://www.worksafe.govt.nz/research/new-zealand-carcinogens-survey-2021/

[5] Fritschi, L., Sadkowsky, T., & Glass, D. C. (2020). OccIDEAS: Web-based assessment of occupational agent exposure. *International Journal of Epidemiology, 49*(2), 376-379. https://doi.org/10.1093/ije/dyaa022

on workplace exposures coming from occupational epidemiologists and hygienists (the Expert Assessment Method[6]).

Workers reply to detailed and targeted questions about their work, but the system is dynamic, so that the answers to each broad question determine if further details are requested from the worker, and users are asked the minimum number of questions. At the end, the tool provides a personalised, automatic assessment of exposure to the risk factors considered in the survey, using rules (i.e. algorithms that determine exposure) that have been defined on the basis of the scientific evidence from the literature and expert consideration.

Exposure rules in OccIDEAS can be very complex, since the probability of exposure to a cancer risk factor for a given worker is the result of combining information on all tasks performed at work during the past working week by the respondent, the availability of protective measures (e.g. closed systems, ventilation), or the use of personal protective equipment (e.g. respiratory or eye protection), depending on the task being considered. Other contextual information collected in the interview, such as distance from the source, or indoor versus outdoor location, is sometimes also used in the determination of exposure. When potential exposure of a worker to a cancer risk factor occurs via different work tasks (that is, several exposure assessment rules for the same agent are activated), the overall estimated higher exposure level will be considered for this person. In total, more than 3,471 rules underly the exposure assessment of WES using OccIDEAS, and each rule can be the combination of two, three or even four specific answers.

OccIDEAS has been successfully applied in previous research studies[7,8,9,10,11] and in larger population surveys such as AWES, the New Zealand Carcinogens Survey and now in WES in Europe.

For WES, OccIDEAS has been customised in terms of the specific questions posed to the workers, new occupations added, and the revision of some rules underlying the estimation of exposure to the selected cancer risk factors, to be relevant to the European work context and consistent with the EU chemical and occupational safety and health legislations.

Estimation of exposure in OccIDEAS is provided in terms of probability of exposure to the cancer risk factors with the following possibilities: i) probable exposure; ii) possible exposure (when there is potential for exposure, but more information is needed to decide on whether there is exposure and, if so, how much exposure there is. In this case, further quantitative information is not provided); and iii) no exposure.

Probable exposure is further divided into three semi-quantitative categories that are approximately related in WES to EU occupational exposure limits (OELs) for the cancer risk factors considered, and are defined as:

- *Probable exposure at a high level* – exposure at or around the OEL;
- *Probable exposure at a medium level* – exposure between about 10% and 80% of the OEL; and

[6] Fritschi, L., Nadon, L., Benke, G., Lakhani, R., Latreille, B., Parent, M. E., & Siemiatycki, J. (2003). Validation of expert assessment of occupational exposures. *American Journal of Industrial Medicine, 43*(5), 519-522. https://doi.org/10.1002/ajim.10208

[7] Boyle, T., Carey, R. N., Glass, D. C., Peters, S., Fritschi, L., & Reid, A. (2015). Prevalence of occupational exposure to carcinogens among workers of Arabic, Chinese and Vietnamese ancestry in Australia. *American Journal of Industrial Medicine, 58*(9), 923-932. https://doi.org/10.1002/ajim.22428

[8] Friesen, M. C., Lan, Q., Ge, C., Locke, S. J., Hosgood, D., Fritschi, L., Sadkowsky, T., Chen, Y.-C., Wei, H., Xu, J., Lam, T. H., Kwong, Y. L., Chen, K., Xu, C., Su, Y.-C., Chiu, B. C. H., Dennis Ip, K. M., Purdue, M. P., Bassig, B. A., Rothman, N., & Vermeulen, R. (2016). Evaluation of automatically assigned job-specific interview modules. *The Annals of Occupational Hygiene, 60*(7), 885-899. https://doi.org/10.1093/annhyg/mew029

[9] Rai, R., Glass, D. C., Heyworth, J. S., Saunders, C., & Fritschi, L. (2016). Occupational exposures to engine exhausts and other PAHs and breast cancer risk: A population-based case-control study. *American Journal of Industrial Medicine, 59*(6), 437-444. https://doi.org/10.1002/ajim.22592

[10] Lewkowski, K., Heyworth, J. S., Li, I. W., Williams, W., McCausland, K., Gray, C., Ytterstad, E., Glass, D. C., Fuente, A., Si, S., Florath, I., & Fritschi, L. (2019). Exposure to noise and ototoxic chemicals in the Australian workforce. *Occupational and Environmental Medicine, 76*(5), 341-348. https://doi.org/10.1136/oemed-2018-105471

[11] Fritschi, L., Crewe, J., Darcey, E., Reid, A., Glass, D. C., Benke, G. P., Driscoll, T., Peters, S., Si, S., Abramson, M. J., & Carey, R. N. (2016). The estimated prevalence of exposure to asthmagens in the Australian workforce, 2014. *BMC Pulmonary Medicine, 16*, Article 48. https://doi.org/10.1186/s12890-016-0212-6

- *Probable exposure at a low level* – exposure that is higher than the general community, but less than about 10% of the OEL.

This working definition is based on the EU OELs set in the CMRD and its various amendments,[12] in the Asbestos at Work directive,[13] or on occupational dose limits set in other pertinent directives for physical carcinogens (e.g. ionising radiation directive[14]). Detailed information on the selected cancer risk factors considered in WES, including their OEL values in place at the time when this work was conducted (2020/2021), can be found in the document Criteria for the inclusion of cancer risk factors in the Workers' Exposure Survey on cancer risk factors in Europe (WES).[15]

An exhaustive list of bibliographic references that supported the exposure assessment in AWES, updated with the additional evidence used for the adaptation in WES, can be found in the Bibliography for the Workers' Exposure Survey on cancer risk factors in Europe.[16]

Since levels of exposure estimated in the survey are not based on direct workplace measurements, the exposure assessment provided by WES should be regarded as indicative of exposure intensity.

Finally, a limitation of the approach identified by its developers is that work circumstances are constantly changing, with introduction of new chemicals (and substitution of old ones), different processes and novel control measures. In addition, new information is continually being published about exposure levels in existing jobs or previously unknown sources of exposure. This requires that OccIDEAS must constantly be updated over time as new evidence emerges and it could lead to some inconsistencies between previous and more recent assessments[17] or between current and future assessments.

2.2 The WES questionnaire adaptation

The work leading to the implementation of WES started in 2017 with the publication of an independent feasibility study commissioned by EU-OSHA, concluding that the OccIDEAS concept used in AWES would be appropriate to deliver accurate, reliable and representative information on the level and likelihood of exposure to carcinogens for all kinds of workers in the EU, requiring some adaptation work for Europe with reasonable investments in terms of time and money.[18]

The adaptation of the AWES questionnaire to the EU context for its use in six European countries represented a key step for the successful implementation of WES, and it involved the contributions of many different actors as described in this report.

EU-OSHA has closely collaborated with Dr Lin Fritschi and Troy Sadkowsky (Data Scientists Ltd, from Australia), two of the original developers of OccIDEAS, who have also been providing support to the implementation of this methodology in other national worker surveys in Australia and New Zealand.

Five national teams of experts were selected through a competitive public call in 2020, and a collaboration agreement was established with Germany, to support EU-OSHA with the content and language adaptation of the survey, to review exposure assessments to the selected cancer risk factors in the EU context, and to provide feedback and suggestions on the translation of the survey and on a glossary of technical terms that was prepared by EU-OSHA based on the English survey questionnaire.

In addition, at the early stages of WES, EU-OSHA created two expert groups to provide technical and strategic input during the entire process: one with international scientists in the areas of workplace

[12] Directive 2004/37/EC. See: https://eur-lex.europa.eu/eli/dir/2004/37

[13] Directive 2009/148/EC. See: https://eur-lex.europa.eu/eli/dir/2009/148

[14] Directive 2013/59/Euratom. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013L0059

[15] EU-OSHA, *Criteria for the inclusion of cancer risk factors in the Workers' Exposure Survey on cancer risk factors in Europe (WES)*, 2024. This document is available as a PDF file to be found under the Related Resources section at: https://osha.europa.eu/en/publications/occupational-cancer-risk-factors-europe-first-findings-workers-exposure-survey

[16] EU-OSHA, *Bibliography for the Workers' Exposure Survey on cancer risk factors in Europe*, 2023. This document is available as a PDF file to be found under the Related Resources section at: https://osha.europa.eu/en/publications/occupational-cancer-risk-factors-europe-first-findings-workers-exposure-survey

[17] Fritschi, L., Sadkowsky, T., & Glass D. C. (2020). OccIDEAS: Web-based assessment of occupational agent exposure. *International Journal of Epidemiology, 49*(2), 376-379. https://doi.org/10.1093/ije/dyaa022

[18] EU-OSHA – European Agency for Safety and Health at Work, *Feasibility study on the development of a computer-assisted telephone survey to estimate workers' exposure to carcinogens in the European Union*, 2017. Available at: https://osha.europa.eu/en/publications/feasibility-study-development-computer-assisted-telephone-survey-estimate-workers

exposure assessment, occupational hygiene and population surveys, including cancer experts and representatives of other EU Agencies (WES Expert Group[19]); and the other with representatives of workers, employers and government, and the European Commission (WES Advisory Group[20]). One or two meetings with each group were organised per year, both online and at EU-OSHA's premises, where both were updated on the progress of WES and consulted on critical matters ranging from prioritisation of cancer risk factors, adaptation of job and task modules or existing/new exposure assessment rules in the EU context, to preliminary data analysis and planification of future studies based on the results of WES, among other topics. Written requests for comments on specific topics were also sent regularly to the groups, for example on draft new modules for WES proposed by the national experts, or preliminary versions of reports for publication on the methods and first findings of WES.

2.2.1 Cancer risk factors included in WES

WES includes exposure assessment for 24 known cancer risk factors relevant in the EU (Table 1), including chemical and physical agents, selected by EU-OSHA,[21] and in consultation with stakeholders and independent experts from the two expert groups described above.

Table 1: List of cancer risk factors included in WES

1,3-butadiene	Acrylamide	Arsenic	Asbestos	Benzene	Cadmium
Chromium VI	Cobalt	Diesel engine exhaust emissions	Diethyl/ dimethyl sulphate	Epichlorohydrin	Ethylene oxide
Formaldehyde	Lead and inorganic compounds	Leather dust	Mineral oils (as mists)	Nickel	Ortho-toluidine
Ionising radiation	Artificial ultraviolet (UV) radiation (including ocular UV)	Solar ultraviolet (UV) radiation (including ocular UV)	Respirable crystalline silica	Trichloroethylene	Wood dust

A key inclusion criterion for any cancer risk factor in WES was that it needs to be already included in OccIDEAS so that the exposure assessment tool had already been used and tested for it. Hence, risk factors not included earlier in OccIDEAS were not eligible for inclusion in WES.

Other additional important considerations were taken into account in selecting the cancer risk factors for WES:

- The risk factor is classified in Group 1 or 2A (human carcinogens or probably carcinogens) by the IARC Monographs.[22]
- For chemical substance/mixture, including those generated by work processes (e.g. respirable crystalline silica or wood dust):
  - it meets the criteria for classification as a category 1A or 1B carcinogen set out in Annex I to the Classification, Labelling and Packaging (CLP) EU Regulation;[23] and
  - it is addressed in the CMRD or in one of the planned or adopted amendments.

[19] The expert group includes Vida Beresneviciute (EU Agency for Fundamental Rights), Agnès Parent-Thirion (Eurofound), Lesley Rushton (Imperial College London), Kurt Straif (IARC, ISGlobal), Jukka Takala (ICOH), head of the department 'Working conditions and health' from the French Dares, and a statistician from the Education, health and social protection unit (Eurostat).

[20] For the composition of the group, see: https://osha.europa.eu/en/about-eu-osha/governance-eu-osha/composition-advisory-groups

[21] EU-OSHA, *Criteria for the inclusion of cancer risk factors in the Workers' Exposure Survey on cancer risk factors in Europe (WES)*, 2024. This document is available as a PDF file to be found under the Related Resources section at: https://osha.europa.eu/en/publications/occupational-cancer-risk-factors-europe-first-findings-workers-exposure-survey

[22] See: https://monographs.iarc.who.int/

[23] Regulation (EC) 1272/2008. See: https://eur-lex.europa.eu/eli/reg/2008/1272/2023-04-20

- The risk factor causes relevant occupational exposures across occupations and sectors in the EU (for example, exposure to diesel engine exhaust emissions may occur in many jobs where vehicles are used).
- The potential number of workers exposed in the EU, where such information was available.[24]

2.2.2 Work organisation of the national teams

Tailoring the original survey to the EU involved six teams of national experts in occupational hygiene and cancer epidemiology, exposure assessment, and occupational safety and health legislation from the countries where the survey was conducted[25] with a good knowledge of the exposure situation in their countries. Each national team consisted of a minimum of six members including a dedicated coordinator per country (and a back-up coordinator in case of unforeseen absences) and at least one senior expert with 10 years or more of professional experience in any of the fields mentioned above. Also, one or two experts per team were required to have expertise, knowledge or experience in the manufacturing sector (e.g. automotive, chemical, plastic, rubber, metal, electronics or pharmaceutical industries), as this was considered an area that would require some specific efforts in adapting the survey from the Australian to the EU work context. In total, 45 European experts from Germany, Ireland, Spain, France, Hungary and Finland were involved in this work, all with previous experience working in English and thorough knowledge of the national language of their respective countries.

The work of the national experts on WES started in December 2020. At the beginning, EU-OSHA organised an online training for the national teams on the work to be conducted, focusing on the structure of the survey questionnaire, the tasks of the experts and the functioning of the OccIDEAS tool, including the exposure assessment rules. EU-OSHA provided an interactive demo on the use of the web interface to which the national teams had been granted restricted access, and created a living Q&A document answering recurrent queries that arose during the training or later, and shared it regularly with the experts.

The coordinators in each country were responsible for organising the work of the expert group, ensuring participation and collaboration of the experts, delivering high-quality and justified opinions, and communicating regularly with EU-OSHA. Each team decided how the review work would be organised internally. While some countries looked at the survey by agents, most of the countries distributed the review of job modules and task modules (including rules) based on expertise in the team in specific sectors or occupations, always in pairs, and used the template provided by EU-OSHA to provide their comments (Table 2). During the first quarter of 2021, teams in each country met regularly to discuss and consolidate feedback at national level, and a small number of queries were also sent by members of the expert groups to other experts or industry representatives external to the project, to clarify technical doubts or confirm terminology used. During this period, EU-OSHA held regular online meetings with country coordinators to discuss progress of the work, timeline, challenges encountered, or any other issues that the teams wanted to bring to the attention of the larger group and EU-OSHA, such as the proposal to develop new modules for the manufacturing or the energy sectors (see below).

Consolidated feedback on WES was delivered to EU-OSHA at the end of February 2021 by the national experts. From then and until October, EU-OSHA staff conducted a detailed internal review of all the suggestions received from the six countries, reached out frequently by email to coordinators for additional clarifications, sought consensus on unresolved issues among experts, harmonised decisions across the entire questionnaire, and reviewed all rules and formulation of questions for consistency and coherence, in close cooperation with Data Scientists Ltd. The national experts formally finalised their cooperation with EU-OSHA in November 2021. In summary, during this period national expert teams were involved in:

[24] Detailed information on all the cancer risk factors included in WES, providing details on their classification and legislation at the time of the survey development, will be published separately.

[25] EU-OSHA contracted the Irish Occupational Hygiene Consultants (IOHC) in Ireland (coordinators: Nuala Flavin and Geraldine Lenehan), ISGlobal in Spain (coordinator: Michelle Turner), NKK in Hungary (coordinator: Ferenc Kudász), FIOH in Finland (coordinator: Milja Koponen) and ALCIMED in France (scientific coordinator: Nazanin Golbamaki). EU-OSHA signed a collaboration agreement with the Federal Institute for Occupational Safety and Health (BAuA) in Germany (main contact: Dag Rother).

- Developing a high-quality adaptation of the existing questionnaire. This included assessing and providing justified opinions, comments and suggestions for new or reworded questions in the existing job and task modules, including changes in exposure assessment rules and provision of supporting evidence (literature, results of measurements at national level, etc.). To facilitate this, EU-OSHA created a template in Excel (for optional use) with predefined fields, for a more harmonised collection of feedback from the expert teams on all the job and task modules from the survey questionnaire (see Table 2 as an example).
- Proposing and developing new sets of questions or modules to ensure coverage of all relevant sectors and occupations where workers could be exposed in Europe, and defining the new related exposure assessment rules.
- Providing expert feedback on the translation of technical terms included in the survey to their national languages (supported by an English glossary of terms), as well as checking the language version of the entire WES questionnaire after translation.

Table 2: Example of template used by experts to provide feedback on WES

Job Module Code	Job module description	Type of modification	Node Number* OR Rule ID (as in OccIDEAS) **For new questions or answers, provide the node number of the answer/question immediately above*	Current wording of entire question/ answer (copy paste from OccIDEAS)	Proposed new wording	(FOR RULES ONLY) Current exposure level	(FOR RULES ONLY) New exposure level	(FOR RULES ONLY) Node number/s of answer/s attached to the rule	Justification	Additional comments
CERA Ceramics	Ceramics industry including brick, tile and pipe making, glass, pottery and sanitary ware.	New rule	7A1A	Chromic acid		No rule exists.	Chromium VI: PROBABLE_ UNKNOWN. Although we could consider (in the same way that in response 7A1A): PROBABLE_ LOW.		The use of this substance could be a source of exposure to Cr(VI).	
CERA Ceramics	Ceramics industry including brick, tile and pipe making, glass, pottery and sanitary ware.	New or Modified answer	1I		Although I'm not sure artificial stone would be considered 'a ceramic material' I would add a new response to question 1 (after response 1I): 'Engineered, agglomerated or reconstituted stone, also known as				It could have processes with high emission of quartz dust (i.e. quartz mineral milling and mixing, etc.).	In Spain the main commercial name is Silestone.

					quartz conglomerate, Caesarstone, EssaStone, Silestone, Smartstone.' Following which the aCTS CUTTING STONE Task module could be inserted. See also related comments on aSAN SANDING Task module in Excel file.					
CLNR Cleaner	Domestic, commercial and industrial cleaners.	No comments	No comments	No comments	No comments	No comments	No comments	No comments	No comments	No comments
CONS Construction Trades	Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers.	Other	Q7A2A and 7A1A1							Unclear what lead flashing is, to check in glossary and after translation.
CONS Construction Trades	Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers.	New or Modified question	1D	Worked on a ship/boat.	Insert Task module aFUM FUMIGATION					

CONS Construction Trades	Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers.	New or Modified question	In Q6		In the last working week did you use a wall chaser / milling cutter?		Silica: with local exhaust ventilation (LEV): Low exposure, without LEV: High exposure.		Within Q6 there should be option for making holes in the wall (for electricity wires, etc.), chaser.	
CONS Construction Trades	Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers.	New or Modified question	3A3A2	In the last working week, did you clean up wood dust?	In the last working week, did you or did someone near you clean up wood dust? (See 1A6 in Cutting Wood Task also).				One should take into account that although the worker him/herself is not performing the task, nearby there is a worker who does perform the task (e.g. cleaning wood dust with a broom or compressed air). This can be rather common on construction sites.	See also comments on Cutting Wood Task.
DRIV Driver	Drivers and transport workers	No comments	No comments	No comments	No comments	No comments	No comments	No comments	No comments	No comments

When providing feedback to EU-OSHA on their work in WES, experts mentioned that the time available to conduct such a broad task was brief (particularly for the first deadline: feedback on the entire questionnaire and rules), and it extended over a longer period than initially planned, since EU-OSHA conducted a detailed review of their feedback and contacted the teams with many questions during the evaluation. Also, perhaps a greater emphasis could have been given to the practical work experience of the team members (e.g. visiting worksites regularly), rather than their academic career.

Some reported that the work highlighted areas where EU legislation has room for improvement (e.g. limited scope of Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)), but also the strength of the European chemical safety framework as compared to other regions of the world. Australian industrial operations, or more generally work practices, were found in many cases to be significantly different from European ones. Finally, it was raised that a growing proportion of the EU workforce in jobs with highest exposures may not have been captured in WES, as they may not speak fluently the national languages (i.e. migrant workers).

2.2.3 Main changes to the survey

The final WES survey contained 51 job modules (including a generic one) and 41 task modules. The experts and EU-OSHA fully reviewed and amended (where necessary) the wording of the questionnaire and the exposure assessment rules for all the included cancer risk factors, also considering potential exposures in specific work settings like unventilated or confined spaces.

After the review, many of the questions and corresponding exposure assessment rules remained unchanged from the original questionnaire. For the next step, the survey was further adapted for use in the European context to reflect exposures in sectors or activities that were not considered relevant in Australia. Questions that were deemed irrelevant to Europe were removed from the survey, for example those related to substances with legal restrictions or authorisations of use in the EU. Substantial harmonisation work was undertaken in ensuring consistency of wording of questions across modules and in exposure rules.

Changes in questions and rules

Some examples of changes implemented in WES are included below, presented by topics:

- **Benzene:** exposure assessment rules were adapted regarding potential exposure to benzene occurring in different tasks across the entire survey, such as metal coating or plating, shoe or textile industry, cleaning tanks, working near generators and so on, to account for EU restrictions on benzene under REACH and its subsequent amendments.[26,27] Specifically, potential exposure to benzene in the shoe industry due to shoe fitting or boot assembly tasks was eliminated, since glues containing benzene are not in use anymore since 1985, based on measurement data available in the EU.
- **Lead and inorganic compounds:** removal of exposure scenarios related to the use of lead-based metallic colorants/salts for covering grey hair in beauty salons, as per 2019 ban,[28] or to its use in the metal industry for thermal spraying, plating or anodising. Potential exposure to lead from paints was reviewed.
- **Ionising radiation:** questions were developed in relation to circumstances relevant in Europe, such as the use of dosimetry badges for air transport, nuclear energy sector, medical or other workers. Also, a question on the use of gammagraphy equipment was included in the survey and workers were asked whether they were protected by a lead, concrete or steel shielding or wall when using such equipment.

[26] Regulation (EC) 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R1907

[27] Annex XVII to REACH – Conditions of restriction (related to benzene). See: https://echa.europa.eu/documents/10162/7c8cf4ac-baf9-a05a-2cc7-c9bca4a9d5b7

[28] Regulation (EC) 2019/831 on cosmetic products. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0831

- **Solar UV radiation:** the list of reflective surfaces that can enhance solar UV exposure was extended to include snow, and the potential for ocular exposure to UV radiation from reflection (by snow, water, sand) was re-evaluated.
- **Artificial UV radiation:** questions related to the use of eye protection (safety goggles or glasses) and new questions regarding time delays before opening equipment or use of UV light for sterilisation purposes were added and consistently asked to workers in several relevant occupations, including transport workers, food workers, hairdressers/beauty therapists, workers in industrial and chemical manufacturing, or laboratory workers.
- **Respirable crystalline silica (RCS):** new questions were created on the use of diatomaceous earth in filters leading to potential exposure to silica in the food industry, based on measurement data from Spain and Finland, and on the use of silica sands to make moulds in the foundry industry; or in sanding of artificial stone (also known as quartz conglomerate or quartzites). Also, potential exposure to RCS was included when workers applied fired enamelling coatings without proper ventilation systems.
- **Mineral oils:** current uses of mineral oils and exposure in the EU were discussed in detail and fully reviewed, considering that most uses in Europe are limited to highly refined mineral oils, which are not carcinogenic. Also, questions on spraying eggshells for conservation with mineral oils in the food industry were removed as this practice is not in use in the EU. Additional questions asking how mineral oils were applied by workers were included (e.g. by dipping, spraying or manual application with a brush), and this was considered in the exposure estimation.
- **Trichloroethylene and chromic acid** in the textile industry: experts provided evidence that these were two exposures not occurring anymore in the EU in this sector and therefore rules of exposure to these two chemicals were removed.
- **Dust, organic and inorganic:** questions on the cleaning of dust in the working area (including wood, leather, RCS) and how this was done (vacuumed with compressed air, swept or mopped) were added consistently in many modules such as mining, cleaners, cutting wood tasks, cleaning furnaces and so on, and the information was used in defining the exposure assessment algorithm for the agent concerned.
- **Industrial manufacturing:** the existing job module was adapted to include the production of medical devices or wooden products (wooden boards, furniture, paper pulp, etc.).
- **Mining:** questions on salt or slate mining were added (with potential for exposure to RCS), and mercury mining was removed as this type of mining has ceased in the EU.

Creation of new job and task modules

The national experts in cooperation across countries and with EU-OSHA developed two entirely new modules for WES, covering important economic activities in the EU that were not present in the original Australian survey, and they also added substantial amendments to an existing task module. Those modules were the following:

- **Chemical and pharmaceutical industry (CHEM):** a new job module was developed for WES (proposed by the Irish experts and concluded with collaboration from the other five countries and EU-OSHA). The module aims at covering workers in production or in close contact with a range of industrial chemicals (e.g. benzene, trichloroethylene, 1,3-butadiene, epichlorohydrin, acrylamide, etc., as well as fertilisers, pesticides, paints, adhesives, dyes and inks) and pharmaceuticals manufactured in Europe. Potential exposure to some metals in production processes was also considered (e.g. nickel, chromium VI or cadmium). Workers in CHEM are also asked specific questions on the conditions of work, for example whether they worked in a fully closed system (pipes, reactors, tanks, vats or vessels), or in a partially enclosed system, using a glove box, a fume hood, a laboratory cabin/ventilated bench or none of these. Given the heterogeneity of the sector covered, many task modules were also included for consideration,

such as sterilising material, use of X-rays for quality assurance, exposure to artificial UV radiation, material handling including truck loading/unloading, degreasing or process cleaning/maintenance tasks including changing and cleaning filters, working near running vehicles and cleaning hands with chemicals.

- **Nuclear energy production and nuclear waste management (aENU):** a specific task module was created for WES (the proposal was led by experts in France and Hungary). It is asked to workers in a variety of sectors handling radiation sources or radioactive material, including waste products, working near the reactor or involved in emergency interventions. The module includes questions on the use of specific radio-protective garments at work such as lead aprons, gloves, leaded glasses, whole protection suits or individual dosimetry badges (including a question on the annual dosimeter readings in millisieverts), as well as on other requirements laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation as per EU legislation,[29] including having attended workplace training on radiation protection and health risks over the past year.
- **Removal of asbestos:** the original task module on removal of asbestos and asbestos-containing products was adapted to reflect the asbestos removal work requirements and procedures in Europe,[30] such as working in an enclosure under negative pressure and conducting a preliminary decontamination of personal protective equipment before leaving the enclosure, the presence of a decontamination unit on site or having received specific training. Also, questions on how dust was cleaned around asbestos removal areas were added, leading to different exposure scenarios depending on the answer selected: vacuum cleaner with HEPA filter, with compressed air, using a brush or sweeping the area with a broom, mopping the area with water, if the area wasn't cleaned or the worker didn't know. In addition, this modified task module included questions on occasional exposure to asbestos arising from non-intended removal of asbestos-containing material, for example during repair or maintenance tasks, and it was asked in a range of different jobs: construction, farming, firefighters, gardeners, caretakers/janitors or road/construction workers, among others.

Preventive/protective measures

The experts from Ireland developed a new wording proposal and suggested to harmonise across the survey the questions and possible answers on preventive and protective measures in place or used at work (ventilation and respiratory protective equipment).

The questions were asked to respondents following the hierarchy of control measures at the workplace (from working in closed systems to technical measures such as local exhaust ventilation and, lastly, the use of respiratory and other personal protective equipment), and systematically included across the job and task modules as relevant, in additional instances as compared to the original survey.

Workplace Ventilation

How was the area where you carried out {*work task*} ventilated?

- By local exhaust ventilation which captured the vapour, dust, fume at the emission point.
- By on-tool extraction to remove dust and fumes away from your face.
- By a general ventilation system.
- By fans in the window or doorway.
- By open doors or windows.
- No ventilation was applied to the area.
- Other, please specify.
- Don't know.

[29] Directive 2013/59/Euratom (consolidated). See: https://eur-lex.europa.eu/eli/dir/2013/59/oj
[30] Directive 2009/148/EC. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0148

Respiratory Protection

In the last working week, did you use respiratory protection?

- Yes.
- No.
- Don't know.

If yes: What types of respiratory protective equipment (RPE) did you use?

- Rubber face mask fitted with a particle/vapour filter or a cartridge.
- Powered Air Purifying Respirator (PAPR).
- Air-supplied respirator or SCBA (self-contained breathing apparatus).
- A filtering face piece mask or dust mask (called an FFP).
- Other, please specify.
- Don't know.

2.2.4 Development of a glossary of technical terms

The WES questionnaire contains many technical terms and expressions related to the broad range of occupations and specific work tasks covered and referring to work processes, technical equipment, machinery and plant, or products or substances used, as well as many abbreviations or acronyms commonly used in the specific occupational context. EU-OSHA developed a glossary based on the survey containing more than 900 technical entries and providing the English definition of the term or expression as used in the specific work context where it appeared in WES. Synonyms were eliminated as much as possible, to simplify the questionnaire and ensure a common understanding and aligned terminology across the survey questionnaire and the translated versions.

The glossary supported the correct translation of technical terms into all the survey languages. The national experts reviewed the content of the glossary in English and provided advice regarding its translation, ensuring that the terms most familiar to workers in the specific sectors and jobs were used. This process improved the next steps of the development of the survey and consequently the quality and informative value of the interviews.

The work to revise, harmonise and update the questionnaire and rules and adapt it from the Australian context to the EU context was also performed in close collaboration with the technical and epidemiological experts of Data Scientists. The flexibility and cooperative approach resulted in a good working relationship that was a major factor in the success of the adaptation process and the final survey process and outcome.

3 Preparation and implementation of the survey

Ipsos – European Public Affairs (EPA unit) led the preparation and fieldwork of the survey, in close collaboration with staff from the International Social Research unit at Ipsos UK. Throughout the project, the Ipsos central team collaborated with EU-OSHA staff and Data Scientists' experts, and local fieldwork agencies were involved in the six countries where WES was implemented. The translation of the main questionnaire, the glossary and the fieldwork materials was carried out by cApStAn, which specialises in the translation and verification of research instruments for high-quality cross-national and/or cross-cultural surveys.

3.1 Preparing the survey master questionnaire

The WES master questionnaire consists of three main sections:

1. **Introductory questions**, including informed consent and screening questions, asked to all respondents including some demographics, occupation and job details as well as OccIDEAS job module selection questions.
2. **Main section**, including job modules and task modules, which are largely based on AWES/OccIDEAS, adapted to the EU context and are specific to each respondent's job as described in Section 2.
3. A short set of **closing questions**.

The draft master questionnaire was first tested for translatability in the first half of 2021, and then a cognitive pretest of the master questionnaire was carried out in two countries.

The aim of a **translatability assessment** was to make the source material fit for translation, solve possible translation difficulties before the actual translation process started, and raise awareness of potential hurdles for the adaptation of certain questions into some of the languages. The exercise consisted of collecting feedback from a pool of linguists, representing four different language groups (Germanic, Romance, Slavic and Uralic), who reviewed the draft version of the questionnaire, identified potential translation, adaptation or cultural issues, and provided recommendations for alternative wording and proposals for translations. Based on this feedback, EU-OSHA decided which of the suggestions or recommendations had to be incorporated into the English source questionnaire.

Ipsos conducted a **cognitive pretest** in two selected countries, Ireland and Hungary. A total of 20 in-depth interviews were conducted per country, targeting 14 job modules that had previously been identified as being particularly complex in terms of wording and length, or that were likely to entail high or frequent exposures to the selected cancer risk factors. This pretest aimed at assessing clarity and understandability of the questionnaire. It provided an opportunity to identify potential issues with use of terminology in these languages, highlighted any potential translation challenges at an early stage of the process, and helped inform the translation process following the finalisation of the survey questionnaire. Overall, only minor adjustments to the questionnaire were needed as most of the tested questions were clearly understood by respondents.

Ipsos, EU-OSHA and Data Scientists agreed on a scripting process for the job and task modules whereby Data Scientists first implemented all the changes to the job and task modules (and rules) directly in the OccIDEAS software, and then delivered a word version of the modules to Ipsos together with a CSV format map for the data delivery. Next, Ipsos scripted all the modules according to the survey flow (with the required routing and filtering) in the fieldwork software and integrated this with the script of the intro and outro sections of the questionnaire. Ipsos first scripted mock modules to test the data mapping[31] and further fine-tune the data mapping rules with Data Scientists as early as possible.

During the scripting process and because of the nature of the project, it became apparent that the questionnaire extract from the OccIDEAS tool received first was a non-final version (including the need to revise response formats or filter instructions), and therefore several revision rounds were initiated to optimise the logic and consistency in all the job and task modules. As changes to the master version of the job and task modules were implemented in the OccIDEAS tool, the data mapping was updated

[31] Data mapping is the process of matching fields from one database to another.

accordingly. Upon finalisation of the master script, Ipsos delivered the dummy data covering all possible survey scenarios to test the export of the survey data and the upload of the data into OccIDEAS. The full script was also extensively tested on screen and via dummy data by Ipsos. For the latter, a checking syntax was developed, allowing for errors in the script to be detected (e.g. routing errors, missing values and invalid answers).

Once the script and data mapping were tested and finalised, Ipsos created an extract of the script (MRT file[32]) and delivered it to cApStAn to include the translations. The use of an MRT file (with script coding included) allowed for a swift and error-free import of the translations in the national languages. The national versions were in turn extensively tested on screen and via dummy data.

3.2 Translation to national languages

Ipsos and cApStAn applied the Translation, Review, Adjudication, Pretesting and Documentation (TRAPD) approach for the translation of the English survey questionnaire into the five national languages. For Ireland, the English survey questionnaire was slightly adapted, considering national language peculiarities and national use of workplace-related terminology.

TRAPD involves multiple stages of review and editing, including a review step by a third expert translator, to ensure a very high level of accuracy and quality of two independent translations. The entire translation process lasted six months, resulting in six comparable and harmonised language versions of the questionnaire that address national language peculiarities and differences in job-related terminology.

The TRAPD procedure started in August 2021 and was completed in January 2022, and consisted of the following main steps:

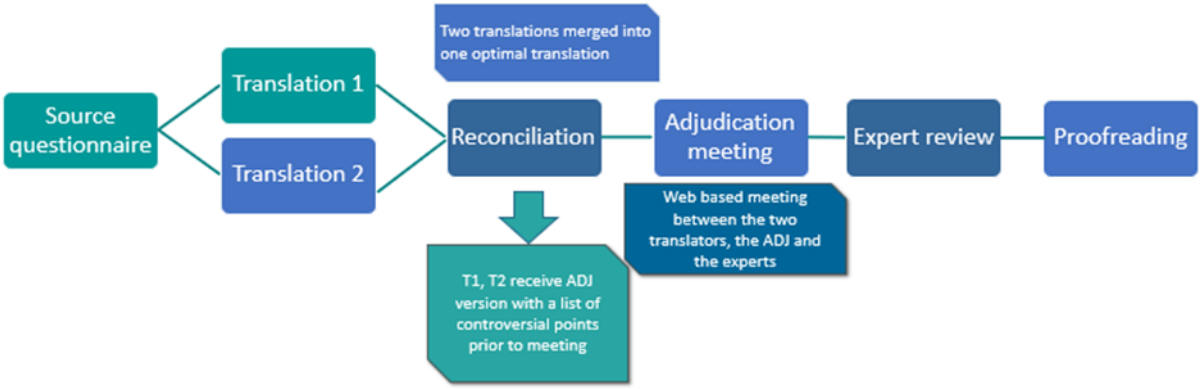
1. The **glossary** of technical and specific terms was localised by cApStAn into five bilingual glossaries in Finnish, French, German, Hungarian and Spanish. The translators used the definitions, links, context references and comments provided by EU-OSHA as support. The completed bilingual glossaries were then reviewed and validated by EU-OSHA national and technical experts.
2. **Translation:** following a translation briefing, two independent draft translations were produced in parallel, hereby making use of the glossary. Translation challenges, doubts and choices were documented.
3. **Reconciliation** (referred to as 'Review' in the TRAPD model): a senior and experienced translator merged the two translations into an optimal version that incorporated the best elements of each of the initial translations or created a third version. The reconciler flagged the issues that needed to be discussed at the adjudication meeting.
4. **Adjudication meeting:** the remaining issues were further discussed and addressed at a web-based adjudication meeting with the team of the two translators, EU-OSHA and the national experts. One senior cApStAn linguist attended each adjudication meeting as a moderator. The adjudicator (the reconciler) finalised the translation based on the adjudicated decisions. The decision-making process was documented.
5. **Expert review:** a review of the document included the feedback form national experts. In addition to the regular TRAPD steps, domain expert review steps were added after the adjudication. Before the proofreading, the adjudicators provided their feedback on the translation.
6. **Proofreading:** a proofreader checked the linguistic correctness (spelling, phraseology, grammar), but refrained from substantial changes.

[32] The MRT is the file exported from the questionnaire script and imported back into Ipsos script to make translations available in the script without the need to copy/paste question by question. MRT files allow change tracking.

7. **Quality assurance:** towards the end of the process, cApStAn ran automated quality assurance routines to ensure that the translation was complete, that repeated segments were translated consistently while keeping deviations where necessary and to ensure consistency in the translation of agreed key terms.

In total, six national language versions of the WES questionnaire were produced. For each of the language versions, the whole process has been documented (draft translations, exchange of comments between the translators, the reconciler, adjudication meeting, feedback from the pilot test, and the final translation). Figure 1 illustrates the stages in the process.

Figure 1: Translations steps followed for the WES questionnaire



Source: Ipsos, methodological and field report, 2023.

All the final language versions of the WES questionnaire will be made available by EU-OSHA during 2024.

In addition to the survey questionnaire, cApStAn underwent a single translation and review of the fieldwork material and documentation needed to implement the survey at local level. The fieldwork material included the following:

- Invitation letter;
- Invitation letter adapted for sending out directly via email;
- Reminder email;
- Privacy notice; and
- Briefing manual for the interviewers.

The national translation teams received a package with all the above material as sources and the invitation letter pre-translated with the translation memory that was a part of the received MRT file. The MRT is the translation Excel exported from the questionnaire script and imported back into Ipsos script to make translations available in the script without the need to copy/paste question by question. This translation was given priority, and the segments were aligned to the MRT translation where necessary.

3.3 Piloting WES

A pilot of WES was conducted between March and May 2022[33] in the six countries to test exposure assessment and questionnaire performance (particularly of the newly developed modules), the technical

[33] Vilahur, N., Cavet, M., Irastorza, X., & Schneider, E. (2023). O-77 Implementation of the Workers' Exposure Survey to assess workplace exposures to cancer risk factors in Europe: Pilot study. *Occupational and Environmental Medicine, 80*(Suppl. 1), A86-A87. https://doi.org/10.1136/OEM-2023-EPICOH.212

set-up, interviewer performance, sampling and contacting procedures, data quality, the online mode of the survey, and the coding of occupation into ISCO[34] and activity sector into NACE.[35]

With the objective to obtain a good representation of the general public, a specific call design with seven call attempts spread over different times in the day and covering both week and weekend days, and with an interval of at least 15 days between the first and the last call attempt, was applied. A large enough sample size was required to gather robust evidence and cover as many job modules as possible and thoroughly evaluate the sampling procedures and the questionnaire. Therefore, the pilot test aimed to collect a minimum of 200 interviews in each country.

The pilot sample design was tailored to the objectives of the pilot test:

1. to evaluate the random digit dialling (RDD) sample design (that was to be used in the main fieldwork); and
2. to test the questionnaire, by:
   - covering as many job modules as possible, and
   - using both CATI (Computer Assisted Telephone Interviewing) and CAWI (Computer Assisted Web Interviewing) formats.

In each country, half of the sample (about 100 interviews) was based on the same sample design that would be used for the main WES (based on RDD). These interviews formed a survey population representative sample that provided information to evaluate the main field sample design.

This was useful for several purposes:

1. The resulting sample distribution was used to inform the oversampling design to be used in the main fieldwork.
2. This part of the sample gave an accurate estimate of the interview length based on a representative mix of different job modules.
3. It provided an indication of the response rates that could be expected in the main survey.

A further 100 interviews in each country were obtained with targeted business-to-business (B2B) samples, which aimed to ensure coverage of all job modules to facilitate a comprehensive testing of the WES questionnaire. To achieve this, the sample was enriched with predicted job occupations, by linking phone numbers to occupation information that can be found publicly either in B2B databases (e.g. yellow pages, but also Google Maps where many businesses are listed with contact details) or on websites and social media platforms. A total of 36 job modules were identified as having a low likelihood of achieving interviews in the pilot RDD sample, based on the mapping of Labour Force Survey occupations to job modules. This part of the pilot sample focused on the 39 occupations potentially covered by these job modules.

Finally, an additional targeted sample was generated that included email contact details. This email sample aimed to cover the full range of occupations. Email invitations were then sent to this sample of workers to test the online version of the survey. The aim was to achieve a minimum of 25 interviews with CAWI per country (in addition to the 200 interviews described above).

In agreement with EU-OSHA, several changes to the script were already implemented during the pilot phase (early May 2022), based on feedback from the local fieldwork agencies about repetition in the job-related questions without making a clear difference between job title, job function and main activity. Also, changes were made to facilitate the job module assignment process to the interviewers, such as including a drop-down list of detailed jobs in the job category question.

At the end of the pilot, trained interviewers had conducted 213 telephone interviews on average in each country, in their national languages (Table 3).

[34] See International Standard Classification of Occupations: ISCO-08, 2012, International Labour Office: https://www.ilo.org/global/publications/ilo-bookstore/order-online/books/WCMS_172572/lang--en/index.htm

[35] Eurostat. (2008). NACE Rev. 2 – Statistical classification of economic activities in the European Community. *Eurostat Methodologies and Working papers*. Office for Official Publications of the European Communities. https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

Table 3: Number of completed interviews according to sampling sources in the pilot study, by country

Country	RDD mobile sample		B2B sample		Email sample	
	Target	Completed	Target	Completed	Target	Completed
Germany	100	110	100	103	25	47
Spain	100	121	100	105	25	38
Finland	100	110	100	101	25	23
France	100	100	100	105	25	34
Ireland	100	110	100	105	25	34
Hungary	100	110	100	102	25	46
Total	**600**	**661**	**600**	**621**	**150**	**222**

Source: Ipsos, methodological and field report, 2023.

In total, 49 job modules were tested in the pilot. The interviews lasted on average 16 minutes, with screening time (obtention of consent, demographics and correct job module allocation) taking three to four minutes. A generic job module (non-specific occupation) was attributed to 9% of the respondents. In terms of socio-demographic distribution, the achieved pilot sample tended to underrepresent the younger age groups while the gender profiles were better aligned with the working population.

The pilot showed that the fieldwork monitoring and quality check tools implemented in the process worked correctly. Relevant additional checks were conducted, including control of the interviews where the generic job module was chosen, to better understand why. Some of the interviewers pointed out that the allocation of the worker to the right job module was sometimes difficult, especially in the case of occupations that are quite similar or jobs that are highly specific. To facilitate the selection process later during the main fieldwork, the job categories were updated with more examples. In addition, the coding team was in close contact with the interviewers during the pilot execution and they provided feedback on the text of open answers that were unclear and indicated what information was missing. Thanks to this exchange, the note-taking by the interviewers and the coding process were facilitated and improved.

In the WES questionnaire, information regarding occupation and economic activity was recorded thanks to open-ended questions. Following this process, the open answers were manually coded into 2-digit NACE and 3-digit ISCO codes. A triple coding process was arranged for 10% of the interviews in each country, where two different coders would assign a code independently, which would then be checked and verified by a third coder. The remaining responses (90%) were coded by the local teams.

Some mismatch was observed between the codes that different coders assigned to a given interview. Based on the feedback, the discrepancies were in the majority of cases related to the use of the ISCO 3-digit code frame, where some of the occupation descriptions are more ambiguous and generic, and not the 4-digit code frame, which is far more detailed and many coders are used to apply. To address this issue, the 4-digit code frames were circulated with the teams, and the process improved. In other cases, no ISCO or NACE code was assigned by the local coders, but upon investigation of the central team afterwards a code could be assigned in most of these cases. Specific feedback was given to the coding teams.

Based on the information obtained from the pilot, a few changes were implemented in the questionnaire in order to:

- decrease the interview duration, which was deemed too long (e.g. shortening the introduction, removing selected questions such as those relating to permission for re-contacting);
- increase the clarity of the questions;
- reduce unnecessary repetitive questions and open-ended questions;
- improve the correct allocation of job modules (including minimising the use of the non-specific generic job module); and
- refine the exposure assessment (i.e. reviewing some rules).

The online completion option of the survey (CAWI) was not successful in the pilot test. In the RDD sample, only six interviews (1% of the total sample) were obtained using the online mode. Despite the low conversion rate (from a refusal to telephone survey to responding to the survey online), it was

decided to keep the online option as a refusal conversion solution for WES, as in the main fieldwork the sample sizes would be substantially larger than in the pilot, and a higher absolute number of online completed interviews was expected. Collecting data from non-respondents via a Key Items Form was tested but not successful either, since only a minority of people who refused to participate were willing to provide this information (94 out of 10,734). Also, the coding of gender and age of non-respondents by the interviewer was challenging on the one hand because this coding is based on perception (voice tone, etc.) and is subject to considerable error, and on the other hand because this information cannot be made available at the individual level to respect the General Data Protection Regulation, or GDPR.

Finally, the pilot allowed to test the correct functioning of the questionnaire routing and the programming of the script with no issues detected by the checking syntax that ran daily.

3.4 Survey implementation

3.4.1 Sampling procedures

Target population and sample sizes

The survey population includes individuals working in all sectors of economic activity during the week preceding the interview, aged 15 years or older, and whose usual place of residence and employment is in the territory of the country where the survey takes place.

The EU Labour Force Survey (EU-LFS) definitions and guidelines were applied as much as possible to ensure consistency between WES and the EU-LFS. Following the EU-LFS guidelines, the target population in Finland was individuals aged 16 to 74 years. The definition of employment also followed the EU-LFS definition, and similar implementation rules were applied: a person was considered as employed if they did any work for pay or profit during the reference week for at least one hour.

The universe of reference comprised all individuals as defined above in the six countries covered, across all the occupations and sectors of economic activity, including those employed in public administration. WES, however, did not cover individuals doing housework for own use (NACE section T), individuals working in extraterritorial organisations (NACE section U), nor individuals in armed forces occupations (ISCO major group 0); hence, individuals belonging to these three categories were screened out.

Sampling frames and coverage

When selecting the highest-quality CATI sampling frames for the survey, the following options were investigated:

- **Individual level registers** where available, and when of sufficient quality: existing in all countries covered by WES, except in Ireland where only an address-level register is available. However, the registers in Spain and France cannot be used for surveys at the individual level, and only address-level sampling frames could be accessed in these countries. The population register in Germany is kept separately by each municipality, and sampling from it would require a clustered sample design pre-selecting municipalities and requesting a sample of individuals from each sampled municipality. This process would take a long time (around seven months), is labour-intensive and expensive (each municipality charges for providing the sample), and may not result in success in each municipality — some of them can refuse to provide the requested sample. The individual registers in Hungary and Finland can be accessed for surveys more easily and are commonly used for face-to-face surveys. However, none of these sampling frames, individual nor address-level ones, include telephone numbers, and it would be necessary to use external phone books and other sources to match telephone numbers to the sampled register records, so that they could be used in a telephone survey. In none of the six countries, except in Finland, is it possible to match phone numbers to sample records. In Finland, various sources (phone books of different providers) can be used for matching; however, based on previous experience, telephones could only be found for around 70% of the sampled individuals.

- **Phone registers** (e.g. phone books) of sufficient quality were considered as an alternative, but these were only identified in Finland, and the coverage of these registers was only at about 70%, as mentioned above.
- **Random digit dialling** was the method that could provide the best-quality samples in all six countries included in the survey. Ipsos used an RDD strategy targeting mobile phones only, which are shown to be used by 97-99% of the working population across the six countries included in the survey.[36] A dual frame approach using landline phones as well was finally discarded, as recent results using it in CATI surveys in Germany, Spain and France showed that most respondents reached via landline phone were unemployed or inactive, while the proportion of employed persons was significantly higher among respondents contacted via mobile phones. Also, an EU-OSHA feasibility study indicated that using mobile phones can enhance the participation of young people and migrant workers — groups that tend to be underrepresented in telephone surveys.[37] This would help improve the sample profile, and consequently decrease variance in calibration weights (See also section 3.5.3 on data weighting).

Generation of RDD samples

The procedure that was used for generating RDD samples is a standard approach used on all high-quality random probability CATI surveys.

The RDD generation of mobile numbers involved the following steps:

1. Identifying all eligible prefixes. The RDD sample was generated using the most recent lists of prefixes allocated in each country, by cross-checking the lists of a global sample provider (Sample Solutions) against the latest published by the organisations overseeing the allocations in each country. These checks were conducted by the Ipsos central team.
2. Drawing a sample of numbers with equal probability from all possible numbers attached to these eligible prefixes (such that all numbers per eligible prefix would have a chance of being included in the sample). A sufficient sample was generated to ensure there was enough for the survey.
3. Screening the selected sample using a provider lookup query that can accurately determine if the phone number is working (i.e. in use by a mobile phone subscriber) to identify active numbers. Additionally, phone numbers that were outside of the country (in roaming) were excluded and considered to be ineligible for the survey in the country they would be called from.
4. Checking the selected sample, by reviewing the sample proportions against external statistics on telecommunications providers, and adjusting where necessary. None of the countries reported a connection between telecommunications providers (available information) and regional distribution in their country. Several countries did report some correlation between migrant population and small, cheaper providers offering prepaid mobile services (e.g. Lebara in Germany, Spain and France). However, the market share of these providers is usually very small, so using it as a stand-alone stratum would not improve the sample design substantially. Finally, the central team in Ipsos checked that all the expected prefixes were included in the sample and that the format of the telephone numbers matched the expected format. The outcomes of these checks confirmed that the samples matched the expected market shares, and the sample conformed to expectations.

The described approach for sample generation gave every working number an equal probability to be selected. However, persons with multiple working mobile phones/SIM cards would have a higher chance of being selected. To allow calculating the probabilities of selection, information about the number of mobile phone numbers each respondent could be reached on was collected during the survey, and

[36] According to the Standard Eurobarometer 92 - Autumn 2019. See: https://europa.eu/eurobarometer/surveys/detail/2255

[37] See: EU-OSHA – European Agency for Safety and Health at Work, *Feasibility study on the development of a computer-assisted telephone survey to estimate workers' exposure to carcinogens in the European Union*, 2017. Available at: https://osha.europa.eu/en/publications/feasibility-study-development-computer-assisted-telephone-survey-estimate-workers

weighting procedures would be later applied to correct for unequal probability of inclusion in the survey (see section 3.5.3 on Data weighting).

Approach to oversampling: estimation of job module prevalence and exposure risk

To obtain robust survey estimates allowing for granular investigation and analysis of the survey results, Ipsos designed a sampling strategy that oversampled occupations with an expected higher risk of exposure to the selected cancer risk factors, and undersampled the occupations with an expected lower risk (e.g. office workers).

Since RDD samples do not contain additional details on mobile phone owners, it was not possible to pre-select a sample of eligible individuals. Additionally, occupation and economic activity sector of the respondent's workplace was not known in advance (this information was not available on the sampling frames), and so these details were captured during the screening interview.

Oversampling the desired job profiles was implemented by setting targets for each WES job module and achieving them through screening, that is, once the targets for the undersampled groups were reached, respondents from these groups were ineligible for further screening.

First, estimations of job module prevalence in the 2020 European worker population were derived by developing a tentative mapping of the occupations (ISCO-08 at 3-digit level) to the WES job modules. The majority of occupations were mapped to just one job module, with some exceptions (for example, 'office worker', the most prevalent job module in the population, was connected to 58 ISCO minor groups). To estimate prevalence, the latest available data from the Eurostat EU-LFS (annual 2020) providing the distribution of the working population at ISCO-08 3-digit level in the six survey countries were used. Using these data, the total numbers of workers per job module were calculated by summing the connected occupations. For around 80% of the population this could be done unambiguously given that each occupation fits just one job module. To classify the remaining 20% of the population, it was assumed that workers would be evenly distributed among the job modules making up an occupation with multiple ISCO mapping options. For example, the ISCO-08 minor group 214 'Engineering professionals excluding electrotechnology' was mapped equally to three modules: Office Workers (OFFW), Construction Trades (CONS) and Miners/Quarrymen (MINE).

With this approach, the expected prevalence of the modules in WES could be anticipated, with Office workers (OFFW) making up between 39% (Germany) and 29% (Spain) of the population, or roadside workers (RDSD) and petrol station attendants (PESA) showing to be among the least frequent job modules.

To consider which job modules to prioritise in the oversampling, those with greater exposure risk to the selected cancer risk factors in WES, several sources of knowledge were considered, including data from the 6th European Working Conditions Survey and the results from the exposure estimations obtained in AWES Cancer (2012). A group of 'low-risk' occupations was defined, with the following common occupations: Office Workers, Retail Workers, Teachers, Store persons and Drivers (OFFW, RETA, TEAC, STOR and DRIV, respectively). The approach used was to undersample the job modules that were classified as 'low-risk', by setting low targets of about 10% of their expected size, to reduce their share in the achieved sample, and sample all the other categories at the same rate. In other words, the 'not low risk' modules would be allowed to fall out naturally, but overall increased in size given that less of the sample was allocated to the 'low-risk' modules.

In conclusion, samples were drawn according to a disproportional sample design, which was later redressed by weighting.

3.4.2 Fieldwork

Interviewer teams and training

A field team was allocated in each country consisting of a project manager, experienced supervisors and interviewers. Both the project manager and main supervisor of each team had at least four years of experience in leading fieldwork for CATI population surveys with a random probability design, and they were (near-)native speakers of the main interviewing language in the country and highly proficient in English. During the main fieldwork, which lasted approximately 20 weeks from September 2022 to February 2023, a total of 393 interviewers were involved in the fieldwork. They all had at least one year

of interviewer experience, had followed a tailored WES interviewing training and had passed at least two test interviews prior to starting interviews.

Each interviewer was requested to conduct a sizable number of interviews — around 50 interviews. This was done to ensure that over the course of the fieldwork interviewers became familiar with the questionnaire and developed routines in addressing common challenges of the survey (such as objections to participation from respondents, correctly assigning the right job module and responding to common questions about the content of the questions). A small subset of interviewers who were performing very well in terms of job module allocation and with low refusal rates were asked to do a few more interviews than the set upper limit. On the other hand, the minimum threshold of 50 interviews was not achieved by 9% of the interviewers in all six countries, due to sickness during the fieldwork period, underperformance (and subsequent removal from the job), or because interviewers left the job.

Training for interviewers was organised as follows: a separate training was provided for national fieldwork managers and supervisors of each country, and for the local interviewers (both before the pilot and before the main fieldwork) with a similar approach. Training seminars were held online, and they covered:

- the background of WES and its purpose;
- the set-up and execution of the survey, including the questionnaire (with emphasis on the job module selection), the sampling, interviewer training and quality monitoring, and coding into ISCO and NACE categories;
- fieldwork timings, reporting and deliverables;
- the specific requirements and purpose of the pilot evaluation (for the pilot training only); and
- self-practice and test interviews.

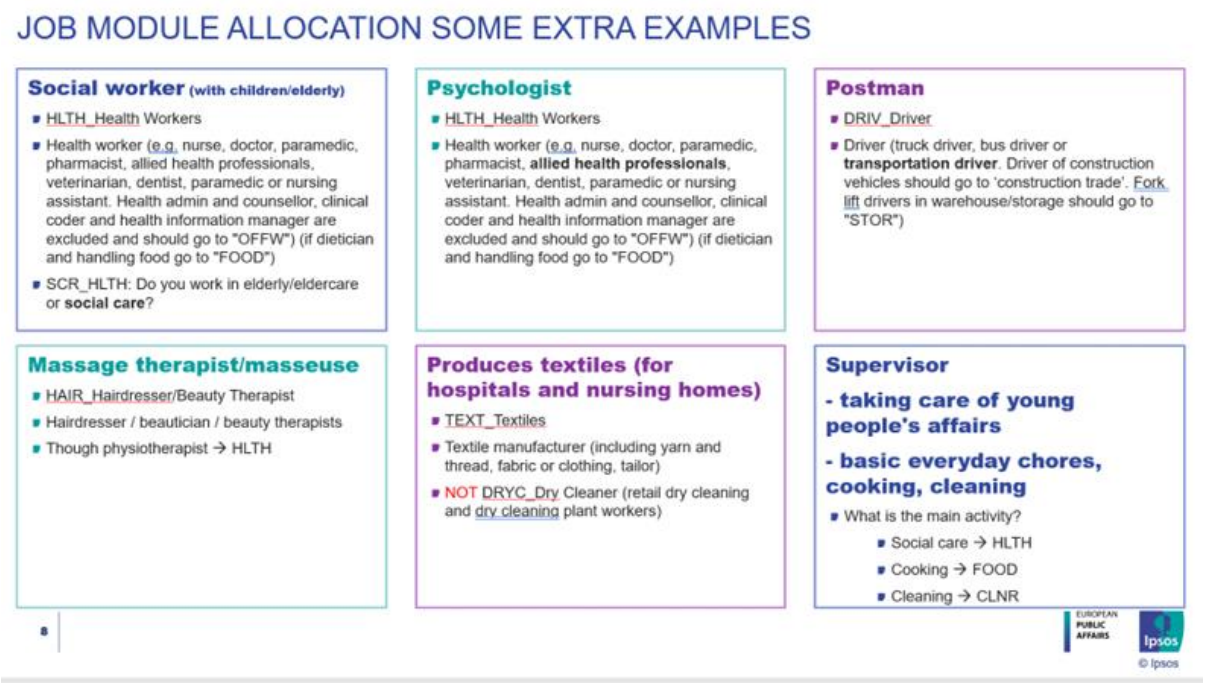
Before the training, all national fieldwork agencies received a set of training materials including the fieldwork manual in their local language, test links of the programmed national versions of the questionnaire and the full master questionnaire in Word format.

The training of the local interviewers was organised by the national fieldwork managers and their supervisors (train-the-trainer approach) and focused even more on the list of job modules and job module allocation and included refusal conversion strategies. In addition, at several time points during fieldwork (e.g. after the Christmas and New Year break period), re-briefings/re-training sessions were organised to optimise the quality of the interviews.

Several improvements in training procedures were implemented before fieldwork, based on the lessons learned from the pilot. These were:

- addition of many examples of specific occupations per job module, using real-life examples from the pilot (see Figure 2);
- more focus on selecting the most accurate job module, via an extended 'quiz' whereby 27 jobs had to be allocated to the right job module with subsequent discussions of the misclassifications; and
- more emphasis on quality control (focus on improving job module allocation) by the central and local teams.

Figure 2: Specific examples related to job module allocation developed for fieldwork training



Source: Ipsos, fieldwork material, 2022.

This process of training also involved a field visit by Ipsos and EU-OSHA at the FFIND main call centre in Palermo (Italy) at the end of November 2022, meeting the interviewer teams for Germany, Ireland, Spain and France. Online meetings were held with Ipsos, EU-OSHA, and the local teams from Hungary and Finland in early December 2022. All meetings were regarded as very instructive and motivating for the local interviewers in the countries.

Finally, a separate coding training was provided to the local coding teams.

Quality control of interviews

Daily monitoring of fieldwork progress and adherence to the call design was conducted by the central project team at Ipsos across the six countries. The percentage of complete interviews was examined by country, by job module and by key subgroup variables. The quality control of the conducted interviews at the central level included checking interview length, item non-response, missing data and job module allocation.

The local fieldwork agencies had access to the fieldwork dashboard for their own monitoring purposes. At the individual country level, the fieldwork agency supervisors monitored the quality of the interviews by listening in to live interviewers or to recordings of interviews. Checks were distributed over different parts of the survey, that is, at least 10% completed interviews, 50% start of the interview (introduction / screener up to the first job module question), 30% mid-interview (job module questions), and 10% end of the interview (outro questions). Different sections of the interview (introduction, screening, main questionnaire) were listened to for the same interviewer, so that further, very specific guidance and feedback could be provided, and corrective measures could be applied early if necessary (including removal from the project). In addition, the generated survey data were directly stored in an Ipsos central database and were checked throughout the fieldwork by the Ipsos central project team. This ensured that any issues were detected as quickly as possible, and that a large proportion of the data was already validated before the fieldwork ended.

Execution of the survey fieldwork

The fieldwork period lasted approximately 20 weeks from September 2022 to February 2023. The fieldwork was paused in all countries between 23 December and 8 January because of the Christmas and New Year holidays.

Table 4: Fieldwork period by country

Country	Start data fieldwork	End data fieldwork
Germany	28 September 2022	22 February 2023
Spain	28 September 2022	8 February 2023
Finland	13 September 2022	10 February 2023
France	28 September 2022	8 February 2023
Ireland	28 September 2022	8 February 2023
Hungary	12 September 2022	10 February 2023

Source: Ipsos, methodological and field report, 2023.

The target sample size for WES was 24,375 interviews. After completion of the fieldwork, 24,402 valid interviews were achieved, including 18 online.

Table 5: Target and achieved sample sizes by country and completion mode

Country	Target sample size	Achieved sample via CATI	Achieved sample via CAWI	Total balance
Germany	7,500	7,485	1	-14
Spain	3,750	3,765	1	+16
Finland	2,500	2,524	9	+33
France	5.000	4,988	0	-12
Ireland	2,500	2,500	0	0
Hungary	3,125	3,122	7	+4
Total	**24,375**	**24,384**	**18**	**+27**

Source: Ipsos, methodological and field report, 2023.

The effective average duration of the WES interviews was between 12 and 16 minutes, close to the initially estimated duration of 13 minutes.

EU-OSHA together with the Ipsos central team worked with the local agencies throughout the fieldwork period to optimise the selection of job module by the interviewer during the interview (as described above in training). In all six countries interviews in all job modules were achieved, except for florists, leather tanning workers, and workers in the manufacture/repair of shoes and leather goods in Finland (FLOR, LEAT and SHOE, respectively) and the generic job module in Spain. In Hungary and Finland, in some modules only a very limited number of interviews were obtained (fewer than 10), while in the other four countries all the modules, apart from the generic job module, were well represented. For some job modules, such as the one for farm workers in Hungary (FARM), the EU-LFS estimate was perceived as too high as it was not in line with national statistics.[38] The local agency in Finland reported that cleaners in Finland may be underrepresented, because not all cleaners (quite often migrants) master the Finnish language well enough to participate in the survey. This observation regarding cleaners not speaking the local language well enough was also supported by the field teams in the other countries, and it applied also to construction workers. Demographics of the sample, in terms of gender, age, or type of employment/weekly working hours or workplace size, will be presented in a detailed WES findings report.

Survey response rates ranged between 7% in Ireland and 22% in Finland. The main reason for non-response was refusal, with refusal rates ranging from 54% in Ireland to 34% in Spain and Finland. Measures to enhance response rates were applied through fieldwork at various levels:

- **Sample management:** a sufficient sample was selected in each country factoring in the response rate and incidence rate assumptions (including the oversampling) plus a margin for

[38] Based on the Hungarian Central Statistical Office 2022 data, 191,900 people out of a total of 4.7 million employed people, or ~4%, are working in the agricultural sector; the incidence rate for the module FARM added up to 3% in the WES sample in Hungary and is thus in line with the Central Statistical Office 2022 figures in the country.

contingency. In each country, the sample was batched into balanced sample replicates and loaded iteratively during fieldwork to maximise the response rate while ensuring that all the dialled sample was fully worked according to the fieldwork rules. The first of these batches was the largest, aiming to achieve 40% of the total sample, based on optimistic response rate estimates. The subsequent batches were smaller, to allow careful management of the final sample size.

- **Call strategy:** the fieldwork protocols consisted of a minimum of seven phone calls, on separate days, before a number could be coded as non-contact. The calls included at least one evening call (after 18.00), one morning call and two afternoon calls on working days, and one call during the weekend. There was also an interval of 15 days between the first and last call attempt. The proposed call pattern was designed to enhance participation of groups that are usually difficult to reach in telephone surveys, due to their long or unusual working patterns.
- **Fieldwork monitoring conducted centrally** (in addition to locally), using the same tools and templates for all six countries.
- **Providing reliable information on the project:** EU-OSHA placed information about WES on its official website page, so that potential respondents could consult it if interested. This information was available in all the languages used in the survey.
- **Providing an online completion mode option** to respondents who refused participation in the telephone interview in all six countries. In total, 1,807 potential respondents provided their email address, indicating that they did not want to participate over the phone but were willing to complete the survey online. However, of the 316 who started the survey online (17%), only 35 reached the end of the survey without being screened out (in the majority of cases because they were not willing to complete the open-ended question providing information on their Job Title and Job Function). Finally, 18 online completed interviews were retained as valid because in the remaining 17 interviews the respondents did not choose the best fitting job module.

3.5 Data processing

3.5.1 Data quality

The data collected for the survey were subject to several technical controls (e.g. accuracy of final scripts before the start of fieldwork to identify unforeseen codes or dummy data) and to consistency and response quality checks.

Regarding quality control, further manual checks were conducted if interviews were flagged on any of the below aspects:

- **Survey duration:** given that the length of an interview depended largely on the routing interviewers/respondents followed within a particular job module, an expected 'length of interview' per job module and per country was determined based on the number of questions answered. If the interview duration was less than half of the targeted duration, the interview was flagged. Normally, incorrectly assigned job modules lead to shorter interviews with a higher number of 'non-response' or 'don't know' answers.
- **Item non-response analysis:** all interviews for which more than 10% of the job module questions were listed as 'don't know' or 'refusal' were flagged.
- **Check on job module allocation:** EU-OSHA and Data Scientists provided Ipsos with identified cases where the accurate job module was probably not selected, for example, cases whereby the respondent only responded with 'other' or 'don't know' to the first questions in the job module. Those interviews were reviewed by the central project team at Ipsos.
- **Allocation of the generic job module:** some interviewers selected the generic job module whereas a more accurate/appropriate job module could have been assigned. Therefore, all interviews where the generic job was selected went through an extra manual review.

- **Marked as 'insufficient information available for coding'** for either the ISCO or NACE recoding by the coding team.

Altogether, the number of disapproved interviews decreased over time as fieldwork progressed.

Within the job modules, some questions allowed for open answers. The Ipsos central team reviewed these answers during the fieldwork with the objective to verify if the open answer was indeed different from the available answer options, or if on the other hand it was possible to recode them into an existing answer option. Such recoding was only applied if there was no routing/filtering impact. Specifically, this recoding of the open answers into an existing answer option was applicable to 13 variables only, and recoding was conducted after review and agreement with EU-OSHA team. In total, data editing on the open answers was done for 194 interviews. Table 6 presents the recoded interviews by job modules.

Table 6: Number of interviews with a recode of the open-end into an existing answer option by job module

Job module	Interviews with open answers recoded to an existing category
HLTH – health workers	60
CONS – construction trade workers	39
CLNR – cleaners	33
FOOD – food workers	25
SHIP – shipping industry workers, seamen or fishermen	13
IMAR – industrial manufacturing, assembly or repair workers	8
CHEM – chemical and pharmaceutical industry workers	6
TEAC – teachers	6
MINE – miners/quarrymen	2
ROAD – road construction and maintenance workers	1
UPHO – upholstery industry workers	1
Total	**194**

Source: Ipsos, methodological and field report, 2023.

3.5.2 Data coding

During the interviews, respondents provided information regarding occupation and economic activity via open-ended questions. The recorded answer was manually coded into ISCO-08 3-digit and NACE 2-digit classifications respectively. The team of coders were trained in March 2022 before the beginning of the pilot of the survey, and they received an additional briefing in October 2022 before starting the coding of data from the main fieldwork. As with the pilot stage, the coding process was spread across the entire fieldwork period. The quality of the open answers' text was continuously monitored in all countries, and in Germany and Hungary extra training was organised to improve quality of interviewer notes (on correct probing and on capturing enough information in the open ended questions. Improvements were observed in those two countries as the mainstage fieldwork progressed. In the other four countries, the open answers' text quality was overall deemed good by the global coding team.

Additionally, a triple coding process was conducted for 10% of the sample in the six countries (two independent coders, and a final review done by a third coder), with overall coding agreement reaching 90% or more of the cases.

Table 7: Percentage of agreement between coders on ISCO and NACE coding

	Total	Germany	Spain	Finland	France	Ireland	Hungary
% agreement between local coders (ISCO)	**93**	100	100	88	100	100	73
% agreement between local and central coders (ISCO)	**94**	99	99	96	100	100	76
% agreement between local coders (NACE)	**87**	91	94	85	87	82	79
% agreement between local and central coders (NACE)	**91**	94	94	96	93	98	78

Source: Ipsos, methodological and field report, 2023.

3.5.3 Data weighting

Data weighting procedures were applied following best practice approaches (commonly used in European cross-national surveys). The weighting process closely followed the sample design, and consisted of the following:

Design weights

These are intended to equalise the probabilities of selection of sample units to create an unbiased sample. Unequal selection probabilities (i.e. where a particular group is sampled at a higher or lower rate relative to another) in the mobile RDD samples could arise due to a variable number of mobile phone numbers each person could be reached on. Most of the population use one mobile phone/SIM card, and this applied to over 85% of the overall WES sample. However, those with multiple phone numbers have multiple chances of being contacted and selected in the sample. Each respondent surveyed was asked to provide information on the number of mobile phone numbers they could be reached on, so that an adjustment could be made for this factor. The weight was calculated as the number of mobile phones owned by each respondent, capped at the 97.5th percentile at a country level (two mobile phones in all countries except Finland, which was three). Cases with item non-response were set to the modal value (one mobile phone).

Oversampling jobs with a higher exposure to cancer risk factors, by undersampling those with a lower expected exposure, also introduced unequal probabilities of selection. The rate of over (and under) sampling was determined by the sampling strategy and approach to screening job modules, and the required information to calculate selection probabilities was captured via the screening questions (job-specific module selection questions). The selection probabilities for a given job module were calculated as the number of respondents actually selected to enter and complete the module (i.e. completed interviews) divided by the number that qualified for it. The latter quantity (denominator) included additional cases in the five 'low-risk' job modules[39] that were screened out once the interview targets for these modules had been met, reducing selection probabilities for such modules and therefore needing a weighting adjustment. The design weight for oversampling was calculated as the inverse of this selection probability.

The full design weight was calculated as the product of the phone ownership and oversampling weight. The weight was capped at a maximum value of 10 to improve sample efficiency.

Calibration weights

To ensure that the sample accurately reflects the socio-demographic structure of the target population, a calibration weighting procedure using rim weighting was carried out on a country-by-country basis.

[39] OFFW, RETA, TEAC, STOR and DRIV.

The principle behind this type of weighting is that by aligning the sample and population on key variables for which population statistics are known, the accuracy of the other variables in the survey (which may have been affected by non-response or coverage bias) is expected to be improved. It is also generally considered preferable in cross-national surveys to use the same set of variables across countries, to promote comparability of the weighted samples.

To consider the most suitable strategy for the survey, a short review stage was undertaken after collection of the data. This involved inspecting comparisons between socio-demographic variables on the survey data and external population statistics that could be used in the weighting. The comparisons used the latest EU-LFS annual data (2021) as reference statistics and covered age, gender, region, occupation, sector of economic activity, contract type within professional status as a single derived variable, and country of birth. Initially, the comparisons contrasted unweighted and design-weighted estimates. Broadly, it showed that the design weights reduced some of the differences between unweighted survey proportions and the reference statistics, with most of the bias uncontrolled. The variables showing more substantial design-weighted improvements were occupations and sector of economic activity, driven by the oversampling adjustments. For the other variables, improvements were modest in most countries with a small number of exceptions. Bias on age was slightly worse in Finland after design weighting (but still very small), region was worse in Hungary, contract type within professional status was strongly improved in Hungary but was worse in Finland, and country of birth was strongly improved in Ireland and was a bit worse in Germany and Finland. The impact of the design weighting on job module profile was also sense-checked against the expected profile.

Several different calibration weighting schemes were run and the profiles checked against the reference statistics. Weighting efficiency was also compared for each of the options. The options were reviewed with EU-OSHA and refinements were made, considering EU-OSHA's expectations on potential correlation with survey measures of the candidate weighting variables. The final calibration weighting scheme included the following variables (weighted to EU-LFS 2021 annual population proportions):

- Age by gender, with age in 10-year bands covering 15-24, 25-34, 35-44, 45-54 and 55+.
- Occupation at ISCO 2-digit level for major groups 3, 5, 7, 8 and 9; and 1-digit level for the other occupations.
- Sector of economic activity at NACE 2-digit level for sections C and G; and 1-digit level for the other sectors.
- Contract type within professional status.

Missing values on any of the weighting variables were assigned the modal value. Small occupation and sector weighting cells were combined at a country level to ensure a minimum of 30 sample cases per weighting cell. Mostly, the same approach was used in each country, and aimed to merge similar categories that might have a similar risk profile. For Ireland, it was not possible to further break down NACE section C and so a slightly different approach was used.

The weights were trimmed a final time by capping the calibration component of the final weight at the 97.5th percentile. The efficiency of the final weight was checked, using both Kish's formula, which approximates sample design effects based on the variation in the weights, and the design effect for three risk variables derived from the survey data. This showed that, although the weights were highly variable, the actual design effects for key survey measures were low. It suggests that the risk variables had a relatively low correlation with the weights, given that the groups that were undersampled (which required large weights) were mainly grouped in the low exposure categories. The only exception was exposure to diesel exhaust, which had higher design effects and hence weight variance across risk profiles most obviously due to undersampling drivers.

As a final step, two weights were created to facilitate cross-country analysis. The first grossed the total weighted sample size to the total survey population in each country. The second scaled this grossed weight so that the weighted and unweighted sample sizes were equal across the six countries combined.

The WES dataset, including the final exposure estimation to the 24 cancer risk factors and demographic and job-related information for all respondents, will be made publicly available for research purposes in 2024.

The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1994 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments, employers' and workers' organisations, as well as leading experts in each of the EU Member States and beyond.

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