

Feasibility study on the development of a computer-assisted telephone survey to estimate workers' exposure to carcinogens in the European Union

European Risk Observatory

Report

Feasibility study on the development of a computer-assisted telephone survey to estimate workers' exposure to carcinogens in the European Union

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List of abbreviations

ANZSCO	Australian and New Zealand Standard Classification of Occupations
ASA Register	Register of Workers Exposed to Carcinogens
AWES	Australian Work Exposures Study
BPR	Biocidal Products Regulation
CATI	computer-assisted telephone interviewing
CAWI	computer-assisted web interviewing
CLP	Classification, Labelling and Packaging (Regulation)
CMD	Carcinogens and Mutagens Directive (2004/37/EC)
COR	Classification of Occupations in Romania
EODS	European Occupational Diseases Statistics
ESENER	European Survey of Enterprises on New and Emerging Risks
ESS	European Statistical System
EU	European Union
EU-OSHA	European Agency for Safety and Health at Work
EWCS	European Working Conditions Survey
FINJEM	Finnish Job-Exposure Matrix
HDO	International Hazard Datasheet on Occupations
IARC	International Agency for Research on Cancer
ICOH	International Commission on Occupational Health
ILO	International Labour Organization
IOM	Institute of Occupational Medicine (UK)
ISCO-08	International Standard Classification of Occupations
JSM	job-specific module (questionnaire module in OccIDEAS)
KIdB	German Classification of Occupations (<i>Klassifikation der Berufe</i>)
KZiS	Polish Classification of Occupations
LFS	Labour Force Survey (Eurostat)
NACE	Statistical classification of economic activities in the European Community

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NOCCA	Nordic Occupational Cancer study
OccIDEAS	Occupational Integrated Database Exposure Assessment System
ODIN	Organisationsdienst für nachgehende Untersuchungen (organisation service for follow-up examinations)
OEL	occupational exposure limit
OELV	occupational exposure limit value
OSH	occupational safety and health
PAHs	Polycyclic aromatic hydrocarbons
PPE	personal protective equipment
RQ	research question
SIREP	Information System for Recording Occupational Exposures to Carcinogens
UV	ultraviolet
WOODEX	International Information System on Occupational Exposure and Health Effects of Wood Dust

Executive summary

Cancer is an important cause of occupational diseases and work-related deaths in the European Union (EU). The disease can have multiple causes, and its causes and their interplay are not fully known. However, it is evident that a number of work-related factors contribute to cancer. It is therefore an important task for employers, safety and health practitioners and regulators to reduce or even eliminate work-related factors likely or known to contribute to cancer.

The prevention of work-related cancer has been an important focus of EU activities in the field of safety and health for years. One of the main aims of the Commission's new safety and health initiative launched in January 2017 is 'to better protect workers against work-related cancer'.

It is known that exposure to carcinogens at work contributes to work-related diseases, including various forms of cancer. The European Commission therefore aims to reduce exposure to carcinogens as far as possible.

For effective, evidence-based policy measures aiming to reduce exposure to carcinogens, reliable data on the occupational exposure of workers are an important prerequisite. Against this background, EU-OSHA launched this 'Feasibility study on the development of a computer-assisted telephone survey to estimate workers' exposure to carcinogens in the EU'. The aim of the study is to assess how far a survey among workers could improve knowledge about exposure to carcinogens at the workplace and to investigate what preparatory steps would be required to run such a survey in the EU.

Five research questions (RQs) were raised and will be tackled in this report:

- RQ 1: complementarity of the survey with existing sources on exposure to carcinogens
- RQ 2: EU-wide availability of the information required to run the survey
- RQ 3: achievable level of reliability
- RQ 4: comparability of results across countries and over time
- RQ 5: preparatory work required for the implementation of the survey.

Types of agents considered for the study

The International Agency for Research on Cancer (IARC) classifies carcinogens into five groups. The **IARC categories provide an orientation regarding the likelihood that an agent contributes to cancer**, reflecting the current state of scientific knowledge:

- group 1: carcinogenic to humans
- group 2A: probably carcinogenic to humans
- group 2B: possibly carcinogenic to humans
- group 3: not classifiable as to its carcinogenicity to humans
- group 4: probably not carcinogenic to humans.

For this feasibility study and a potential worker exposure survey, **only agents of IARC groups 1 and 2A will be considered**. For the remaining IARC groups, there is currently not sufficient evidence as regards their carcinogenic potential.

Not all cancer risks emanate from substances. There are a number of different **risk factors for occupational exposure to carcinogens**. The following major groups of carcinogens can be distinguished:

- gases (for example formaldehyde)
- liquids (for example trichloroethylene, mineral oils, hair dyes)
- solids, including dusts and fibres (for example respirable silica, wood dust, asbestos, lead, bitumen)
- fumes (for example diesel exhaust, welding fumes)

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- pesticides (for example DDT)
- pharmaceuticals
- biological factors (for example bacteria, viruses, certain types of fungi)
- physical factors (for example X-rays, solar radiation, ergonomic factors such as sedentary work)
- other factors (for example shift work involving circadian disruption, stress-related obesity, drinking).

Information needs

To be able to effectively reduce exposure and protect workers against cancer, it is necessary to know more about the nature and dimensions of the exposure. In particular, it is essential to have information on:

- the overall **number (and proportion) of workers exposed** to carcinogens;
- the **types of workers most exposed** to carcinogens (by age, sex, occupational group, etc.);
- the **exposure situations most prevalent at workplaces** in Europe;
- the **carcinogenic materials and agents** responsible for the most prevalent exposure types.

Further issues of interest are:

- How far are affected workers aware of being exposed to carcinogens?
- What is done to protect workers from the exposure and what are the workers themselves doing in this respect?

More knowledge of these aspects would help to prioritise and better target legislative measures, prevention initiatives or awareness campaigns. With regular updates of this information, changes in, for example, the number and type of exposed workers or in the most prevalent agents could be observed.

Existing data sources

So far, only some EU countries collect information on carcinogen exposure in a reliable and systematic way. Various data sources can be distinguished:

- National exposure registers, information systems or measurement databases fed by data collected from employers or safety and health organisations and authorities;
- national surveys on working conditions, including questions related to cancer;
- national cancer registers;
- registers of occupational diseases.

Because of large differences in, for example, which diseases are recognised as occupational, these national sources are not comparable. Having this type of information available EU-wide in a harmonised form would, for example, allow the identification of best practice examples as well as sectors where the need for action is particularly high.

One of the few existing EU-wide data sources containing information related to the exposure to carcinogens is the **European Working Conditions Survey (EWCS)**, conducted by Eurofound every 4 years. The EWCS is a survey among workers and collects information on a broad variety of working conditions. This includes some information that can be useful for an analysis of the exposure to carcinogens. The **questions** related to these exposures are, however, **mostly rather general, not allowing a clear identification of exposure to specifically carcinogens**.

The **European Occupational Diseases Statistics (EODS)** are another supra-national source of information. The EODS collect data on, among other things, the occupation of the victim and the exposure circumstances leading to the occupational disease, for example cancer. This knowledge is based on cancer cases and improves knowledge of exposure circumstances likely to lead to cancer. However, there are large differences between countries as regards the recognition of occupational diseases, and not all workers are covered in the EODS. For Germany, Greece and Lithuania, data are

even totally missing. Another drawback is that the EODS cannot map the exposure of workers not yet suffering from cancer. Information on their exposure is important because it allows more timely setting up of preventive measures.

In an effort to improve the collection and harmonisation of data, the European Commission, Directorate-General for Employment, Social Affairs and Inclusion, launched **HazChem@Work** in 2014. The set-up and testing of a Europe-wide database with measurement data on occupational exposure to a list of hazardous chemicals was the object of this initiative. So far, the national sources of measurement data on carcinogens differ greatly from each other in terms of the general nature of information, the substances considered, the quality of information and the sources from which the information derived (employers, safety and health institutions, labour inspectorates). The idea was that a harmonised EU-wide register building on the existing national registers could possibly improve this situation. If set up EU-wide according to harmonised standards, HazChem@Work could provide measurement-based information on the number and kind of workers exposed to a broad array of chemical substances, including, to a somewhat limited extent, to carcinogens.

Another possibility to get more and better information on the exposure of workers to carcinogens is the **set-up of a worker survey focused on the exposure to carcinogens**. EU-OSHA's idea of considering setting up such a survey was inspired by AWES-cancer, a worker survey run in Australia on behalf of Safe Work Australia, the Australian government body responsible for safety and health of workers.

AWES/OccIDEAS: the survey concept in brief

The AWES-cancer survey, conducted in Australia in 2011/2012 among 5,000 workers, is the most comprehensive application of the exposure assessment system OccIDEAS (Occupational Integrated Database Exposure Assessment System), developed by a team of researchers from Curtin University in Australia. Since then, OccIDEAS has also been applied in Malaysia and has been broadened to include further safety and health risk factors such as asthmagens or noise and vibrations.

The basic principles of the OccIDEAS concept are described on the project website (www.occideas.org):

OccIDEAS is a web-based ¹ application which is used to assess occupational exposure in epidemiological studies. It is used to determine whether workers are exposed to various chemical and physical hazards (agents) based on their answers to questions about their work tasks [...]. It provides assessments of the likelihood of exposure to specific agents for each job on an individual basis. The process involves [four] steps:

- *determining the job category for a person's job*
- *asking a set of questions (a module) about tasks which are specific for that job*
- *automatically assessing exposure to [the] selected agents using preprogrammed algorithms*
- *allowing manual review of those assessments.*

The targeted persons are thus interviewed about their job and asked a number of customised questions related to working tasks performed in this job that can be associated with an exposure to potentially carcinogens. Depending on the tasks actually performed and the protective measures taken when doing them, the likelihood and the degree to which a subject is exposed are estimated on a 3- or 4-point scale²:

- **probability of exposure** (none, possible, probable) for all agents
- **level of exposure** (none, low, medium or high) for carcinogens.

¹ Although OccIDEAS is web-based, it has so far been applied not in any online surveys, but only in computer-assisted telephone interviewing (CATI). The term 'web-based' refers not to the survey mode, but to the environment in which OccIDEAS is programmed and made available. For telephone surveys using OccIDEAS, the call centre is linked online to the OccIDEAS questionnaire hosted at Curtin University.

² It should be noted that the investigation and assessment of the job history of a person, an essential element of the Expert Assessment Method, is not part of OccIDEAS and the underlying algorithms. The OccIDEAS questionnaire maps only the work currently performed by an interviewee, not the work performed in earlier years. For this, a lot of additional questions would be necessary which in turn would make the survey far too long.

The amount of wood dust a carpenter is exposed to might, for example, depend on whether he or she used power or hand tools, whether he or she worked indoors or outdoors, whether or not a dust extraction fan was present and whether or not he or she wore a mask. Based on these criteria, the probability and level of exposure are determined. The level of exposure related to a particular task has been defined *ex ante*, based on previous research in epidemiological studies and the expertise of a team of experts. The overall exposure situation of a person is determined based on the sum of exposures in all tasks that turn out to be relevant to the person.

The OccIDEAS questionnaire provides more than 50 job-specific modules with customised questions about tasks, materials used and possible exposure circumstances. Assigning a respondent's job to the module that fits it best is key for the success of the survey. The module is assigned on the basis of a sequence of two or three closed questions asking about the sector of activity and main characteristics of the person's job. The questionnaire collects free text descriptions of the sector and occupation in addition, which allow *ex post* coding of the job in accordance with official classifications such as ISCO-08, the ILO classification of occupations.

Exposure data collected with the OccIDEAS instrument can be analysed from three different angles: by **agents**, by **sectors of activity** and by **occupational groups**. Particularly for the last, however, the number of interviews available for the group puts some limits on the analyses. The roughly 5,000 interviews conducted in AWES-cancer were distributed very unevenly over the job-specific modules, with some modules answered by just one worker and others by a few hundred workers. Modules with only a small number of respondents cannot be used for any occupation-specific analyses.

Information obtainable from a survey based on OccIDEAS

- A worker exposure survey could significantly fill the gaps regarding harmonised information on the number of workers exposed and their characteristics. It can provide representative information on exposure to carcinogens for all kind of work activities or exposure situations.
- The OccIDEAS survey concept is able to map exposure to any cancer risk factor considered in the questionnaire. The current version of OccIDEAS already maps 38 risk factors currently known to be relevant, including UV radiation, diesel fumes, silica, X-rays and shift work.
- A big advantage of a worker survey mapping exposure is its ability to map multiple exposure situations of individuals. Many other sources, such as those based on reporting by employers (HazChem@Work), can indicate the number of exposed persons only for each agent separately.

However, there is some information which is not obtainable from a survey based on OccIDEAS.

- OccIDEAS can map only exposure situations and circumstances that are already known and included in the questionnaire. It cannot map any exposure the researchers were not aware of.
- In its current form, a survey based on OccIDEAS can provide **only very limited information on the frequency and duration of exposure situations**. In earlier versions of the survey concept, questions related to these time dimensions had been included, but they were abandoned because of measurement problems and annoyance on part of the respondents about the length and repetitiveness of the questionnaire.

In principle, the OccIDEAS concept can be augmented by additional questions, thus further enhancing its added value:

- A few questions related to the respondent's overall awareness of carcinogenic hazards at their workplace would allow comparison of data on the real (estimated) risk situation with awareness data, providing hints on where to best target preventive measures.
- Questions related to barriers to better protection of workers from carcinogenic hazards could also be useful for the prioritisation and targeting of preventive measures.

Thanks to its objective, fact-based questions on concrete tasks and exposure situations, a worker survey based on OccIDEAS is likely to deliver data with a high degree of cross-national comparability. In contrast to many other surveys on working conditions, the data do not depend on the risk awareness

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and risk perceptions of respondents. The independence of individual perceptions and risk awareness also ensures generally high comparability of the data over time. A limitation to comparability over time is, however, the lack of questions related to the time dimensions of exposures: changes of frequency or duration of the exposure to a carcinogen over time are not visible if the number of affected workers remains stable.

Provided that the survey instrument is well adapted and tested before its large-scale implementation in Europe, the data quality can generally be regarded as high. The only concern in terms of data quality is that low-skilled workers in some jobs might not always be able to provide the requested information accurately.

Although the worker survey would partly deliver similar information to that of HazChem@Work, the different modes of data collection also lead to some substantial differences. A worker survey provides more information on the characteristics of workers, it allows the analyses of multiple exposures and it is able to cover a broad variety of workers, including e.g. also family workers, self-employed or employees of micro enterprises. Likewise, the exposure survey is able to cover all types of agents, whereas HazChem@Work is limited to chemicals. HazChem@Work could in turn provide more information on the frequency and duration of exposure situations and possibly more detailed information on agents and materials. Because of how the data are collected at the national level, these would, however, be less homogeneous and less representative.

Prerequisites for setting up an EU-wide Worker survey

Before implementation in the European Union, OccIDEAS would have to be thoroughly checked on any need for adaptations. Example research done for two job-specific modules ('farmers' and 'construction painters') indicate that substantial differences between Australia and Europe regarding tasks, agents and materials are rather unlikely. Nevertheless, all questionnaire modules would have to be scrutinised on possible differences. Some jobs and exposure circumstances not relevant to Australia and therefore not included in OccIDEAS might, for example, be relevant to Europe.

The feasibility study has also shown that some agents relevant to Europe are not covered by OccIDEAS and thus need to be added. For this, new questionnaire modules and assessment algorithms have to be developed.

Sources with descriptions of job-specific tasks and exposure circumstances have been identified in the feasibility study. The ISCO-08 job descriptions or the job profiles from the International Hazard Datasheets on Occupations (HDOs) issued by the International Labour Organization (ILO) could, for example, be used for this purpose. In addition, sector-specific experts with good knowledge of tasks, materials and health hazards need to be consulted.

In a further step, relevant differences between the EU Member States need to be assessed for all modules. Although sample research has not shown any major differences between EU countries, this needs to be verified for all jobs and questionnaire modules. If substantial differences exist between EU countries, the questionnaire needs to take account of this.

Required sample sizes and survey costs

Although national samples of just 1,000 to 1,500 interviews would allow reasonably precise conclusions on the overall exposure situation in a country to be drawn, it is strongly recommended that the survey be launched with a considerably larger sample size in order to allow national analyses by sectors or occupational groups. A good compromise between survey costs and quality requirements would be 3,000 interviews per country.

Fieldwork for an EU-wide exposure survey conducted with 3,000 interviews per country is estimated to cost roughly EUR 4 million to EUR 5 million, depending on the average interview duration. The cost estimate includes translations and a large-scale pilot of the survey in up to five countries. It does not include the preparatory work for an adaptation of the survey to Europe. This work would have to be done

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in close cooperation between a European team of researchers and the OccIDEAS team at Curtin University, Perth, Western Australia.

Table 1: Required sample sizes, duration and survey costs for different variants

Variant	Interviews per country	Interviews in total (EU-28)	Average duration (minutes)	Estimated price (2017) (EUR)
1	1,000	28,000	15	2,400,000
2	1,000	28,000	20	2,600,000
3	2,000	56,000	15	3,300,000
4	2,000	56,000	20	3,700,000
5	3,000	84,000	15	4,100,000
6	3,000	84,000	20	4,800,000

The costs relate to a CATI survey with a dual frame sampling approach, that is with a sample including both landline and mobile telephone numbers in a representative way. The dual frame approach will ensure better representation of groups that are usually underrepresented in telephone surveys – for example young, unskilled or migrant workers. For adequate coverage of migrant workers, additional measures such as the offer of multilingual interviewing would be worth considering.

Although OccIDEAS has so far been conducted as a CATI survey only, it is recommended that its implementation as a mixed-mode survey be tested, offering both the telephone and the online (CAWI) mode to respondents. In this way, the applicability of the survey as an online survey could be tested. Most EU countries do not currently have representative address registers listing email addresses of individuals, so a genuine online survey is not an option EU-wide. However, if mixed-mode applications of the survey do not show any significant mode effects, future survey waves could be conducted online in countries where an adequate sampling frame exists for this.

Final conclusions and recommendations

An EU-wide survey following the OccIDEAS model would be able to deliver highly relevant, harmonised and representative information on the exposure of workers to carcinogens. The fact-based questionnaire concept is largely independent of the expectations and awareness of respondents. The data would therefore have a high degree of validity and cross-national comparability. A thorough adaptation of the survey to the situation in the European Union and the consideration of intra-EU differences in jobs or tasks are, however, essential for achieving high data quality.

The research team recommends the implementation of a worker survey on exposure to carcinogens in Europe, closely following the OccIDEAS concept and adapting it only in details (Scenario 1). OccIDEAS has reached a high degree of maturity, has been extensively validated and is constantly being further improved. The lack of questions related to the frequency and duration of exposure would, however, have to be taken into account in this scenario.

The alternative would be to set up a new exposure survey from the scratch (Scenario 2). This would be a huge task, requiring much higher investments in terms of time and money. The main benefits could be greater resulting harmonisation of job-specific modules with the ISCO-08 classification and the introduction of an additional time dimension. However, these modifications might endanger the practicability of the survey concept by leading to a much larger number of questionnaire modules and to a very lengthy, repetitive questionnaire.

1 Introduction

Cancer is an important cause of occupational diseases and work-related deaths in the European Union (EU). According to Jukka Takala, president of the International Commission on Occupational Health (ICOH), cancer at work is even 'the biggest individual threat when looking at the number of deaths in the developed world' (Takala, 2015, p. 1). Although the causes of cancer are not yet fully understood, it is evident that some work-related factors contribute to cancer, in particular to lung cancer. As far as possible, these factors should be eliminated or at least minimised in order to improve the health of workers and their life expectancy. According to Takala, the chances of this are comparatively good if the problem is tackled with determination: 'While cancer is a multifactorial disease and some causal factors are difficult to modify, it is clear that cancers caused by work can be prevented by reducing or eliminating the exposures leading to the disease. In fact these cancers are the easiest ones to tackle' (Takala, 2015, p. 1).

Reliable knowledge of the occupational exposure of workers to carcinogens is an important prerequisite for effective, evidence-based policy measures aiming to reduce exposure to carcinogens. Against this background, the European Agency for Safety and Health at Work (EU-OSHA) launched this 'Feasibility study on the development of a computer-assisted telephone survey to estimate workers' exposure to carcinogens in the EU'. The aim of the study is to assess how far a survey among workers could improve knowledge about exposure to carcinogens at the workplace and to investigate what preparatory steps would be required to run such a survey in Europe.

The idea of possibly setting up a worker survey on exposure to carcinogens in Europe was inspired by AWES-cancer³, a worker survey run in Australia on behalf of Safe Work Australia, the Australian government body responsible for safety and health of workers. The AWES-cancer survey is based on the Occupational Integrated Database Exposure Assessment System (OccIDEAS), developed by a team of researchers from the Curtin University in Perth, Australia. To sum up, the OccIDEAS concept consists of a survey questionnaire, asking workers about the tasks they perform, and an algorithm-based expert assessment system that assesses the likelihood and degree of exposure on the basis of these data.

Five research questions (RQs) were raised and will be tackled in this report:

RQ 1: complementarity of the survey with existing sources on exposure to carcinogens

RQ 2: EU-wide availability of the information required to run the survey

RQ 3: achievable level of reliability

RQ 4: comparability of results across countries and over time

RQ 5: preparatory work required for the implementation of the survey.

The report starts with an assessment of the information needs at the EU level as regards the exposure of workers to carcinogens. The information needs will then be compared with the information that already exists from different types of sources.

Having identified the information needs, the AWES/OccIDEAS concept will be explained and its potential to meet (part of) the information needs will be assessed. Potential weaknesses of the AWES/OccIDEAS survey concept will also be discussed and ideas on how to improve these will be presented.

Since AWES/OccIDEAS was developed for the situation in Australia, it is not necessarily implementable in the European context. Chapter 4 will discuss how the survey concept could be adapted for use in Europe, and with what types of modifications. Differences between Australia and Europe as well as differences between the various EU Member States will have to be taken into account.

³ AWES stands for Australian Work Exposures Study. In order to distinguish the AWES survey conducted in 2011/12 on exposure to carcinogens from AWES surveys carried out in later years on other agents, the team in charge of that survey calls it AWES-cancer.

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A further issue of relevance to the decision on implementing the AWES/OccIDEAS survey concept in Europe is how good the exposure estimates are that can be derived from such a survey. The quality dimensions include the reliability and accuracy of the estimates as well as aspects related to the comparability of results across countries and over time.

The report will conclude with an estimate of the time and costs likely to be needed to set up an exposure survey in Europe, and a summary of the research team's final recommendations regarding the adaptation and application of this instrument.

2 Exposure of workers to carcinogens: information needs and existing data sources

The first of the research questions relates to an investigation of the information needs and the already existing sources of information on the exposure of workers to carcinogens in the EU. What information is needed, who needs this type of information and for what purpose?

2.1 Information needs

The European Commission Directorate-General for Employment, Social Affairs and Inclusion is the main political actor in the field of safety and health at work at EU level, supported by EU-OSHA. According to the Commission's assessment, 'Health and safety at work is one of the areas where the EU has had the biggest impact – with a solid legal framework covering the maximum number of risks with the minimum number of regulations'⁴. Most of the EU legislation on safety and health at the workplace has been drafted as framework legislation. All EU Member States have to use the framework as a guideline and minimum standard, but are free to adapt the framework to a certain degree to the national situation, for example existing national legislation or particularities in the national economy.

Exposure to carcinogens at work contributes to work-related diseases, including various forms of cancer. It is therefore an explicit aim of the European Commission to reduce exposure to carcinogens as far as possible. The prevention of work-related cancer has been an important focus of EU activities in the field of safety and health for years and has recently received particular attention. In January 2017, the Commission launched a new initiative to improve the safety and health of workers. According to the announcement of this new initiative on the Commission's website, its main aims are:

- **to better protect workers against work-related cancer**
- *to help businesses, in particular SME's and micro-enterprises, in their efforts to comply with the existing legislative framework*
- *to put a bigger focus on results and less on paperwork*⁵.

The protection of workers against work-related cancer is thus one of the three main aims of the current initiative. To be able to protect workers against cancer, it is necessary to know about possible causes of work-related cancer, to identify which types of workers are most exposed to these causes and where, that is at what locations, and during the performance of which tasks the exposure occurs. Knowledge of this could also be helpful for the monitoring of effects of EU legislation on carcinogens. The Commission has, for example, recently committed itself to setting exposure limits for seven additional cancer-causing chemicals⁶. With improved knowledge about the exposure of workers to these chemicals (and others that were already on the list of carcinogens), changes in the number of exposed workers and possibly also in the average duration and frequency of exposures can be observed. This information can be used to assess whether or not the existing legislative measures are appropriate and sufficient.

Comparable data on these aspects will be helpful not only for EU policy-makers and experts, but also for relevant actors at the national level (national policy-makers, labour inspectorates, safety and health institutions, safety and health specialists in enterprises). So far, only some EU countries already collect information on carcinogen exposure in a reliable and systematic way, while for others this information would be new. However, even the countries that already have sources of exposure data would profit by being able to compare the situation in their country with other countries and would possibly learn from best practice approaches to the prevention of work-related cancer. Better knowledge about exposure to carcinogens is a prerequisite for well-targeted measures to reduce the exposure. The type of knowledge required for this is, for example, information on the number of exposed workers, the exposure levels, the duration of the exposure and the application of protective measures. Currently, there is no possibility of getting an EU-wide picture on these issues, with data that are comparable between countries. It is therefore an aim to have statistics on exposure to carcinogens, including information on exposure

⁴ <http://ec.europa.eu/social/main.jsp?catId=148>

⁵ <http://ec.europa.eu/social/main.jsp?langId=en&catId=89&newsId=2709>

⁶ <http://ec.europa.eu/social/main.jsp?langId=en&catId=89&newsId=2709>

situations and exposure intensity. A survey on exposure to carcinogens could provide information that allows a better assessment of the health burden caused by exposure to carcinogens and enables the design of effective prevention measures.

The development and implementation of an EU-wide survey on workers' exposure to carcinogens or other potentially hazardous elements is a costly undertaking. Although survey participation would be voluntary, it puts a certain burden on respondents. Before launching such a new survey, it is therefore imperative to ensure that it will deliver information that is (a) highly relevant to the responsible actors and (b) not already available from other sources. The identification of the relevant actors, a mapping of their information needs and – based on this – an assessment of the type and usefulness of the information that a worker exposure survey would contribute are therefore among the first steps to be taken within this feasibility study.

To enable us to examine how far an EU-wide worker survey on exposure to carcinogens at the workplace could complement existing sources of information, first the type of information that can in general be considered useful for any policy measures in this field will be mapped. Then it will be assessed how far and from what sources this information is already available. Chapter 3, which presents AWES/OccIDEAS in detail, will then examine how far a worker exposure survey would be able to deliver the missing information.

2.1.1 Cancer risk factors

To shape effective measures to avoid or reduce the exposure to carcinogens at the workplace, it is first and foremost important to have information about the substances and other factors (such as vapours, dust, radiation) known or suspected to cause cancer.

Information on cancer risk factors is already available. This information mainly originates from epidemiological studies and other medical scientific sources. The list of acknowledged and suspected carcinogens is constantly being updated, following new insights from scientific studies and other sources.

Although there is not one globally acknowledged list of cancer risk factors at the workplace, the list of agents compiled by the International Agency for Research on Cancer (IARC)⁷ serves as a guideline for many actors in the field. The IARC differentiates agents into five groups:

- | | |
|-----------|--|
| group 1: | carcinogenic to humans |
| group 2A: | probably carcinogenic to humans |
| group 2B: | possibly carcinogenic to humans |
| group 3: | not classifiable as to its carcinogenicity to humans |
| group 4: | probably not carcinogenic to humans. |

For this feasibility study (as well as for OccIDEAS), only agents of IARC groups 1 and 2A are considered. For the remaining IARC groups, there is not sufficient evidence (yet) as regards their carcinogenic potential.

There are a number of risk factors for occupational exposure to carcinogens. Not all cancer risks emanate from substances. Lißner et al. (2014, pp. 11-12) distinguish between the following major groups of carcinogens:

- gases (for example formaldehyde)
- liquids (for example trichloroethylene, mineral oils, hair dyes)
- solids, including dusts and fibres (for example respirable silica, wood dust, asbestos, lead, bitumen)
- fumes (for example diesel exhaust, welding fumes)
- pesticides (for example DDT (dichlorodiphenyltrichloroethane))
- pharmaceuticals
- biological factors (for example bacteria, viruses, certain types of fungi)
- physical factors (for example X-rays, solar radiation, ergonomic factors such as sedentary work)

⁷ <http://monographs.iarc.fr/ENG/Classification/>

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- other factors (for example shift work involving circadian disruption, stress-related obesity, drinking).

The IARC categories provide an orientation regarding how certain it is that an agent actually contributes to cancer, reflecting the current state of scientific knowledge. They are hazard assessments (which identify what the carcinogens are), not risk assessments (which would calculate the chance and extent of harm from them). The question of how carcinogenic a substance is, or how great the risk of getting cancer is on being exposed to the agent in a certain type of situation, is not answered by the IARC grouping. Medical studies and examinations by safety and health research institutes provide some information on this, but, for many agents, the degree of risk depends heavily on factors such as the duration and form of exposure.

2.1.2 Exposure circumstances

Having identified substances and other factors that may contribute to cancer, it is important to know more about circumstances or situations where exposure to these substances and other factors occurs.

- In which sectors of activity and in which types of jobs does exposure occur?
- Within these jobs, on what occasions are workers exposed to cancer risk factors, in other words during the performance of which tasks, when handling which substances, etc.?
- Where does exposure occur, that is in which types of workplaces and work environments (indoors, outdoors, at mobile workstations, etc.)?
- In what way(s) does exposure occur (for example by skin contact with substances or by breathing them in)?

At the national level, several countries already have at least some information on jobs and activities in which workers are exposed to health risks. The main sources for this type of information are national registers of occupational diseases including cases of cancer and specific national cancer registers. Both types of sources count cases of cancer.

To a certain degree, this information allows analyses on occupations or sectors of activity in which a disproportionate percentage of workers is affected by cancer. However, both types of sources have also clear limitations as regards their potential to provide more details about exposure circumstances in terms of jobs or sectors of activity (see sections 2.2.3 and 2.2.4 for more information).

For information on exposure circumstances, epidemiological studies are again an important source, particularly as regards insights in the means of exposure that may lead to cancer.

2.1.3 Number and characteristics of exposed workers

Quantitative and qualitative information about the number and kind of workers that are exposed is another important type of information needed for shaping adequate policy measures. Relevant questions in this context are, for instance.

- How many workers (absolute and as a percentage) work in sectors and jobs where exposure occurs and are thus potentially affected?
- How many of those working in jobs where exposure may occur are actually exposed?
- Are there specific types of workers that are more exposed than others, differentiated for instance by age group, sex, occupational status or migration background?
- How intensively are workers exposed to the carcinogens?

Knowledge of the number and characteristics of workers exposed to carcinogens is crucial for various purposes and reasons.

- It provides policy-makers and other relevant actors in the field of safety and health with an idea about the magnitude of risks and of possible harm (cancer) to be expected if no further measures are taken. This knowledge helps to prioritise political actions.

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- Demographic information about the exposed workers and information about characteristics of their workplace facilitate the identification of groups for which risks are particularly high. These groups of workers and types of workplaces can then be targeted more effectively and efficiently, for instance with information campaigns.
- Regular collection of information on the number of exposed workers facilitates the observation of developments over time, for instance changes in the number of affected workers.

Currently, there is no harmonised, Europe-wide source for information on the number of workers exposed to carcinogens. At the national level, such information exists in several EU countries, but these data are not harmonised (see section 2.2.1). Valid comparisons are therefore not possible.

2.1.4 Extent and intensity of exposure

For an assessment of the risks of health damages caused by the exposure to carcinogens, it is not sufficient to know the number of exposed workers and the risk factors. In order to get a comprehensive picture of the magnitude of exposure, it is also important to know more about **the frequency, duration and intensity of workers' exposure** to carcinogens. These factors are relevant to an assessment of the overall danger related to a particular situation. They can be broken down into three key questions.

- How closely are workers exposed to the carcinogen(s)?
- How often are they exposed?
- How long are they exposed?

Information on the carcinogenic potential of substances and agents is available from epidemiological studies and experiments. What is largely missing at both the national and European levels, however, is information on the time dimension of exposure and on the form in which exposure takes place.

- ▶ Exposure to carcinogens contributes to cancer. Cancer is among the most prevalent occupational diseases in Europe.
- ▶ The protection of workers against work-related cancer is among the main aims of the most recent safety and health at work initiative of the European Commission.
- ▶ Harmonised, EU-wide knowledge about the kind and extent of workers' exposure to carcinogens would allow the identification of fields of action and existing best practices. It could help to prioritise and effectively target preventive measures.

2.2 Existing information sources

In Europe, some databanks and surveys mapping the exposure to carcinogens are already available, although mostly not EU-wide. In the description of the information needs above, some of these sources have already been mentioned. Generally, the existing data sources can be grouped into four categories.

- **National exposure registers:** These registers collect exposure data. They focus on occupational diseases and they are usually structured by occupations and sectors. Examples are the Finnish Register of Workers Exposed to Carcinogens (ASA Register), the Italian Information System for Recording Occupational Exposures to Carcinogens (SIREP), the German ODIN Register⁸, and the Polish Central Register of Data on Exposure to Carcinogenic or Mutagenic Substances, Mixtures, Agents or Technological Processes.

⁸ The ODIN registry (ODIN = Organisationsdienst für nachgehende Untersuchungen) is a registry of persons who in the course of their working career have been exposed to carcinogens. The register is maintained by the German employer's liability insurance associations. Its main aim is to ensure that affected persons receive medical surveillance and prevention measures, even after having terminated the activity that was related to an exposure to carcinogens. For more information on the ODIN registry (available only in German): <http://www.odin-info.de/pages/informationen-allgemein/>

- **Exposure measurement databases:** These databases focus on measurement data and the description of context at the workplace level, rarely including disease or production/consumption data. Examples are the Measurement data relating to workplace exposure to hazardous substances (MEGA) database (Germany), the Exposure Database on Lung Carcinogens (ExpoSYN) database (18 European countries and Canada), the Occupational Exposure to Chemical Agents COLCHIC database and the SCOLA occupational exposure database (France) and FINJEM (Finnish Job-Exposure Matrix).
- **Exposure information systems:** The existing national exposure information systems provide comprehensive and nationally consistent exposure information enabling users to better understand the potential elements of risk in one or more countries. The most important information systems are CAREX (CARcinogen Exposure, an international information system on occupational exposure to known and suspected carcinogens, Finland), WOODEX (International Information System on Occupational Exposure and Health Effects of Wood Dust; EU-25), FINJEM (Information System on Occupational Exposure, Finland), NOCCA (Nordic Occupational Cancer study; Denmark, Finland, Iceland, Norway and Sweden), Matgéné (France), MatEmExp (Spain), and DOM-JEM (the Netherlands). A recent effort to build an EU-wide exposure database based on national exposure information systems is HazChem@Work (see section 2.2.1 for further information).
- **Data from surveys:** The European Working Conditions Survey (EWCS) and various national surveys (for example the SUMER survey on exposure to health hazards at work in France or the BiBB/BAuA worker survey on working conditions in Germany) provide some information about the number and type of workers exposed to hazardous working conditions. These surveys are mostly not customised for exposure to carcinogens, but ask about various types of working conditions, including exposure to hazardous substances. The existing national surveys are not harmonised.

In the following, the most important Europe-wide sources of information on exposure to carcinogens available so far will be described in some more detail. Among these, there are two harmonised data sources – the recent HazChem@Work database project and the EWCS. CAREX, another international data source, will not be further explained because this initiative, launched in the early 1990s, has meanwhile been abandoned in the majority of European countries. HazChem@Work takes up several ideas and elements of the former CAREX system.

2.2.1 The HazChem@Work database

In 2014, the European Commission, Directorate-General for Employment, Social Affairs and Inclusion, launched HazChem@Work, a project for the set-up and testing of a database on occupational exposure to a list of hazardous chemicals. The starting point for the HazChem@Work project was that, despite long-existing EU legislation for workers' protection (and sometimes even longer national traditions), aggregated data on workplace risks from chemical exposure exist at national level in some Member States. There has not been a collection of such data in a harmonised way at EU level. Such information should be readily available for policy-makers, trade associations, workers and unions.

The national data sources on carcinogens differ greatly from each other in terms of the general nature and quality of information or the substances considered. They are also not all run by state authorities; some are run by industry associations or large enterprises. Therefore, information from these sources can hardly be used for the design of any measures at the EU level.

A harmonised EU-wide registry building on the existing national registers could possibly improve this situation. The HazChem@Work project was therefore initiated and is meant to compile national data in order to show a representative picture of the situation in Europe. According to the authors of the final HazChem@Work project report (European Commission, 2016, p. 9):

The overall aim of the HazChem@Work database was to make available valuable information on the exposure of groups of workers to chemical agents in the EU member states and the EFTA to allow

interested stakeholders to access and use this exposure data for risk management measures at enterprise level and for improving occupational health, for example by setting priorities for prevention, regulatory risk management, as well as occupational disease recognition at national and European level.

In a first step of the project, an overview of available data sources and existing data on occupational exposures to chemicals in the EU was developed. In a second step, challenges and obstacles to the collection of exposure data were identified. Based on information collected about data sources and discussions with providers about the possibility of transferring data from national data sources into the HazChem@Work database, a common data format has been developed to facilitate data collection and harmonisation. Employers are meant to submit their exposure data to the national institution in charge of collecting it, using this template in order to ensure harmonised data entry.

As the description of the HazChem@Work project shows, this initiative aims to a large degree to fill similar information gaps to a worker survey on exposures to carcinogens: both initiatives aim to collect (harmonised) information on the exposure of workers to potentially dangerous substances, in both cases including carcinogens. However, HazChem@Work is based on measurement data. Although the data source is different – employers, labour inspectorates and other sources in HazChem@Work versus employees in a worker exposure survey – for both initiatives the final aim of the collected information is the improvement of risk management measures and prevention policies.

In order to avoid parallel investments in two initiatives pursuing similar aims, one of the tasks of the feasibility study on a worker exposure survey is to analyse potential overlaps, synergies, etc. between the two projects. These aspects will be discussed in section 3.4.4, after a more detailed description of AWES/OccIDEAS.

2.2.2 The European Working Conditions Survey

The EWCS is an EU-wide survey among workers conducted by Eurofound, an EU agency responsible for research on working conditions in a broad sense. Since 1990, the EWCS has been conducted every 5 years. It covers all EU Member States and some additional European countries, with national sample sizes mostly varying between 1,000 and 2,000 interviews⁹.

The EWCS collects information on a variety of working conditions that workers may be exposed to. This includes some information that can be useful for an analysis of the exposure to carcinogens. In the sixth wave of the EWCS, the following questions can be considered rough indications for situations with a possible exposure to carcinogens.

- Q29 asks workers on a 7-point scale¹⁰ to what degree they are exposed to different agents, of which the following may imply exposure to carcinogens:
 - E: Breathing in smoke, fumes
 - F: Breathing in vapours such as solvents and thinners
 - G: Handling or being in skin contact with chemical products or substances
 - H: Tobacco smoke from other people
 - I: Handling or being in direct contact with materials that can be infectious, such as waste, bodily fluids, laboratory materials, etc.
- Q35, which asks how often the respondent works in 'an outside site (e.g. construction site, agricultural field, streets of a city)', can be used as an indicator for potential exposure to ultraviolet (UV) radiation. Answers are differentiated on a 5-point scale (daily – several times a week – several times a month – less often – never).
- In Q31 and Q32, the EWCS asks about the requirement to use protective equipment and whether or not this equipment is in fact used by the person¹¹. The question is, however, asked

⁹ Because of nationally funded sample boosts, sample sizes can be larger for individual countries.

¹⁰ The scale is: All the time – almost all the time – around ¾ of the time – around half of the time – around ¼ of the time – almost never – never.

¹¹ Q31: Does your job ever require that you wear personal protective equipment? (yes/no); Q32: Do you always use it when it is required? (yes/no).

in a general way, without the possibility of differentiating between various exposure scenarios. A worker exposed to 'breathing in smoke [or] fumes' and also exposed to 'skin contact with chemical products or substances' might use protective equipment such as gloves for handling chemical substances, but might not have or use any protective equipment minimising the hazards from breathing in smoke and fumes.

- In Q41, workers are asked if they do shift work¹². Recent research has shown that shift work 'involving circadian disruption' is another factor that is likely to contribute to cancer (Straif et al., 2007).

Since the EWCS was designed not as a survey on carcinogen exposure, but as a survey on working conditions more generally, it is obvious that it does not provide the same wealth of information on carcinogen exposure as AWES/OccIDEAS. Its results might however be of use for the development or adaptation of job-specific modules in an exposure survey and also for the validation of results from a worker survey on the exposure to carcinogens.

2.2.3 National cancer registers

In national cancer registers, all cases of cancer diagnosed in hospitals or surgeries are registered¹³. The registered information usually contains patient characteristics, such as the age, sex and place of residence, and details about the type of cancer identified. Information on their job and workplace is not, or at least not systematically, collected¹⁴. Where these data are collected, they give some hints about jobs where cancer occurs particularly often. However, these data are hardly able to allow conclusions regarding specific circumstances of exposure at work. Moreover, the interpretation of the data can be misleading because cancer may have different causes¹⁵.

This kind of registers provide first and foremost hints on the most immediate or obvious carcinogens, and less so on the more hidden, long-term work-related causes of cancer (for example causes not yet recognised as possibly causing occupational diseases). Likewise, for new kinds of jobs and substances (for example certain potentially carcinogenic nanomaterials¹⁶) these registers provide little information because of the usual time lag between the regular contact with the material and the incidence of cancer resulting from it.

2.2.4 The European Occupational Diseases Statistics

Since 1995, efforts have been made to establish European Occupational Diseases Statistics (EODS), based on national data sources on occupational diseases.

First data for the EODS were issued in the year 2001. The statistics are differentiated by the type of diseases. Among others, it includes cases of cancer attributed to the exposure of affected workers to

¹² Q41: Do you work ... Daily split shifts – permanent shifts – alternating/rotating shifts?

¹³ The existing cancer registers have a partly different focus. In some countries, clinics and surgeries have to report all cancer diagnoses to these registries, in others not. While in so-called clinical registries there is a focus on the treatments and their results, in epidemiological registries the focus is more on collecting statistics of the occurrence of cancer, with the aim of mapping the development over time and in different regions and age groups.

¹⁴ In 2005, the European Network of Cancer Registers issued a recommendation for the harmonisation of national cancer registries ('Recommendations for a Standard Dataset for the European Network of Cancer Registries'). In this, occupation and industry are recommended, not as 'essential' data for registration, but only as 'optional' elements (for the list of recommended data entries see: <http://www.enrcr.eu/images/docs/recommendations/recommendations.pdf>). The examination of three easily accessible cancer registries – those of Ireland, Austria and Germany – did not provide any hints that these criteria were included.

¹⁵ A high proportion of cancer diagnoses among workers in a particular occupational group may not necessarily be an indication of a strong exposure to carcinogens at the workplace. Workers in particular occupational groups may, for example, smoke more often.

¹⁶ Regarding the carcinogenic potential of nanomaterials, for example, there are currently hints that contact with some specific nanomaterials (such as titanium dioxide) might contribute to cancer (see Bundesinstitut für Risikobewertung, 2010). It will, however, probably take a long time until more certainty regarding this is reached and until a substantial number of workers in contact with these substances suffer from cancer and are thus registered in the national cancer registries. An exposure survey could include such new substances at an earlier stage.

carcinogens in the workplace. The EODS provide detailed information on the causative agent of the occupational diseases. The collection of information about the use or purpose of these causative agents is planned as well.

According to Aaltonen, Kauppinen and Saalo (2013), the EODS do not have a complete coverage of occupational diseases from all groups of workers: 'It should be noted that not all workers are covered by the national data collection systems in member states. With respect to occupational disease, problems arise from underreporting and differences between the national social security systems'.

For the EODS, the following type of information is collected: age, sex, occupation at time of the harmful exposure of the victim, economic activity of the employer at time of harmful exposure, diagnosis, severity of disease, exposure, year of first recognition, severity of disease of first recognition. As of the year 2010, Eurostat had collected new cases of occupational diseases recognised by the national authorities in all Member States, except three: Germany, Greece and Lithuania.

More recent information on the EODS was not available to us. However, even if it is still being regularly updated, the usefulness of the EODS as a source of information on workers' exposure to carcinogens is limited, mainly for two reasons.

- The kind and number of diseases recognised as occupational diseases vary greatly from country to country. While in some countries recognition is very restrictive (for example because of compensation claims related to recognised occupational diseases), in others a much larger number of diseases are recognised as occupational disease. Because of these large national differences in recognition practices, the compiled data are not cross-nationally comparable. Since there is no specific plan for the establishment of common EU standards for the recognition of occupational diseases, this situation will not change in the near future.
- The EODS collect data on the occupation of the victim and on the circumstances of exposure leading to the occupational disease, for example cancer. This knowledge is very valuable. It is based on facts and improves knowledge about circumstances of exposure likely to lead to cancer. A worker exposure survey following the model of OccIDEAS could, however, also map the exposure of workers not yet suffering from cancer. This would allow more timely setting up of preventive measures.

2.2.5 Summary on existing data sources

- ▶ Information on carcinogens is already available from epidemiological studies and collected in international databanks such as the IARC list of agents.
- ▶ Data on exposure circumstances or the number and characteristics of exposed workers exist in some countries only. They are collected in national registers, databases or surveys that are not harmonised.
- ▶ The HazChem@Work database initiated by the European Commission aims to fill part of this gap by collecting harmonised information on agents and exposed workers.

3 The OccIDEAS survey concept

3.1 OccIDEAS and AWES – definitions and clarifications

As the short summary of information needs and existing information sources has shown, harmonised information about the exposure to carcinogens is currently not available EU-wide. An EU-wide worker survey focused on carcinogens could be a way to improve this situation. In the call for tender and the discussions on the concept of a worker exposure survey, reference has been made to OccIDEAS and AWES-cancer as models for a possible EU-wide worker survey on the exposure to carcinogens. The abbreviation OccIDEAS (Occupational Integrated Database Exposure Assessment System) refers to the automated system developed by the research team of Professor Lin Fritschi at Curtin University for the assessment of the exposure of workers to carcinogens and other health hazards¹⁷. OccIDEAS basically consists of two elements:

1. a survey questionnaire with various job-specific questionnaire modules trying to identify circumstances and levels of exposure in the workplace by means of a set of closed questions;
2. an algorithm-based assessment system using these data to estimate an individual respondent's probability and level of exposure.

The AWES-cancer surveys are concrete applications of this concept in the form of telephone surveys conducted in Australia. The first survey took place in 2011/12, among about 5,000 workers resident in Australia. In 2013, a further AWES survey on the exposure to carcinogens followed, this time targeting only migrant workers living in Australia, with around 750 completed interviews¹⁸. In both applications, 38 carcinogens were covered. So far, AWES has been the most comprehensive application of the OccIDEAS concept. It has resulted in a number of reports analysing exposure situations for different occupational groups and to different carcinogens (see Table 4). There have also been a number of further applications in Australia, Malaysia and other countries, although these were mostly smaller in scope or focused on particular sectors of activity or agents.

For the feasibility study, we will mostly refer to OccIDEAS rather than AWES, because OccIDEAS would be the base for the development of a worker exposure survey adapted to the situation in Europe. In a way, OccIDEAS can be considered a kind of toolkit for setting up an exposure survey. It is not a fixed system, but, as its application to Malaysia has shown, it can to a certain extent be adapted to specific needs, for example national differences in agents, circumstances of exposure or prevention cultures.

Triggered by the interest of Safe Work Australia, the OccIDEAS concept has in recent years been broadened to include exposure to a number of further safety and health risk factors. To map these risk factors among the Australian workforce, further AWES studies have been commissioned: the AWES-asthma survey conducted in 2014 and the recently finalised AWES survey on 'Hearing, noise, vibration and 10 ototoxic agents' (2017). Where not explicitly stated otherwise, in this report we will refer only to the OccIDEAS questionnaire modules related to exposure to carcinogens.

¹⁷ The authors would like to express their gratitude to Professor Lin Fritschi and her team for their ample support in our research on OccIDEAS. The OccIDEAS team provided the authors with access to the full survey modules, additional data from the AWES survey and support in all questions related to how OccIDEAS works.

¹⁸ The study focused on three groups of migrant workers, namely workers of Arabic, Chinese and Vietnamese ancestry. The sample was selected from telephone lists, by applying onomastic procedures, which allow the identification of migrant populations by analysing the geographical and linguistic origin of first names and surnames listed in the telephone directory. For more information on the experiences of interviewing migrant workers and for an analysis of the results see, for example, Boyle et al. (2015).

- ▶ An EU-wide worker survey on the exposure to carcinogens could fill existing information gaps.
- ▶ AWES, based on the OccIDEAS assessment concept, could serve as a model for such a survey. The concept has been applied already in large-scale surveys and is empirically validated.

3.2 The survey and assessment concept

The basic principles of the OccIDEAS concept are well described on the project website (www.occideas.org/occideas, www.occideas.org/agents, www.occideas.org/questionnaires and www.occideas.org/rules).

OccIDEAS is a web-based¹⁹ application which is used to assess occupational exposure in epidemiological studies. It is used to determine whether workers are exposed to various chemical and physical hazards (agents) based on their answers to questions about their work tasks [...]. It provides assessments of the likelihood of exposure to specific agents for each job on an individual basis. The process involves [four] steps:

- *determining the job category for a person's job*
- *asking a set of questions (a module) about tasks which are specific for that job*
- *automatically assessing exposure to [the] selected agents using preprogrammed algorithms*
- *allowing manual review of those assessments.*

The targeted persons are thus interviewed about their job and asked a number of customised questions related to tasks performed in this job that are associated with potential exposure to these hazards. The main use of OccIDEAS has so far been to assess the exposure of workers to carcinogens.

The starting point for the development of the OccIDEAS method was the Expert Assessment Method:

When actual measurements of hazards are unavailable, the Expert Assessment Method [...] is considered to be best practice. In this method, a full job history is provided by the subjects; the subjects are then asked questions from job-specific modules relevant to their job history to collect information about tasks undertaken within each job; and then an expert reviews the interview responses and assigns exposures (www.occideas.org/history).

These traditional expert interviews and assessments are very time-consuming and costly. They can therefore be done only for a very limited sample of workers. In order to make the expert assessment process more efficient and to allow the assessment of a larger number of job histories, the team developing OccIDEAS has elaborated automated expert assessment algorithms. In this way the assessment of the information collected about a job is done not by individual experts ex post, but by an algorithm programmed in the OccIDEAS tool. Depending on the tasks actually performed by a subject and the protective measures taken when doing it, this algorithm classifies on a 3- or 4-point scale the likelihood and the degree to which a subject is exposed²⁰:

- **probability of exposure** (none, possible or probable) for all agents
- **level of exposure** (none, low, medium or high) for carcinogens.

¹⁹ Although OccIDEAS is web-based, it has so far been applied not in any online surveys, but only in computer-assisted telephone interviewing (CATI). The term 'web-based' refers not to the survey mode, but to the environment in which OccIDEAS is programmed and made available. For telephone surveys using OccIDEAS, the call centre is linked online to the OccIDEAS questionnaire hosted at Curtin University.

²⁰ It should be noted that the investigation and assessment of the job history of a person, an essential element of the Expert Assessment Method, is not part of OccIDEAS and the underlying algorithms. The OccIDEAS questionnaire maps only the work currently performed by an interviewee, not the work performed in earlier years. For this, a lot of additional questions would be necessary, which in turn would make the survey far too long.

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The amount of wood dust a carpenter is exposed to might, for example, depend on whether he or she used power or hand tools, whether he or she worked indoors or outdoors, whether or not a dust extraction fan was used and whether or not he or she wore a mask. Based on these criteria, the probability and level of exposure are determined.

On the website of OccIDEAS, the following two examples are provided to illustrate how the assessment works:

- Example of a simple rule for the agent benzene:

If the person used petrol to clean used paint brushes then exposure to benzene is probable, with medium level.

- Example of a more complex rule:

If the person degreases machinery using petrol and they used a dip tank, with heating, but without a cover, and without an extraction fan and without cooling coils then exposure to benzene is probable, with high level.

The level of exposure related to a particular task has been defined ex ante, based on intensive previous research in epidemiological studies and the expertise of a team of occupational hygienists, epidemiologists and other safety and health experts and practitioners. The overall exposure situation of a person is determined based on the sum of exposures in all tasks that turn out to be relevant to the person.

- ▶ OccIDEAS uses a standardised questionnaire with modules customised for a broad variety of jobs.
- ▶ Based on the data collected, algorithms previously defined on the basis of expert knowledge determine the probability and level of a worker's exposure to carcinogens.

3.3 Structure of OccIDEAS

On the website of OccIDEAS (www.occideas.org), questions can be viewed with free test access²¹ whereby the structure of the system and the types of questions become visible. The different components of OccIDEAS are also explained in a short document²².

The questionnaire for OccIDEAS starts with some general questions about the respondent, such as age, sex and region (for example postcode). After completing this introductory part, the respondent is asked to name his or her occupation in a free text answer: 'What is your current occupation (e.g. job title)?' This question is followed by another free text question trying to collect more information on the respondent's job: 'What are the main tasks you do in your job?' The answers to these free text questions are stored in the system. After completion of the survey, they can be coded into a classification of occupations such as the International Standard Classification of Occupations (ISCO-08), allowing additional checks and analyses based on this code.

After the free text questions on the characteristics of the job, a closed question on the sector of activity is asked: 'Which of the following best describes your job category?' In total, 12 sectors of activity are distinguished, with an additional residual category for those who cannot assign their job to one of the sector groups read out by the interviewer. For the selected sector group, all jobs that the OccIDEAS authors considered to be relevant in this sector group are then read out by the interviewer. The number of jobs read out at this point varies from 8 jobs in 'Emergency services, defence or involved in public order and safety' to 25 jobs in 'Trade'. For each job, there is a 'job-specific module' (JSM), a

²¹ For the test access, click the 'contact' button and then follow the instructions placed below the contact information.

²² http://media.wix.com/ugd/2ba4c3_08dc5b255c8a42189d564797088d10af.pdf

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questionnaire module customised for that job. Each JSM, in turn, consists of a number of 'fragment lists' (questions on particular tasks, agents or processes).

Table 2 below shows all sector groups and the number of jobs assigned to them. For the residual category 'none of the above', all jobs have to be asked about. Since many jobs are asked about in multiple sectors, there are in total 55 JSMS (and not 174, which would be the simple total of all modules in sectors 1 to 12 by addition). Jobs asked about in several sectors are, for example, 'drivers', 'office workers' or 'cleaners'. Whereas most drivers will work in the sector 'transport or warehousing', drivers may also be employed in firms in other sectors, for example in construction or healthcare.

Table 2: Sectors of activity asked about in OccIDEAS and number of jobs differentiated within these sectors

Sector no.	Question bloc	Sector(s) of activity	No. of job specific modules
1	A	In professional, scientific services, healthcare or education	12
2	B	Construction industry	13
3	C	Trade	25
4	D	Farming, forestry, gardening, pest control or agricultural teaching	10
		Customer service, which includes accommodation, food preparation or	
5	E	retail	19
6	F	Food, hospitality or entertainment industries	10
7	G	Heavy industry or mining	19
8	H	Manufacturing or production	21
9	I	Cleaning, recycling, repair, maintenance	17
10	J	Emergency services, defence or involved in public order and safety	8
11	K	Transport or warehousing	9
12	L	In utilities (water, sewage, rubbish collection)	11
13	M	None of the above (task modules here include 'generic')	55
	A to L	Average of all specified sectors of activity	14.5

Source: Count of all questions shown in the read-only test access of www.occideas.org

The attribution of the correct job for each respondent is key for the success of the survey. If the job is wrongly assigned at this stage, then the wrong questionnaire module is asked, with tasks that are mostly not relevant to the person's actual job. Exposure situations in that module are likely not to apply, while on the other hand those exposure situations that actually occur in the person's daily work are not asked. The results are measurement errors. The frequency and magnitude of these measurement errors depend on how often wrong job attributions occur and on how different the job characteristics of the wrongly chosen module are from those of the correct one. If there is a large overlap between the two

job categories (the correct one and the equivocally selected one), measurement errors will be moderate. If they are totally different, large-scale measurement errors may result²³.

Individual misattributions can often be detected only afterwards, by comparing the job module used in the interview with the free text description of the jobs and tasks in the initial questions. If this kind of misattribution occurs only sporadically, it may be sufficient just to delete the affected interviews before starting any analysis. If they occur repeatedly and accumulate in specific sectors or occupations, the validity of the entire survey can be in danger.

Persons who cannot be assigned to any of the 12 sector groups asked in the closed sector questions are interviewed using the 'generic' JSM instead. This module is, however, lengthy and tiring; therefore, interviewers were advised to use this category only as a last resort. In the AWES survey 2011/12, the category was chosen in 106 of the 4,993 valid interviews (2.1 %).

Although the association with a JSM is in principle made automatically on the basis of the answers of respondents to the closed sector questions, the possibility of having interviewer support is important in this step. It is the interviewers' task to assist in this process or to assess the respondents' own attribution on the spot, based on the free text job and sector descriptions previously provided. In cases of doubt, the interviewer is meant to intervene and clarify in conversation which of the modules would be the most appropriate. The successful attribution depends to a large degree on the abilities of the interviewers and their familiarity with the sector groups and questionnaire modules. For AWES, interviewers were therefore very intensively trained on the various steps of the attribution.

OccIDEAS works with three types of question lists: a module list, a fragment list and an agent list. These will be briefly explained below.

1. Job-specific module lists

The module list contains all modules elaborated for OccIDEAS so far. In total, there were 54 modules (and a generic job module) at the time of assessing the website (February 2017). These are called job-specific modules or JSMs. The modules contain only questions on tasks and exposure situations that are considered potentially relevant to the job of the respondent.

Table 3 provides an overview of the JSMs and how often they were asked about in the AWES-cancer survey. Among the roughly 5,000 participants, 2,501 belonged to job categories for which no exposure to carcinogens was assumed. The remaining 2,492 interviews were distributed among the 55 JSMs as shown in the table. For the analysis of the results from these modules, between just one interview (asbestos removal, foundry, metal-coating, roadside worker and upholstery) and 328 interviews (driver) were available.

Table 3: Job-specific modules asked about in AWES-cancer 2011/12, by incidence

JSM	%	Number	JSM	%	Number
Aluminium	0.1	7	Labourer	0.8	38
Asbestos removal	0.0	1	Machinist	0.6	32
Baker	0.1	6	Mechanic/metal beater	1.6	78
Barber/hairdresser	0.4	21	Metal coating and finishing	0.0	1
Butcher	0.3	14	Military	0.3	14
Carpenter	1.5	73	Miner/quarryman	1.4	68

²³ According to the OccIDEAS team, such misattributions happened only occasionally in AWES-cancer. In most cases where they occurred, they did not render the data of the concerned interviewees useless because of the logic of how the JSMs are composed: for each module, it is considered what other tasks such a person might do. Drivers, for examples, are asked not only about tasks relevant to travelling on roads, but also about other tasks drivers might do (such as maintenance tasks or office work).

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JSM	%	Number	JSM	%	Number
Ceramics	0.0	2	Painter	0.6	28
Chef	1.2	62	Pesticide user	0.2	8
Cleaner	1.3	63	Petrol	0.2	9
Construction	3.9	193	Plasterer	0.1	6
Driver	6.6	328	Plumber	0.7	33
Drycleaner	0.1	5	Police	0.2	12
Electrician	1.6	79	Primary metal	0.2	9
Farmer/animal worker	3.2	158	Printing	0.4	19
Firefighter	0.4	21	Railway	0.2	10
Flight attendant	0.2	11	Road construction	0.3	15
Floor laying	0.2	8	Roadside worker	0.0	1
Food processing	0.5	27	Seasonal farm worker	0.2	8
Forestry	0.3	15	Shift work	1.1	57
Forklift	0.7	34	Shipping/fishing	0.2	8
Foundry	0.0	1	Teaching	1.2	62
Frequent flyer/air transport worker	2.2	111	Textiles/leather tanning	0.1	5
Gardener/florist	1.0	51	Upholstery	0.0	1
Health	7.4	367	Waste management	0.1	4
Hospitality	1.3	66	Welder	0.7	36
Industrial manufacturing	1.0	50	No exposure (for example office worker)	50.1	2,501
Janitor/caretaker	0.2	10	Not applicable/generic	2.1	106
Laboratory worker/chemist	0.8	40		100.0	4,993

3. Fragment list

The second list available for OccIDEAS is the fragment list. Fragments are smaller sets of questions that can be used to build up a module. One type of fragment is the task submodules, which are a set of questions about a specific task or set of tasks (such as soldering or driving). Task submodules are included in all JSMS where they are considered relevant. For example, the task submodule 'aPES Pesticides' includes questions related to the use of pesticides, which are relevant to all people using herbicides, insecticides, fungicides, fumigants or rodenticides. The pesticides task submodule is therefore included not only in the questionnaire for the job called 'pesticide user', but also in the modules for farmers/animal workers, janitors/caretakers, forestry/timber mill, gardeners/florists health workers, lab workers/chemists, military, railway, sewage, water and waste management. The pesticides task submodule is not the only list asked about to these workers because exposures to other categories of carcinogens may be relevant as well. In addition, for the job category 'pesticide user', questions about other possible exposure situations (such as the use of motor vehicles) are asked. The overview of task submodules available on the OccIDEAS test access includes indications of all job modules in which a specific fragment list is used.

4. Agent list

In the agent list, all agents considered or suspected to cause cancer are listed. This list is constantly being updated by the OccIDEAS team. The agent list used for the AWES survey consisted of 38 agents, whereas the current list includes 46 agents²⁴, not counting the shift work modules. While the modules for the 38 agents as used in AWES have been thoroughly tested in empirical practice, this is not necessarily the case for the new agents. The following carcinogen groups are included in OccIDEAS:

Shift work:	Graveyard shift, Light at night, Phase shift, Sleep disturbances during shift work, Alcohol during shift work, Diet during shift work, Physical activity during shift work, Vitamin D during shift work
Industrial chemicals:	1,3 butadiene, Acid mists, Acrylamide, Carbon Disulphide, Diethyl/dimethyl sulphate, Epichlorohydrin, Ethylene oxide, Formaldehyde, MOCA, Nitrosamines, Ortho-toluidine, PCBs, Vinyl chloride
Inorganic dusts:	Asbestos, Silica
Metals:	Arsenic, Beryllium, Cadmium, Chromium VI, Cobalt, Iron, Lead, Mercury, Nickel
Oils:	Mineral oils
Organic dust:	Leather dust, Wood dust
Pesticides:	Organochlorines, Organophosphates, Phenoxy herbicides, Other herbicides (glyphosate), Other pesticides
Combustion products:	Diesel exhaust, Environmental tobacco smoke
Radiation:	Artificial UV, Extremely low frequency (ELF), Ionising radiation, Ocular solar UV, Radio frequency (RF), Solar UV
Solvents:	Alcohol, Aliphatic solvents, Benzene, Chlorinated solvents, Tetrachloroethylene (perc), Trichloroethylene

- OccIDEAS currently has more than 50 job-specific questionnaire modules. In these, customised questions about tasks involving possible exposure to any of 46 carcinogens are asked.
- The attribution of the correct module is key for the success of the survey.
- Data can be analysed from three angles: by agents, sectors of activity and occupational groups. Analyses by sectors and occupational groups require sufficiently large subsamples.

3.4 Information obtainable from a survey based on OccIDEAS

3.4.1 Analysis perspectives

In section 2.1 we briefly described the types of information relevant to policy-making in the field of the prevention of health hazards originating from carcinogens at the workplace. In section 2.2, we then had a look at existing sources of information on carcinogens at work, assessing which of the previously identified information needs are already met by existing sources. The current section examines which of the identified information needs could be covered by an exposure survey based on OccIDEAS and where this concept has its limitations in this regard.

²⁴ This list was provided by Lin Fritschi of the OccIDEAS team on 24 April 2017. These modules can currently be requested for an OccIDEAS study.

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Exposure data collected with the OccIDEAS instrument can in principle be analysed from three different angles: by **agents**, by **sectors of activity** and by **occupational groups**. For the data of AWES-cancer, reports for all three perspectives have been drawn up²⁵, as Table 4 shows.

Table 4: Reports based on AWES data²⁶ (as of August 2017)

Analysis of exposure situations by agents	Year of publication	Empirical base/no. of interviews
Formaldehyde	Nov 2014	5,023
Lead and lead compound	Nov 2014	5,023
Polycyclic aromatic hydrocarbons (PAHs)	Nov 2014	5,023
Diesel engine exhaust	June 2015	5,023
Respirable crystalline silica	June 2016	5,023
Analysis of exposure situations by industries/sectors of activity	Year of publication	Empirical base/no. of interviews
Carcinogen exposures in the construction industry	May 2016	459
Carcinogen exposures in the manufacturing industries	May 2016	281
Carcinogen exposures in the agricultural industry	May 2016	156
Analysis of exposure situations by occupational groups	Year of publication	Empirical base/no. of interviews
Occupational exposure to carcinogens in Australian road transport workers	Sept 2015	162

3.4.2 Information by type

Cancer risk factors

A worker exposure survey is not a suitable instrument to deliver any additional information on substances or other factors that may cause cancer. The carcinogenic potential of any agents so far not considered carcinogenic cannot be detected by such a survey. On the contrary, information on correlations between certain risk factors and an increased incidence of cancer is needed as an essential input for the development of the survey.

The OccIDEAS survey concept is in principle able to map exposure to any cancer risk factor if considered in the questionnaire. In fact, the current version of the OccIDEAS questionnaire already maps most of the risk factors currently known to be relevant, including UV radiation, diesel fumes, silica, X-rays and shift work.

Exposure circumstances

All types of different exposure situations may be introduced to the survey, thus allowing a full picture of possible risks. OccIDEAS can map only exposure situations and circumstances that are already known and that are included in the questionnaire. While it can thus provide a full panorama of all situations and

²⁵ See e.g. Driscoll et al. 2014, Driscoll et al. 2015, Darcey et al. 2016.

²⁶ Figures for the number of interviews used in the reports and the counts on the modules asked in AWES do not necessarily correspond. The reports are mostly sector-based while the counts on the modules asked in AWES (see Table 3) are job-based (jobs for which specific modules were created). The number of road transport workers included in the analysis report on 'Occupational exposure to carcinogens in Australian road transport workers' is, for example, considerably smaller than the number of drivers according to Table 3 because not all drivers belong to the subsector 'road transport workers'.

circumstances the researchers had considered when setting up the survey, it cannot map any circumstances the researchers were not aware of. This drawback is shared by most other methods of empirical data collection on carcinogens. With thorough preparation of the questionnaires, including intensive literature research and the consultation of experts from different sectors of activity and from different countries, it can be ensured that the great majority of exposure circumstances are mapped. While this preparatory work has already been done for the agents currently included in OccIDEAS, it would also have to be done for all new agents to be covered.

Number and characteristics of exposed workers

A worker exposure survey could to a large degree fill the gaps regarding harmonised information on the number of exposed workers and their characteristics. It can provide representative information on exposure to carcinogens in all kinds of work activities or exposure situations that occur with a certain frequency.

Exposure intensity

In its current form, a survey based on OccIDEAS can provide only very limited information on the intensity of exposure to carcinogens. We define 'intensity of exposure' by a combination of three factors:

1. the frequency of the exposure
2. the duration of each exposure
3. the carcinogenic power of the agent.

For most exposure situations, the OccIDEAS questionnaire modules ask about the performance of tasks and the handling of different substances used therein in simple yes/no questions ('Do you perform this task? Are you in contact with substance x during the task? Do you use personal protection?'). These mostly do not provide any indication of the frequency and duration of the exposure situation. The only exception is the exposure to UV radiation: there, a question related to the duration of the exposure is asked.

In earlier versions of the survey concept, questions related to the frequency and intensity of an exposure had been systematically included. They were abandoned because of measurement problems²⁷ and annoyance on the part of the respondents. Another difficulty was the analysis of exposure for agents to which exposures can occur in different tasks, in different ways and with varying impacts or intensities. An example would be lead – a substance included in 10 different questionnaire modules, involving a variety of different tasks. In the current version of OccIDEAS, in the case of various exposures to one substance (for example the exposure to lead in different forms and in different tasks or on different occasions), the highest degree of exposure resulting from all situations where exposure occurs for a particular person is considered. This facilitates the analysis, although at the expense of an overestimation of the exposure to that agent.

3.4.3 Mapping of multiple exposure situations

A big advantage of a worker survey mapping exposure to all known carcinogens is its ability to map multiple exposure situations of individuals. Many other sources, for example those based on reporting by employers (such as HazChem@Work), can indicate only the number of persons exposed for each agent separately. Multiple exposure of a person to several risk factors can be assumed to be particularly harmful. An example might be workers with disruptive shifts who are exposed to carcinogenic chemicals, diesel fumes and UV radiation. Even if the exposure to each one of these factors might be only moderately dangerous, the combination of the factors can have a high risk potential.

²⁷ According to the OccIDEAS research team, numerical questions asking the number of hours dedicated to certain tasks proved to be generally too difficult to answer. Asking closed questions using categories (for example 'between 5 and 10 hours in a normal week') alleviated the task for respondents considerably. However, even here, checks of the data revealed measurement problems in the form of considerable overestimation of the indicated exposure time.

3.4.4 Worker survey versus HazChem@Work: a systematic comparison

As outlined in section 2.2.1, HazChem@Work is another EU initiative to collect harmonised data on the exposure of workers to carcinogens in the workplace. Having described the basic features of both HazChem@Work and a worker exposure survey applying OccIDEAS, the complementarity or overlap between both data sources will now be analysed in more detail. This analysis will be guided by two aspects:

1. the scope of the information that is or can be made available;
2. the quality of the information in terms of, for example, its completeness, unbiasedness, accuracy and reliability.

Table 5 compares the scope of information that can be provided by both types of data sources. It is structured using the data format template developed by the HazChem@Work project team for the submission of national data to the pilot EU database. The overview shows which of these data a survey on workers' exposure could generally also map and which ones it could not. It is important to point out that the data template developed for HazChem@Work shows which data should **ideally** be collected at the national level and transmitted to a central EU database. So far, only a few of the national databases – if any at all – collect and store all the data listed in the template. Even data classified as 'mandatory' by the HazChem@Work research team (red letters in Table 5) in this list are not available from all national sources existing so far. There are even countries where a national database on carcinogen exposure does not exist at all and would first have to be set up if HazChem@Work is meant to cover all EU countries. The decision process about the set-up and shape of such a national database and its practical implementation would probably take several years.

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Table 5: Data template developed for HazChem@Work and overlaps with a potential worker exposure survey (x = yes, - = no)

Type of information (red letters: information that should be made mandatory)	HazChem@Work	AWES/OccIDEAS	Worker exposure survey (modified and extended adaptation of OccIDEAS)	Comments
1 Chemical substances				
Name of substance	x	x	x	
ID number	x	Possible to include	Possible to include	The ID number of the chemical substances included in the survey can be searched and added
2 Exposure and contextual data				
Kind of exposure (inhalation/dermal)	x	x	x	
Measurement method	x	Known, uniform across countries	Known, uniform across countries	
Exposure measurement (details on measurement methods and types of values measured)	x	No exact measurement of exposures, but exposure estimates (high/medium/low), calculated on basis of the survey data; measurement uniform across countries	No exact measurement of exposures; exposure estimates uniform across countries; degree of detail depends on possibility of inserting questions on frequency and duration of exposure	In the worker surveys, exposure is measured for each exposure situation with a fixed algorithm using exposure to a carcinogen (yes/no) and applied protective measures as key indicators
Work process, kind of workplace, task, technology	x	x	x	
Number of exposed workers	x	x	x	In the surveys, the number of exposed workers can be extrapolated on the basis of the collected data (figures on the universe of workers available from Labour Force Survey)
Characteristics of exposed workers	Partly	(x)	x	The worker surveys can provide data on the demographic characteristics of exposed workers, for instance age, sex, educational level, migration background, type of contractual arrangement
Duration and frequency of exposure	x	-	Possible to include at least for 'key carcinogens'	With the exception of the exposure to UV radiation this information is not requested in OccIDEAS so far; but it can be included for a few selected further exposure situations
Risk management measures	x	x	x	

Type of information (red letters: information that should be made mandatory)	HazChem@Work	AWES/OccIDEAS	Worker exposure survey (modified and extended adaptation of OccIDEAS)	Comments
Multiple exposures of individual workers	-	x	x	Unlike a databank following the concept of HazChem@Work, a worker exposure survey will be able to map multiple exposures of workers (although only for the main job if a respondent has several jobs)
Actual application of risk management measures on part of workers	- (?)	-	x	It is possible to include such questions in a worker exposure survey
3 Production and use of chemicals at national and European level				This type of information cannot be collected by a worker survey
Production	x	-	-	
Consumption	x	-	-	
Uses	x	-	-	
4 Disease data and adverse effects				The inclusion of questions on adverse effects attributed to exposure is generally possible, but the reliability of answers would be questionable
Type of diseases	x	-	-	
Contextual data	x	-	-	
Sector, occupation	x	-	-	
Type of workers	x	-	-	
5 Sector and occupation data				
Categorisation for sector	x	x	x	
Company size	x	x	x	
Categorisation for occupation	x	x	x	
6 General information				
Procedure of data collection	x	Known, uniform across countries	Known, uniform across countries	
Name of database	x	Known, uniform across countries	Known, uniform across countries	
Owner of the data source	x	Not relevant	Not relevant	
Year of collection	x	Known, uniform across countries	Known, uniform across countries	

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Table 6 summarises and evaluates both data sources in more general terms, tackling aspects related to both the scope and the quality of information that can be obtained.

Table 6: Strengths and weaknesses of a worker exposure survey versus HazChem@Work – overview

Worker exposure survey (if OccIDEAS is implemented and augmented with additional questions)	HazChem@Work (if all issues laid down in the template are reported)
1. Scope of information	
Allows analysis of exposure by demographic characteristics and characteristics of the workplace; most vulnerable groups can be identified	Exposure can be analysed on company level (by company characteristics); for workers, only the number of affected workers is reported, no demographic characteristics
Provides information on types of workers that are affected by multiple exposures	Multiple exposures are not planned to be mapped
Information on frequency or duration of exposure can be collected for key risk factors only, in order to keep the questionnaire short and easy	Reporting template includes information on frequency and duration of exposure
Information on workers' awareness of carcinogen exposure can be included in the survey and awareness can be measured against actual exposure; useful for the shaping of awareness-raising measures	The extent to which carcinogen exposures are reported by employers indicates their awareness; but there is no possibility of comparing awareness and real risk
Information on the actual use of protective equipment and barriers to its use can be included	Includes information on the provision of protective equipment/measures, but not on their application
2. Quality of information	
More honest answers because no politically correct answers to be expected when asking workers	Politically correct information to be expected, for instance owing to fear of more inspections if high exposure is reported; in this regard, it is a problem that HazChem@Work would be hosted by an official state/occupational safety and health institution
No content-related bias in participation to be expected (unequal non-response by demographic factors can be corrected by weighting)	If participation is voluntary or obligatory but without sanctions, participation can be expected to be higher for organisations with no or only a few exposures
Random mistakes and inaccuracies in the extrapolation; scope of errors depends on sample size	If participation is obligatory, a large amount of data will be compiled; extrapolations will be necessary only for the (probably few) non-participants
Updates will be available only every few years (depending on the survey periodicity), although these will be real updates	Not all organisations will send updated data at the requested intervals; some might just report the same figures every year, since this implies less effort
Workers may not always be aware of the substances asked about in the survey (for instance chemicals used for cleaning); some substances require some expert knowledge	The accuracy of the data can be very high if the reporting is done by a well-informed person within the organisation; this is, however, not guaranteed, as there is no control on who provides the data
High degree of cross-national comparability due to objective questioning and classification, based on questionnaires translated with high quality standards	Given the planned common template for all, cross-national comparability is high if firms honestly report their exposure situations and fill in all fields, but it is not self-evident that that will happen; reporting mistakes are to be expected particularly for countries that previously used different standards for reporting
No measurement data to be obtained from such a survey; for some agents, approximate exposure values can, however, be calculated based on the indicated frequency and intensity of exposure	For some exposures and from some organisations, data from objective measurements may be reported (for instance concentration of carcinogenic substances in the air of working rooms)

- ▶ OccIDEAS allows the analysis of exposure from three different angles: by agents, sectors of activity and jobs. For the analysis of subgroups, sufficient interviews need to be made available.
- ▶ The ability to measure multiple exposure situations for a person is a big advantage of the survey over, for example, exposure databases based on reporting by enterprises.
- ▶ The current OccIDEAS questionnaire covers a large number of risk factors.
- ▶ By its nature, the concept can map only hazards the researchers were aware of. Like most other sources of exposure information, the instrument is not able to discover new exposure situations.
- ▶ The HazChem@Work initiative launched by the European Commission aims to compile information that is partly similar to that available from a worker exposure survey (e.g. the number and characteristics of exposed workers). The data are however gathered by different ways – measurement data collected from employers in case of HazChem@Work and survey data collected from workers in case of an exposure survey following the OccIDEAS mode.
- ▶ Data from a worker exposure survey based on OccIDEAS are likely to be more complete, more objective and more cross-nationally comparable than data from HazChem@Work.
- ▶ The full implementation of HazChem@Work is a lengthy process with many obstacles and an unclear outcome. It is, in particular, not clear whether or when all EU countries would implement the standards proposed by the HazChem@Work project team and whether employers in all countries would honestly report their exposures.

3.5 Assessment of the survey concept

3.5.1 Main advantages of OccIDEAS over other surveys mapping exposures

In our view, OccIDEAS is a very sophisticated survey and assessment tool that has a high potential regarding the delivery of objective information on workers' exposure to carcinogens.

In several EU countries, other large-scale national worker surveys have already been carried out in order to assess the exposure of workers to work-related safety and health hazards, among them carcinogens. Compared with most of these surveys, OccIDEAS has a number of distinctive characteristics.

- Most surveys on exposure rely on the subjective perception of workers, asking them how much they are exposed to certain agents or feel affected by any cancer risk factors. This depends on the subjective perception of being at risk. Some carcinogenic risk factors are better known to people than others, for example because they are more obvious or have received more attention from employers, the media or other sources. Moreover, some persons are more risk aware and less risk averse than others doing the same job. With its focus on the performance of tasks, OccIDEAS largely avoids the problems related to differences in the perception of risks.
- This objective way of asking questions is particularly advantageous in the context of a cross-national survey, with national levels of awareness and risk attitudes likely to differ largely between countries, depending on, for example, the national safety and health culture.
- With its customised task questions, OccIDEAS is able to discover exposure situations that workers are usually not aware of. OccIDEAS is therefore likely to reveal exposure situations not captured by other surveys. This is particularly apparent in the case of UV radiation, but also applies to many other carcinogens such as silica dust or other agents that are not commonly associated with cancer at all or whose carcinogenic potential is underestimated by non-experts. A survey applying the OccIDEAS concept can therefore be expected to measure considerably

higher exposure values than other surveys among workers, particularly for agents not commonly associated with cancer.

- The coverage of a broad variety of agents and risk factors is a big advantage over many of the existing databases, which often concentrate on solids, liquids and gases.
- OccIDEAS is not only a questionnaire tool, but at the same time also includes algorithms programmed to analyse the results. This not only saves time and costs for analysis, but also ensures that the main results will not be calculated differently by different researchers. Researchers' own further analyses using the dataset or corrections of the results obtained with the algorithm are nevertheless possible.

Nevertheless, the system also has its general limitations and applying it faces a few difficulties in detail. These will be presented in the following sections.

3.5.2 Possible overstrain of the knowledge of untrained workers

As outlined above, OccIDEAS is not based on the risk awareness of workers. As a concept based on self-reporting, it does however rely to a certain extent on the knowledge of respondents: in this case, particularly knowledge about work processes, about materials handled at work, about personal protective equipment (PPE) or about other protective measures taken by the employer (for instance the installation of a ventilation system).

For the majority of tasks, agents and protective measures asked about in the survey, respondents should normally be able to provide an accurate, well-informed answer. There are however a few exceptions where this may not necessarily be the case, at least not in all countries and for all types of affected workers. An example is the case of cleaners. The following questions extracted from the cleaners module of OccIDEAS illustrate that, even for workers in this usually rather low-skilled job, a significant amount of job-specific knowledge is necessary to answer the survey questions accurately²⁸.

- What type of buildings do you usually clean?
 - * Houses
 - * Hospitals or pharmacy
 - Do you clean rooms where radioisotopes or radiotherapy has been administered to patients?*
 - * Industry buildings or factory floors
 - Where do you usually clean?
 - Factory floor
 - Do you regularly clean industrial chemical spills on the factory floor?*
 - If Yes: Please specify which chemicals you clean up on factory floor.*
 - Do you usually use any of the following acid based products?*
 - Drain cleaner*
 - What is the brand name of the drain cleaner you use most often?
 - Do you usually wax floors?
 - Do you use solvent-based, or petroleum-based waxes?*
 - What is the name of the wax you use?

Cleaners with some type of vocational training in cleaning or with a reasonably thorough knowledge from on-the-job training should usually be able to answer this type of questions. However, for cleaners who have been in the job for only a short time or those who are just part of a cleaning squad, this is not necessarily the case. In cleaning squads, the team leader is probably well aware of these details. The team members, however, might just receive the cleaning substance(s) to be used and possibly a superficial introduction to the specifications of the cleaning site. Knowledge of the applied substances and the places to be cleaned may be particularly limited among migrant cleaning workers. They often

²⁸ The questions in italic letters may, according to our assessment, present difficulties for some cleaners.

have neither vocational training as cleaners nor a good knowledge of the local language. At the same time, this group of workers may often be in charge of cleaning the more dangerous sites²⁹.

Another example is the JSM for foundry workers. This module seems hard for an unskilled assistant worker in a foundry to answer. It presumes substantial knowledge about the foundry process and the materials used therein.

A lack of knowledge of details of the materials used in working tasks will result in high percentages of item non-response or in wrong answers – for instance by workers who do not want to show their lack of knowledge to an interviewer. Wrong answers may lead to measurement errors, while item non-response prevents a clear assessment of that particular respondent's risk and degree of exposure. Another reaction may be to break off the interview. Break-offs due to a lack of knowledge about the subject are likely to be selective and not randomly distributed: assistant workers will react in this way more often than more skilled workers. Assistant workers in cleaning or foundry jobs, for example, may be more exposed to carcinogens than lead workers or supervisors in this type of jobs.

3.5.3 Varying ways of asking about activities as a potential obstacle to measurement equivalence

A closer look at the OccIDEAS questionnaire modules reveals a certain inconsistency as regards the questioning on the performance of tasks. In the three modules examined on this as examples (firefighters, foundry workers, farmers), the following ways of asking for tasks and exposure situations were encountered.

- **Do you ever** extinguish fire at electrical transformers?
- **Do you** solder, weld, braze or cut metal?
- Which of the following fire types **do you usually** fight?

The examples above are ordered in an ascending way: from tasks done 'ever' (this can be just once in a decade) to tasks that are done at least from time to time ('do you') and tasks that are a standard component of work, although not necessarily done daily ('do you usually')³⁰.

While these varying forms of asking reduce the monotony of the questionnaire for the respondents to a certain degree, they render extrapolations difficult and introduce an element of error as regards the comparability of exposure situations between different jobs and tasks, but also between types of risks.

In the questionnaire modules related to the exposure to carcinogens, the forms 'do you ever' (rarely; for very important exposures only) and 'do you usually' are prevalent. The form 'do you' (without 'usually') is currently being replaced with 'do you usually' in order to avoid recording situations of very tiny exposure. In an adaptation of the survey for use in Europe, the remaining inconsistencies can probably be solved rather easily. The authors recommend concentrating on tasks typical of the job, that is those 'usually' done. In order to maximise cross-national equivalence, at the first instance where the terminology is used, an explanation should be provided of what is to be considered a 'usual' task (for instance a task you do at least once in a typical working week or month). This explanation should then be repeated once or twice during the questionnaire in order to make sure that it is taken into account in the answers.

²⁹ It must, however, be noted that migrant workers with a very limited command of the local language would probably not participate in the survey anyway, as long as it is not offered in the languages spoken by the migrant workers.

³⁰ The most restricted form of asking for the performance of tasks in OccIDEAS is the reference to 'your last working day'. Here, only tasks done on a daily basis are normally reported. For working tasks with a seasonal character or for tasks done on only some days of the week, this can be a problem. This form of asking is, however, currently used not in the modules on carcinogen exposure, but only in those related to exposure to loud noise.

3.5.4 The linkage between JSMs and occupational classifications

As described, OccIDEAS is based on job-specific questionnaire modules. The jobs differentiated for this aim do not, however, directly correspond to occupations as defined in official codifications of occupations such as ISCO-08 or the counterpart used in Australia, the Australian and New Zealand Standard Classification of Occupations (ANZSCO). While some of the JSMs in OccIDEAS can be clearly linked to just a few minor ISCO-08 groups pertaining to the same major groups, for others several different occupational groups would apply (see Table 18 in the Annex for more details). In exceptional cases no direct correspondence with any single occupational group can be found at all. The JSMs in OccIDEAS are a mixture of sectors of activity, occupations and – in some cases – even single tasks. Thus, for example, construction trades, ceramics, rubber industries or shipping/fishing are rather sectors than occupations. There is no such occupation as 'pesticide users'; this is rather a specific task performed in other occupations (such as by farmers or gardeners).

This apparently not very systematic definition of jobs for the development of JSMs is the result of a rather practice-oriented bottom-up approach by the OccIDEAS team. The starting point for the development of questionnaire modules was not so much occupational groups but agents:

We mostly started with agents. Then we would think about a job and what agents those workers might be exposed to. Then think about the tasks that lead to that exposure. [...] we tried [...] to create a job specific module (tasks) wherever we could and then reused them in other modules. So say we were doing a module for laboratory workers and we asked about cleaning animal cages, then we would go through all the job specific modules and decide if that task was something that the teachers would do. If so, we would add that job specific module (JSM) to the teachers' module. When we are doing the teacher module we might create a JSM for photocopying [...] and then we go back to review the laboratory workers module we might add the photocopying JSM to that. We ended up with a big spreadsheet of which JSM [is] in which module³¹.

Sample checks of task modules for related jobs confirm a high degree of consistency between the modules and a complete coverage of the array of tasks relevant to the jobs in question.

What does the rather loose linkage of the jobs used as base for the JSM imply for practice? Is it a major problem for the implementation of the survey concept in Europe or not? According to our assessment, this depends on the purpose of the survey and the use made of its results.

- Although the questionnaire modules are not systematically aligned to ISCO-08 codes, it is possible to code the interviews ex post to ISCO-08 or a similar classification by using the free text job and task descriptions available from the interviews. In the analysis, the survey findings can thus be extrapolated to the populations in the respective ISCO-08 groups. Results on the degree of exposure by ISCO-08 group may, however, imply a measurement error because respondents from the same ISCO-08 group may have answered different JSMs, depending on the job and sector to which they assigned themselves³². The risk of getting erroneous exposure estimates due to this is limited because of the bottom-up approach in the design of questionnaire modules, but it exists.
- As will be discussed later, the job descriptions of the occupational classification systems (such as ISCO-08) are the most comprehensive sources for getting task descriptions. If a linkage between the JSMs and ISCO-08 is not easily possible, that will limit the usefulness of the task descriptions in ISCO-08 for the adaptation of the questionnaire for use in Europe. Thus, for the adaptation, other sources will have to be used in addition.
- The definition of job categories for OccIDEAS was initially driven by the search for tasks relevant to carcinogens. When extending OccIDEAS to cover exposure to asthmagens and noise too, this had some repercussions on job categories. Some additional job categories had to be set

³¹ Personal communication from Lin Fritschi, the leader of the OccIDEAS team, on the question of how modules were defined and developed (email excerpt).

³² Most farm workers, for example, would certainly continue to the farmer module. However, some might instead be classified and interrogated as pesticide users, animal workers, drivers or market vendors, depending on what they considered the most important task in their job.

up and some of the categories relevant to carcinogens were not relevant to asking questions about asthmagens and noise.

As long as the OccIDEAS system is implemented in Europe without any major changes to the job definitions and modules, the loose linkage to ISCO-08 is not a problem. For the analyses of the results, for the production of statistics and for the derivation of action plans on that basis, the linkage to the sector coding (Statistical classification of economic activities in the European Community – NACE) is anyway more important than the linkage to the occupational groups (ISCO-08). Organisations are characterised by their sector of activity rather than by the occupational groups they employ.

Being only loosely linked to ISCO-08 is the price to be paid for keeping the concept practicable. The development of meaningful questionnaire modules corresponding to ISCO-08 would, as a minimum, require reference to the three-digit ISCO-08 level (ISCO-08 minor groups). At this level, currently 130 occupations are distinguished. Occupations at this level may, however, still comprise activities of quite different natures. From the point of view of a clear mapping of tasks, therefore, the 436 unit groups (ISCO-08, four-digit level) might be more appropriate. Setting up, translating and programming such a huge number of questionnaire modules would imply an enormous amount of work. The questionnaire would be hardly manageable any more and would require huge sample sizes in order to have interviews available for each occupational group.

3.5.5 Ambiguities in the choice of the most appropriate job-specific module: a practical example

As previously mentioned, the selection of the most appropriate module is crucial for achieving a high quality of measurement. In order to get an idea of whether or not the process is likely to present any problems in practice, the mechanism of the module attribution was checked for the example of the construction sector. The results show that the mechanism works.

According to the Labour Force Survey data, approximately 10.8 million employees work in the construction sector (NACE F) within the EU-28. These 10.8 million employees are distributed over 127 different occupational groups at the level of minor groups in the ISCO-08 classification (ISCO-08, three-digit level). In many of these occupational groups, however, only a few hundred or thousand workers are to be found (within the construction sector). We therefore concentrated on the most prevalent minor groups, namely those accounting for at least 1 % of the total workforce in the sector. The resulting set of 19 minor groups represents in total 84 % of the workforce in the construction sector.

Table 7 shows the job modules from which interviewers from the construction sector can choose. Table 8 shows where workers of the 19 most prevalent groups in the sector would probably categorise themselves.

Table 7: Job-specific modules available in OccIDEAS for respondents associating themselves with the construction sector

Number	Job modules for construction
1	Construction trade or anyone who works on a construction site (including managers and supervisors, not including machinists or welders)
2	Road construction worker
3	Railway construction worker
4	Fitter and maintenance mechanic
5	Welder
6	Line worker/power station worker
7	Driver (truck driver or transportation driver; driver of construction vehicles should go to construction trade)

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Number	Job modules for construction
8	Metal finisher and coater
9	Machinist
10	Forestry/timber mill worker
11	Store person
12	Upholsterer
13	Office worker

The analysis shows that the attribution is likely to be clear and straightforward for 11 of these 19 occupational groups. For the remaining eight groups, some doubts may arise on which of the categories to select when being asked: 'You chose the construction industry. Which of the following best describes your job role?' Engineering professionals may, for example, hesitate between 'construction trade and anyone who works on a construction site' and 'office worker'; some of the clerks between 'office worker' and 'store person'. For 'wood treaters, cabinet makers and related trades workers', the attribution may be quite unclear if these persons do not directly work on a construction site. Machinery mechanics and repairers may be undecided between the categories 'machinist' and 'maintenance mechanic'.

Many of these doubts can be solved by a hint indicating that one should choose the category which best fits the activity done for the largest proportion of one's working time. This leads to a certain degree of underestimation because engineers spending slightly more time in the office than on the construction site would be asked the questions for office workers only and would thus not be counted as persons exposed to hazards typically occurring at construction sites. In other cases, some specific hints might need to be added which explain where workers in particular occupational groups should categorise themselves. These hints may be customised to the terminology commonly used for the respective groups in the national vocational training system and/or in everyday speech. Some misattributions may nevertheless occur, but a certain degree of blurring will have to be accepted for such a survey.

Table 8: Attribution of the occupational groups to the job-specific modules

ISCO-08 3-digit	Construction (NACE 41, 42, 43)	Appropriate modules		
		Most likely	Other options	Comments
132	Manufacturing, mining, construction and distribution managers	13	1	Unclear if partly office, partly construction site
214	Engineering professionals	13	1	Unclear if partly office, partly construction site
311	Physical and engineering science technicians	13	1	Unclear if partly office, partly construction site
312	Mining, manufacturing and construction supervisors	1		Clear-cut
334	Administrative and specialised secretaries	13		Clear-cut
411	General office clerks	13		Clear-cut
412	Secretaries	13		Clear-cut
431	Numerical clerks	13	11	Unclear if partly office, partly store
432	Material recording and transport clerks	11	13	Unclear if partly office, partly store

ISCO-08 3-digit	Construction (NACE 41, 42, 43)	Appropriate modules		
		Most likely	Other options	Comments
711	Building frame and related trade workers	1		Clear-cut
712	Building finishers and related trade workers	1		Clear-cut
713	Painters, building structure cleaners and related trade workers	1		Clear-cut
721	Sheet and structure metal workers, moulders and welders, and related workers	5		Clear-cut
723	Machinery mechanics and repairers	4	9	Differentiation between machinist and maintenance mechanic difficult
741	Electrical equipment installers and repairers	1	6	Depends on persons' specific tasks
752	Wood treaters, cabinet makers and related trades workers	1		Unclear if not working on a construction site
833	Heavy truck and bus drivers	7	1	Clear-cut
834	Mobile plant operators	1		Clear-cut
931	Mining and construction labourers	1		Clear-cut

- ▶ OccIDEAS is a very sophisticated, well-elaborated and extensively tested concept.
- ▶ A high quality of measurement and a high degree of cross-national comparability can be expected thanks to the short, precise and factual customised questions. Answers do not depend on the risk awareness of workers.
- ▶ Some questions on agents and materials may, however, overstrain the knowledge of unskilled workers, possibly leading to measurement errors.
- ▶ Some details of the concept could profit from further fine-tuning.

3.6 Possible amendments to the OccIDEAS survey concept

3.6.1 Information on drivers and barriers for the application of protective measures

The addition of two or three questions related to barriers to the use of protective equipment could provide further information useful for improving prevention activities.

OccIDEAS already includes some questions on the application of protective measures, such as the use of PPE. Depending on the tasks and substances involved, the questions ask about the application of protective measures as simple yes/no questions or differentiate between two or more subtypes of protective equipment. For some protective measures, a rough time dimension is also included in the questions.

An example from the rubber industry module (RUBB_Rubber Industry).

- *Do you use respiratory protective equipment when doing your job (yes/no)?*
- *If yes: What type of respiratory protective equipment do you use (Chemical cartridge respirator – air supplied or SCBA respirator – simple dust mask)?*

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- *How often do you use this respiratory protective equipment (always – most of the time – half of the time – rarely)?*

In all cases where workers who are presumably exposed do not use the protective equipment at all or use it only rarely, a question on the main barriers could be added, for example:

Why do you not use/only rarely use protective equipment when doing this type of work? Which of the following statements apply?

- *The employer does not provide the equipment*
- *The provided equipment is in poor conditions*
- *The protective equipment is a hindrance at work*
- *Usage is uncommon in our team/company, none of the colleagues uses it.*

There are alternative ways of asking about the barriers, for instance split up into two or three separate questions: 'Does your employer provide protective equipment (yes/no)?', 'Is the protective equipment in acceptable functional and hygienic conditions (yes/no)?', etc.

Such additional questions on barriers could provide valuable information for the design of campaigns on the application of protective measures or even for legislative measures. If the non-use of protective equipment is mostly due to its non-existence or poor state, then legislative measures or stricter enforcement of the existing regulations on the provision of protective equipment by the employer could be appropriate reactions. If the equipment is mostly provided, but hardly used by workers, campaigns among workers could help to improve the situation.

3.6.2 Awareness of potential risk factors

In OccIDEAS, questions are consequently restricted to short and precise factual questions related to tasks and the substances used for these. As already outlined, this concept has clear advantages over approaches with a focus on the perceptions of strains and dangers, particularly in a cross-national survey conducted in countries with widely differing perceptions regarding health risks and expectations of the employer.

Nevertheless, the introduction of a short, general question about the respondent's overall perceptions of being at risk of cancer due to the situation at the workplace could open up further opportunities for analyses. A possible formulation could be, for instance:

All in all, to what degree do you think the work environment and the working conditions at your workplace put you at risk of getting cancer? Do you consider the risk factors at your workplace as high, rather high, rather low or low?

or:

On a scale from 0 to 10, with 0 meaning no risk and 10 a very high risk: How would you rate the overall risk that the conditions at your workplace may foster the development of any type of cancer?

The answers could then be compared with the risk profile resulting from the factual questions on exposure situations and the application of protective measures. Multivariate analyses could, for instance, test whether or not there are certain risk types (exposure situations or carcinogens) which are rarely perceived as risks by employees. Analyses of cancer risk awareness could also be differentiated by employee characteristics such as sex, age, educational level, nationality, occupation and sector of activity as well as the size of the workplace where they are currently employed. This information could, for instance, be valuable for the targeting of awareness-raising campaigns.

The possibilities of analysis would evidently be limited by the fact that an employee may be exposed to various substances. A clear attribution of the awareness to one single factor will therefore often not be possible – for this, questions on the perception of risks would have to be asked for each single exposure situation that applies. This is not feasible in terms of interviewing time, nor is it useful to mix the factual approach of AWES in this way with a perception-based approach. If one applies multivariate analysis models, a single overall risk awareness question will nevertheless deliver valuable insights.

3.6.3 Employer information on how to reduce the exposure or how to protect oneself

For the proper protection of workers from health hazards, the provision of PPE (such as respiration masks), the optimisation of the work environment (such as by the installation of a proper ventilation system) and the awareness of workers on the existence of the hazards are important prerequisites. These factors alone, however, will often not be sufficient for effective protection. A further essential prerequisite is knowledge of how best to protect oneself, be it by avoiding or minimising the exposure to the health hazard or – where this is not possible – by minimising its impact, such as by actually using the protective equipment provided. The provision of this knowledge is among the basic duties of the employer in the area of safety and health at work.

OccIDEAS does not so far include any questions asking if the interviewee has received any instructions on how to protect oneself from exposure to carcinogens. Since improving prevention would be one of the aims of an EU-wide worker exposure survey, it seems worth considering adding one or more questions on this issue.

Including such aspects into the questionnaire is, however, not easy. Depending on the job, some respondents are already confronted with a number of questions related to tasks and the use of certain materials in them. Asking, for each of the materials, whether or not the employer has provided proper instructions for its handling could make the interview very lengthy and tiresome. Therefore, one or few summarising questions regarding instructions received from the employer side could be a more practicable way. Such a question could be, for example: 'Your answers to the previous questions suggest that your work does in some instances involve exposure to carcinogens. Have you received proper instruction on the potential danger of being in contact with carcinogens and on ways to protect yourself from (excessive) exposure?'

This question does obviously not allow differentiation between different exposure situations or different agents. It may well be that the employee is made aware of the potentially carcinogenic hazard originating from some tasks and agents, but not of others that are also relevant in that workplace. However, again, the introduction of this additional dimension separately for each task asked about in the questionnaire would render the questionnaire extremely lengthy. Asking an overall question may nevertheless provide some valuable information on the information and training practices of the employer as regards exposure to carcinogens.

3.6.4 Introduction of a time dimension

As already outlined, for most carcinogenic substances and exposure situations, the current version of OccIDEAS does not include any questions related to the duration or frequency of tasks and the related potential exposure situations. Instead, mostly dichotomous answer categories (yes/no) are provided. According to the OccIDEAS team, questions related to the frequency and duration of exposure situations were included in earlier versions of the questionnaires.

These earlier efforts to include a time dimension did not render satisfactory results. The omission of the time dimension in subsequent versions of the questionnaire modules is therefore for good reason. Nevertheless, the lack of any time dimension in the questions has a potential consequence for the usefulness and comparability of the data:

- In the absence of any time dimension, exposure values as measured by OccIDEAS tend to be overestimated. In the analysis, even very short and occasional exposure situations are considered exposure to a risk, since further differentiation is not possible based on the data collected. While very occasional and short exposures may carry considerable risks for some carcinogens, this is certainly not the case for all of them.
- The comparison between tasks and substances and a ranking of the most urgent issues becomes difficult if the only indicator available for an exposure is the number of workers affected. A risk to which only few workers are exposed, but frequently and for a long time, may require more urgent action than a risk that affects many persons, but only for a short time.

- The duration of exposure may also have an impact on the use of protective measures.

If an inclusion of the time dimension is considered essential for an exposure survey, the practical difficulties with this in earlier versions of OccIDEAS do not yet, in our view, discount OccIDEAS as a model for a worker exposure survey. Further research on experiences with questions on frequency and duration in other studies and methodological experiments might show more promising alternatives for this type of questions. One option might be, for example, the inclusion of a summarising multi-item question towards the end. There, the frequency or duration of the exposure could be asked separately for the exposure situations considered most important. The selective insertion of questions on the duration of exposures for only situations for which exposure is considered very frequent or very intensive could be a solution.

Any addition of a time dimension would in any case require intensive testing. Likewise, it might require the revision of some of the assessment algorithms included in the OccIDEAS system.

- ▶ The survey can be augmented with further questions, for instance on the awareness of cancer risks or barriers to the use of protective equipment.
- ▶ If more information on the time dimensions of exposure is considered essential, the addition of questions on frequency and duration should be investigated and tested.

3.7 Applicability of the OccIDEAS concept to other health hazards

EU-OSHA's main interest with regard to a worker survey is currently the collection of more information on workers exposure to carcinogens. One of the tasks within the feasibility study was however to assess in how far the survey concept would have the potential to also serve for the measurement of workers exposure to other hazardous agents or working conditions. The applicability of the survey concept to other health hazards could raise the "return of investments" into the set-up of the survey concept since synergies could be expected. Besides, it would enable researchers to combine workers exposure to carcinogens with their exposure to other hazards.

In fact, the OccIDEAS team has in the meantime already developed questionnaire modules for three other types of health hazards, namely the exposure to noise, vibration and ototoxic chemicals, the exposure to asthmagens and, most recently, the exposure to psychosocial hazards (with fragment lists on job strain, job precariousness, bullying, discrimination and distress). In Australia, the applicability to other hazards thus has already been tested.

It may even be possible to combine questions on different hazards in one survey, as has been done in Australia recently by combining questions on a set of ototoxic chemicals and on noise and vibration in the AWES-hearing study. The combination increases the number of questions to be asked to a person, but this turned out to be critical only for very few jobs where all types of risks asked about can occur.

The application of OccIDEAS to other hazards can in principle have similar advantages than its application for carcinogens, namely first and foremost a high degree of cross-national comparability due to the concentration on objective, factual questions. For Europe, further applications of OccIDEAS should however be considered only after having successfully implemented a study on exposure to carcinogens. Likewise, it should also be thoroughly checked beforehand whether the information to be gained for an adaptation to other hazards is not already available.

3.8 Conclusions and recommendations

- ▶ An EU-wide worker survey on the exposure to carcinogens following the OccIDEAS model could fill many existing information gaps in a convincing manner. Compared with HazChem@Work, it is easier and quicker to implement and is likely to provide a higher degree of data quality, particularly in terms of cross-national comparability. It can include all types of workers, including self-employed or family workers, and is able to map the exposure of a person to multiple carcinogens.

Recommendations

- ▶ If considering an implementation of the survey in Europe, decision-makers should clarify how important the inclusion of information on the time dimensions of the exposure is for their purposes. It should also be decided at an early stage whether or not the survey is to be augmented with further questions, for instance related to the awareness of workers.

4 Adaptability of the OccIDEAS survey concept to Europe

OccIDEAS has been developed for the work situation in Australia and has so far been run on a larger scale only in Australia and Malaysia. To date, there is no experience of applying OccIDEAS to any European country. The implementation of the survey in the European context will require some changes to the questionnaires. These may range from small adaptations, for example in the demographic questions, to the set-up of totally new job-specific questionnaire modules or other major adaptations. The degree of adaptations will depend on the number and scope of differences existing between Australia and Europe regarding the definition of jobs, tasks, exposure situations and carcinogens. It will also depend on the demands that EU-OSHA has regarding the customising of the survey to Europe.

In addition, within Europe, national adaptations of the survey concept might be desirable or even indispensable. The European Union has set guidelines and some binding rules (such as exposure levels for some substances) ensuring a certain degree of harmonisation of national legislation and enforcement practices in the field of safety and health at work. The legislation is, however, not fully harmonised. Many of the legislative initiatives take the form of framework directives. These ensure common basic rules, but leave room for national adaptations. Therefore, there may also be differences between the EU countries requiring adaptation of the survey for individual Member States.

It is not among the tasks of the feasibility study to check and assess such differences for all tasks, agents and protective measures tackled in the survey. In view of the large number of different modules, this would require a project of its own. Instead, two occupations (farmers and painters) in three countries (Germany, Poland and Romania) were selected and analysed in more detail. The findings are based on qualitative interviews with safety and health experts and consultants in these fields, literature research, internet research and further enquiries, such as at national safety and health institutes. This sample examination will allow a first judgement on the general need for any country adaptations and the scope of potential adaptations.

Throughout this chapter, both dimensions – differences between Australia and Europe as well as differences between the various EU Member States – will be discussed.

- ▶ OccIDEAS is tailor-made for the situation in Australia. For application in Europe, differences in jobs, tasks, agents or materials might require the adaptation of the survey instrument.
- ▶ Differences in jobs, tasks and materials may also exist between EU countries and lead to the necessity of developing country-specific questionnaire variants.

4.1 National differences in jobs

The OccIDEAS team used ANZSCO as a starting point and rough orientation for the design of the various job-specific task modules in OccIDEAS. This classification is not fully compatible with the international ISCO-08 classification or with any of the relevant national classifications (those in Germany, Poland and Romania). The structural differences in the analysed classifications of occupations are summarised in Table 9. The summary shows large quantitative differences particularly for the finer differentiations. The Romanian classification (*Clasificarea Ocupatiilor din Romania* – COR) is the most differentiated among the five classifications and ISCO-08 is the least, with one level of differentiation fewer. Although the number of sub-major groups in ANZSCO and ISCO-08 is identical, there are considerable qualitative differences in the definition of these 43 groups, so that, also on this level, the classifications are not easily compatible.

Table 9: Classification of jobs and occupations

Classification/country	Major groups	Sub-major groups	Minor groups	Unit groups	Occupations groups
ANZSCO	8	43	97	358	1,023
ISCO-08	10	43	130	436	Not applicable
KZiS (Poland)	10	43	133	445	2,443
KldB2010 (Germany)	10	37	144	700	1,286
COR (Romania)	10*	43*	129*	434*	4,327**

KldB2010, *Klassifikation der Berufe 2010*; KZiS, *Klasyfikacja Zawodów i Specjalności*.

* including Major Group 0 – Armed Forces; ** without Major Group 0 – Armed Forces.

For the examination of farmers and painters regarding tasks, risk factors and protective measures, we included occupational groups for low-skilled workers (ISCO-08 major group 9) and skilled workers (ISCO-08 major groups 6 and 7):

1. mixed crop and livestock farmers (ISCO-08 sub-major groups 61, 63, 92)
2. painters in construction (ISCO-08 sub-major group 71).

An analysis of ANZSCO and ISCO-08 for these examples shows generally high comparability of both classifications regarding farmers. The national classifications KldB2010 (Germany), KZiS (Poland) and COR (Romania) also show high comparability to ISCO-08 for this occupational group. Nevertheless, there are some relevant differences that render a comparison of tasks for specific groups of workers difficult. The ANZSCO classification does not, for example, include a unit group for subsistence farmer (ISCO-08 unit group: 6330 – *Subsistence Mixed Crop and Livestock*), nor does the German classification. In the Polish and Romanian systems, the subsistence farmer is listed and plays an important role in the national agriculture.

For painters (in construction), the ANZSCO and ISCO-08 classifications contain only one unit group. This group consists of skilled workers. The German classification also includes another unit group for helping/learning activities: German unit group 33211 – *Occupations for painting and varnishing jobs – Helping/learning activities*. Overall, the differences between ANZSCO, ISCO-08 and national systems are considerable for construction painters. The Romanian system refers officially to what could be called a wall painter (with tasks such as whitewashing). In practice, Romanian construction painters do wall as well as other painting tasks (wood, metal structures, etc.) – the latter being assigned to different occupational groups in other classification systems.

As these examples show, comparisons of the situations for selected occupational groups are not straightforward because of differences between the classifications. However, correspondence tables between ANZSCO and ISCO-08 as well as between ISCO-08 and national European classifications are available. With the investment of some extra effort, a reasonably clear correspondence can thus be established and occupations can be compared on this basis as regards, for instance, tasks, exposure circumstances or protective measures to be applied.

- ▶ Although job definitions in OccIDEAS do not directly follow any official classification of occupations, such classifications are useful for comparing jobs with regard to country-specific differences that may have an impact on the exposure situation.
- ▶ The classification of occupations used in Australia differs from the ISCO-08 classification commonly used in EU-wide surveys. Within the EU, there are also different national classifications in use. Although correspondence tables exist, this renders comparisons more difficult and time-consuming.

4.2 Availability of information on occupations and tasks

As shown, the OccIDEAS questionnaire is mainly based on working tasks. For each job type, different customised task questionnaire modules have been prepared by the OccIDEAS team. For this, the nature of the jobs and the working environment that are typical in Australia were used as orientation. For any adaptation of the survey to other national contexts, it is therefore necessary to check how far jobs, working environment and tasks are comparable with the situation in Australia. For these checks and eventual adaptations, the availability of systematic descriptions of jobs and tasks is an important prerequisite.

In this section, first international (ISCO-08), Australian and European national classifications of occupations will be investigated as possible sources of task descriptions and for the analysis of national differences regarding the task profiles of occupations. In a second step, further possible sources for the derivation of task descriptions will be discussed.

4.2.1 The International Standard Classification of Occupations (ISCO-08)

The ISCO-08 is a classification structure issued by the International Labour Organization (ILO), for organising information on labour and jobs. It is part of the international family of economic and social classifications of the United Nations. The current version, known as ISCO-08, was published in 2008. EU-wide surveys such as the European Working Conditions Survey (EWCS) of Eurofound or the Labour Force Survey (LFS) coordinated by Eurostat use ISCO-08 for the classification of the occupations of respondents.

In the ISCO-08 structure, the skill level is the most decisive criterion. The 10 major groups mostly reflect different skill levels, ranging from managers to elementary occupations. Exceptions are major groups 6 'Agricultural, forestry and fishery workers' and 0 'Armed forces occupations', which reflect sectors of activity rather than skill levels.

The ILO has drawn up descriptions for all occupations differentiated in the ISCO-08 classification. In the ISCO-08 job descriptions, the main tasks related to each job are briefly described. The descriptions are available up to the four-digit level (unit groups, the finest level of differentiation existing in ISCO-08). The ISCO-08 job descriptions are however not focused on aspects of safety and health at work, but have rather been developed for purposes of research on education, training and skill needs. Below, there is an example of the job descriptions issued by the ILO.

ISCO-08 6130 Mixed Crop and Animal Producers

Mixed crop and animal producers plan, organize and perform farming operations to grow and harvest field, tree and various other crops, as well as to breed, raise and tend animals and to produce a variety of animal husbandry products, for sale or delivery to wholesale buyers, marketing organizations or at markets.

Tasks include –

- a) *monitoring market activity and conditions, determining kinds and amounts of crops to be grown and animals to be raised, and planning and coordinating production accordingly;*
- b) *purchasing seeds, fertilizer, and other supplies;*

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- c) performing operations such as land preparation, sowing, planting, cultivating and harvesting crops;
- d) producing or buying fodder and other food supplies;
- e) breeding, raising and tending animals;
- f) killing and skinning animals, and preparing animals or animal products for market;
- g) renting or investing in and maintaining and cleaning farm buildings, machinery, equipment, and structures;
- h) storing and carrying out some processing of produce;
- i) promoting and marketing products, arranging the sale, purchase and transportation of livestock, produce and supplies and maintaining and evaluating records of farm activities and transactions;
- j) training and supervising workers in animal care procedures, maintenance duties, and health and safety precautions and hiring and discharging workers and contractors.

As the example shows, the ISCO-08 job descriptions provide a quite comprehensive picture of the tasks that workers in these occupations perform. It is nevertheless not an easy task to derive job exposure matrices on this basis. This requires more in-depth knowledge about the described work processes, the materials used and the shape of typical workplaces. Relevant questions for the example above are, for example: Is the task mainly done outdoors or indoors? Are any fertilisers, pesticides or other chemicals used for sowing, planting and cultivating crops? Do any of the working tasks involve exposure to potentially carcinogenic dusts?

To define in a scientifically sound manner, for each of the ISCO-08 unit groups, the tasks that may be related to exposure to carcinogens and the materials involved in these tasks implies a huge amount of work. It includes ample research on specific exposure literature and the collection of advice from experts with specific knowledge of these sectors and jobs/occupations³³. This was done by the OccIDEAS team when developing and revising OccIDEAS, although not with a focus on ISCO-08.

4.2.2 National classifications of occupations

Another source for job descriptions can be national classifications of occupations. The national classifications of Germany, Poland and Romania will be briefly described and evaluated with regard to their usefulness as sources of task descriptions or for the comparison of tasks between EU countries.

Polish Classification of Occupations and Specialisations for Labour Market Needs (KZiS)

The Polish Classification of Occupations and Specialisations for Labour Market Needs (*Klasyfikacja Zawodów i Specjalności* – KZiS), published in 2014, is a national adaptation of ISCO-08 compiled by the ILO. In order not to lose comparability with ISCO-08, the ambition was to minimise the changes on the three highest levels. For the listed occupations, KZiS provides task descriptions similar to those available for ISCO-08.

German Classification of Occupations 2010 (KldB2010)

The goal of developing a new German Classification of Occupations (*Klassifikation der Berufe* – KldB) was to create an up-to-date and generally accepted classification of occupations for Germany which on the one hand satisfies the pronounced occupation-specific structuring of the German labour market and on the other hand enables a linkage to ISCO-08. KldB2010 provides a detailed description of tasks, very similar to the descriptions available from ILO for the ISCO-08 classification.

Romanian Classification of Occupations (COR)

The current Romanian job classification system (COR) is harmonised with ISCO-08; for the groups with up to four digit codes the two systems are almost identical. Unlike ISCO-08, the Romanian system has not a description (enumeration) of tasks, but only a very brief overall description (like the introductory

³³ In setting up such a survey in the EU, experts of different countries should be involved at some point in the light of possible differences between jobs within the EU. In the example of agricultural workers, for instance, the type of animals raised or the type of crops (for example olive trees in southern Europe, but not in other parts) may differ and imply different types of exposures to carcinogens.

description in ISCO-08). The Romanian system does not include clear reference to education, either. To the best of our knowledge, in Romania there is currently no systematic, unified description of tasks for different jobs or sectors. Descriptions of occupational standards do not manage to compensate for these omissions because there is only partial standardisation (not all jobs are standardised) and information on tasks is scarce.

Although all three national classifications provide some sort of description for the listed occupations, these descriptions are not always very comprehensive and in some cases (such as in the case of the COR codification used in Romania) do not include the listing of tasks to be done in the occupation. Owing to the different definitions of the jobs in the classification systems, the task descriptions will inevitably differ to some degree.

For setting up task lists in a European master questionnaire, using the ISCO-08 task descriptions as a starting point would certainly be preferable to using any of the national descriptions. The national descriptions are customised to the specific national situation in terms of educational systems, materials relevant in the workplaces, job titles, etc. Although these national classifications are mostly roughly compatible with ISCO-08 up to the three-digit level, beyond this level they may deviate considerably. For identifying tasks and analysing cross-national differences in these, assessments of the finer differentiations would however be useful. These are difficult to achieve on the basis of the national classifications because real differences in tasks can hardly be disentangled from differences between the classification systems.

4.2.3 International Hazard Datasheets on Occupations

An alternative (or additional) source of task descriptions for setting up or adapting a worker survey on exposure could be the International Hazard Datasheets on Occupations (HDOs) compiled by the ILO. The datasheets list, in a standard format, typical tasks (and other relevant information) and hazards for a worker in the occupation. They provide several measures for the prevention of occupational accidents and diseases. These datasheets are a source of information for occupational physicians and nurses, safety engineers, hygienists, education and information specialists, inspectors, employers' representatives, workers' representatives, safety officers and other competent persons. A description of the datasheet structure is available at: <http://www.ilocis.org/documents/chpt103e.htm>.

The currently available datasheets (71) have been developed in a project undertaken by the ILO and the Israel Institute for Occupational Safety and Hygiene (IIOSH), in cooperation with the European Union and ILO-CIS (Centre International d'Informations de Sécurité et de Santé au Travail) Centres³⁴ throughout the world.

As an example, the description of the occupation 'painter (non-art)' is shown in the Annex, as Figure 2.

4.2.4 Expert contributions

A further important source of data on tasks is expert contributions. Labour inspectors have such expertise in general, although they do usually not have any predefined lists of tasks per job.

Current or former supervisors of different sectors/activities may also have this type of knowledge. Such expert knowledge is however usually not available in written form. It could be brought in by inviting experts to revise and enlarge task descriptions drawn up based on other sources.

Another type of experts with a broad knowledge about exposure circumstances and hazardous agents is sectoral organisations active in the area of safety and health, such as the employers' mutual insurance corporations existing in some countries (for example *Berufsgenossenschaften* in Germany).

To check the appropriateness and completeness of the job-specific questionnaire modules, it should not be necessary to send these to experts in all EU countries. The careful selection of a few countries that

³⁴ The Collaboration Network, formerly known as the network of CIS National and Collaborating Centres, provides a basis for collaboration among OSH agencies, institutions and organisations.

can be considered representative of others in the same region may be sufficient. Alternatively, sectoral experts with good EU-wide knowledge about the sector could be selected for this.

- ▶ For an adaptation of OccIDEAS to Europe, the availability of task descriptions for the various jobs is crucial.
- ▶ The ISCO-08 classification provides task descriptions. These are not focused on safety and health at work, but may serve as a starting point for the analysis of tasks with a possible exposure to carcinogens or other health hazards.
- ▶ International hazard datasheets on occupations provide information on tasks and hazards. They can be used for checking the completeness of the exposure matrices applied in OccIDEAS and for developing new questionnaire modules where needed.
- ▶ National classifications of occupations available in many EU countries mostly also provide task descriptions. These can serve as a basis for the analyses of relevant differences between EU countries in jobs and tasks.
- ▶ Safety and health experts can assess or amend information on exposure situations typical of a job.

4.3 Information on exposure circumstances and protection measures

4.3.1 Sources of information on exposure circumstances and protection measures

Exposure circumstances are situations or activities in which exposure to a substance – here carcinogens – occurs. At the international level, there are some databanks that contain important information regarding the exposure to carcinogens.

- Exposure measurement databases: these databases focus on measurement data and the description of the exposure context at the workplace level. In a few cases, such as the ExpoSYN database (which covers 18 European countries and Canada), they also include disease or production and consumption data.
- Exposure information systems: these systems provide comprehensive and nationally consistent exposure information enabling users to better understand the potential elements of risk in one or more countries. Examples are WOODEX (EU-25) and NOCCA (Denmark, Finland, Iceland, Norway and Sweden).

Another international source could again be the HDOs compiled by the ILO (see section 4.2.3 for more details). The datasheets list in a standard format not only tasks but also the equipment used for them and different hazards a worker may be exposed to in them. The hazards are differentiated into five groups: accident hazards, physical hazards, chemical hazards, biological hazards, and ergonomic and social factors. For an assessment of the completeness of the existing OccIDEAS questionnaire modules in terms of the coverage of all relevant hazards, the HDOs are a valuable source (see Annex, Figure 2).

A further possible source of information on exposure circumstances is the Institute of Occupational Medicine report (IOM, 2011). It assesses health, socio-economic and environmental aspects of 25 occupational carcinogenic substances identified by the European Commission. In addition to the summary report, there are separate dossiers for each substance describing in detail the underpinning data and the rationale for the assessment.

At the national level, in several countries information does already exist on jobs in which workers are exposed to health risks in particular and to cancer risk factors in particular. The main sources of this type of information are:

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- national registers of occupational diseases including cases of cancer, for example the Polish Central Registry of Occupational Diseases;
- national cancer registers, for example the Finnish ASA Register and the Polish National Cancer Register;
- national registers including hazardous substances and exposure data, for example the Polish Central Register of Data on Exposure to Carcinogenic or Mutagenic Substances, Mixtures, Agents or Technological Processes, the Italian SIREP and the German ODIN Register;
- databases focused on measurement data, for example MEGA (Germany), COLCHIC and SCOLA (France) and FINJEM (Finland);
- exposure information systems, for example CAREX (Finland), FINJEM (Finland), Matgéné (France), CAREX (Canada), SUMER survey (France), MatEmExp (Spain) and DOM-JEM (Netherlands).

Furthermore, national occupational safety and health (OSH) institutes regularly conduct research, collect information, and publish reports and other informative materials regarding exposure circumstances. They include hazards, protective measures, tasks, etc.

4.3.2 Examples: exposure circumstances of farmers and painters (in Germany, Poland, Romania)

In the following, exposure circumstances will be analysed for the examples of farmers and construction painters in Germany, Poland and Romania.

The chemical risks to which **farmers** are exposed include contact with plant protection products, fertilisers, fuels, lubricants and dusts in a variety of situations. Most workers in agriculture are also exposed to UV radiation because much of the work is done outdoors.

A look at the tasks listed by ANZSCO shows that between Australia and the three countries there are some differences in the types of crops and livestock raised. However, these do not lead to any substantially different tasks or exposure situations.

In practice, the Australian tasks might on average be less manual than in Romania or Poland, which may reduce the level of exposure (for example to pesticides) or the time of exposure (for example to UV radiation). The organisation in small subsistence farms, which are prevalent particularly in Romania, is also more likely to be inefficient, spontaneous and with a lot of improvisation, which may have an effect on the exposure. Many such enterprises do not have resources to buy modern equipment and to maintain equipment in good technical condition. Larger enterprises are in principle more able to conduct modern farming with suitable equipment, which may reduce exposure (for example tractor cabins with air conditioning and air filtering, PPE). Bigger enterprises are also more able to attract and maintain better-trained and more highly skilled workers, to use external maintenance services and to have safer working procedures.

These differences do not have any general repercussions on the tasks and exposure circumstances to be mapped in the survey. In all countries, small subsistence farming, implying more manual work, coexists with large-scale, often export-oriented farming using more advanced technology. The differences are rather quantitative, that is in the proportion of small-scale farmers among all farmers in a country.

The three selected EU countries have implemented the general EU legislation on chemicals including the Biocidal Products Regulation (BPR). Therefore, they all observe the EU restrictions on carcinogenic compounds. However, as Romania has a large non-EU border, there is the possibility that non-compliant products will be used, because of illegal trade.

Regarding the degree of exposure to carcinogens, there are some differences between countries.

- Exposure to process-generated carcinogens such as diesel exhaust, used mineral oil or hard wood dust is very likely to take place in all countries. The exposure level and duration may be

higher in countries with technically less developed agriculture, because of the less efficient work organisation and the use of inappropriate or second-hand equipment by some farmers.

- In Romania, exposure to historically contaminated sites may occur, including those polluted with persistent organic products.
- Exposure to biological agents is likely to differ between countries because it lasts longer for manual tasks and there may be bad practices in some of the countries.
- Exposure to sun is common to European farmers. Although gradual exposure, starting early in spring, avoids burns, there is still an increased risk of skin cancer among farmers. Risk differs, however, between countries due to regional differences in the intensity of UV radiation or in the duration of exposure, with more manual work usually leading to greater exposure.
- In Poland and Romania, there is relatively little use of fertilisers and plant protection products compared with Germany. On the other hand, in Germany the harm emanating from the use of these substances may be lower thanks to more widespread use of advanced protection technologies (for example sealed enclosed tractor cabins).

The use of collective and personal protective equipment is rare among Romanian farmers, especially for those working in very small or family enterprises, according to the OSH inspectors interviewed for this project. In addition, in Poland, the economic situation of farms has adverse effects on working conditions and the use of PPE.

An analysis of protective measure types to be applied in the three countries does not show any significant general differences. Considerable differences do actually exist as regards the quality, up-to-dateness and age of the protective equipment in use. Thus, for example, small farmers in Poland or Romania often work with technically less sophisticated and more outdated protective equipment than large farm enterprises in these countries or the majority of farmers in Germany³⁵.

Painters may be exposed to a variety of chemical hazards due to the material they are using for work (paints, solvents, etc.). The selected countries implemented the EU regulations regarding chemicals but in Poland and Romania counterfeit materials may be used by smaller companies because of the price and lack of awareness of risks. There are also risks from legacy substances (asbestos, lead in paints, etc.). Although these risks generally exist in all countries, the awareness and control measures may differ.

The use of collective and personal protective equipment in construction is better than in agriculture, but this does not always apply, especially in small enterprises and during hot weather. Protective measures used by painters in construction include PPE for hands, head, eyes and respiratory system; work wear, protective clothing, varied from season to season; and portable ventilators. Analysis of types of protective measures in Poland and Germany does not show any significant differences. For Romania, there are no specific recommendations about PPE construction painters should use.

- Information on exposure circumstances in EU countries is available from exposure measurement databases and systems. A variety of national hazard registers and information from national safety and health institutions are further sources.
- For the analysed examples of farmers and painters, exposure circumstances are similar across the countries. Differences in the type of equipment and its maintenance state are, however, likely to lead to some differences in the duration of exposure and the effectiveness of the protection.

³⁵ While, for example, many farmers use a tractor with a cabin when applying pesticides, there are big differences between these cabins. Small farmers often use simple cabins, with old seals and no or inadequate air filters, while large farmers may have the newest tractors, with fully sealed cabins and a sophisticated air-conditioning system thoroughly filtering the air.

4.4 Materials and substances: sources of information and national differences

4.4.1 Number of carcinogens relevant to workers

The set of carcinogens selected for OccIDEAS does not necessarily cover all carcinogens relevant to workplaces in Europe. Likewise, OccIDEAS might include substances that are relevant to Australia, but not to Europe. This may, for instance, be a result of national differences regarding the assessment of agents as carcinogenic, or specificities of the national industry – some industries (such as the mining or the chemical processing of specific substances) may exist in one of these two regions, but not in the other. An important step in the preparation of a worker exposure survey is therefore the selection of carcinogens considered relevant to the study.

The number of carcinogens currently subject to regulation is rather large. The list of substances on the ECHA website with a (both harmonised and non-harmonised) classification as Carcinogen 1A, H350, or as Carcinogen 1B, H350 – as updated on 16 June 2017 – comprises 245 entries. With a harmonised classification as Carcinogen 1A, H350, or as Carcinogen 1B, H350, the list still comprises 125 entries.

The IARC has identified over 165 occupational carcinogens (IARC, 2013).

Henning Wriedt (Occupational Health & Safety Advice Centre, Hamburg, Germany) has identified 71 carcinogens as relevant to workers' exposure via inhalation at a considerable number of workplaces in Europe (Wriedt, 2016). For these 71 carcinogens a binding occupational exposure limit (BOEL) will be suggested under the Carcinogens and Mutagens Directive (CMD, Directive 2004/37/EC). According to Wriedt, for dermal exposure, however, OELs might be of scientific and regulatory interest, but not of practical interest, given the absence of suitable instruments for monitoring dermal exposure at the workplace.

In the IOM report (IOM, 2011), among the 25 assessed occupational carcinogenic substances identified by the European Commission, it is suggested that the strongest cases for introducing an OEL are for respirable crystalline silica, hexavalent chrome and hardwood dust. Other substances for which the evidence supports the introduction of a limit include diesel engine exhaust emissions, rubber fumes, benzo[a]pyrene, trichloroethylene, hydrazine, epichlorohydrin, o-toluidine, mineral oils and used engine oil, and 4,4-methylenedianiline (MDA).

In the SUMER 2010 survey, the 24 most important carcinogens were identified (Dares, 2013).

4.4.2 Relevance of the carcinogens addressed by OccIDEAS

The list of agents included in the AWES-cancer survey conducted in 2011/12 included 38 carcinogens considered relevant to working conditions in Australia (Fernandez et al., 2012). It includes both chemicals and non-chemicals (radiations, shift work, etc.). Wriedt (2016) has identified 71 carcinogens as relevant for workers in Europe. These are 33 agents more than identified in the study by AWES-cancer survey. The following criteria provided the assessment framework to establish a list of priority carcinogens for AWES/OccIDEAS:

- evidence of carcinogenicity using criteria set by IARC: Group 1 or Group 2A
- use in occupational circumstances
- use in Australia.

Most of the carcinogens in OccIDEAS have an occupational exposure limit value (OELV) already established or recommended (indicative) by EU directives. The coming amendments of the CMD include proposals for OELVs for some further substances (chromium VI, quartz, etc.). Other carcinogens might not yet be included in the amendments (such as diesel exhaust or used mineral oil). Existing or proposed OELVs show the concern at EU level for the management of carcinogens included in OccIDEAS. They could allow an evaluation of the estimated level of exposure.

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To assess the relevance of the agents in OccIDEAS for the EU, a systematic comparison of data on the most relevant carcinogens at EU and national level was performed (see Table 21 in the Annex). For the assessment, the results of three recently published studies were considered:

- Dares (2013)
- IOM (2011)
- Wriedt (2016).

The comparison shows that most of the carcinogens in OccIDEAS have been also identified as most relevant to exposure in the EU by the three studies mentioned. This makes the OccIDEAS list of carcinogens relevant to exposure in the EU. It can therefore be used to estimate exposure for a high number of EU workers.

There are only a few exceptions, such as acid mist or 'environmental tobacco smoking', that are acknowledged as carcinogens in the EU and addressed by OccIDEAS but not included in the three above studies on high-relevance carcinogens in the EU. Mists from strong inorganic acids are classified by the IARC as carcinogenic Group 1. Their omission in the three studies mentioned may have various possible reasons, such as differences in the selection methodology used by each study.

The IOM report and the study by Wriedt listed benzo[a]pyrene, hydrazine and MDA as important substances for European industry which are missing from the OccIDEAS list. For these substances, national OELVs have been established in some EU countries, such as Germany and Poland.

The Dares study listed cytostatic agents. However, the OccIDEAS list explicitly excluded pharmaceuticals because these were not considered primarily occupational exposures.

Some of the substances in OccIDEAS have legal restrictions in the EU (for example cadmium or chromium VI compounds, some chlorinated solvents, some pesticides) and these restrictions should be considered when evaluating exposure.

In his study, Wriedt included additional substances classified as 'potential regulatory carcinogens'. The reason for considering 'potential regulatory carcinogens' is the expectation that in the foreseeable future many of them will become 'actual regulatory carcinogens' by inclusion in Annex VI of the CLP regulation, classified as Carcinogen 1A, H350, or Carcinogen 1B, H350, or, in the case of process-generated carcinogens, by inclusion in Annex I of the CMD.

There are six carcinogenic substances/ groups of substances frequently listed in current studies regarding the most relevant EU carcinogens which are currently not included on the OccIDEAS list: hydrazine, 4,4-diaminodiphenylmethane, rubber process fume and dust, refractory ceramic fibres (aluminium silicate fibres), 1,2-dibromoethane and 1,2-epoxypropane (see Annex, Table 21). Because of their relevance to the occupational setting in the EU, they could be taken into account in an EU-wide survey. This would imply the preparation of new questions asking about tasks in which any of these agents may be involved.

4.4.3 Differences in occupational exposure limits: do they matter?

OccIDEAS uses OELs in the assessment algorithms programmed for determining the level of the exposure based on the survey answers. OELs may differ considerably. For example, for crystalline silica most Australian states have adopted a recommendation suggesting using 0.1 mg/m³ (=100 mcg/m³) as the exposure limit (AIOH, 2009, p. 14). Within Europe, there is no common obligatory OEL set. The OELV for crystalline silica varies considerably within Europe, ranging from 50 mcg/m³ in Italy, through 75 mcg/m³ in the Netherlands and 100 mcg/m³ in Sweden, to 300 mcg/m³ in Poland. The variations in OELs between the countries stem from differing methods and practices used to define or review existing national OELVs (Mengeot et al., 2014) (see

Table 19 and Table 20 in the Annex for a systematic comparison of OELs).

The CMD sets binding workplace exposure limits for only three substances, whereas indicative OELVs have been adopted for 122 substances under the Chemicals Directive 98/24/EC. Recently the European

Commission has proposed new OELs for 13 occupational carcinogens, including respirable crystalline silica.

For carcinogens, in many countries, exposure limits are not established at all because it is not possible to determine safe exposure levels. Instead of proposing an exposure limit, a quantitative risk assessment may be carried out. Various government agencies and national or international organisations active in establishing or proposing admissible exposure levels for carcinogens use the concept of so-called acceptable risk. The level of acceptable risk depends on commonly accepted social and economic criteria. In this respect, the decision is usually taken by three interest groups made up of employee, employer and government representatives, whose task is to perform law enforcement surveillance. A few Member States (for example Germany, the Netherlands and Poland) are reported to apply criteria on acceptability of risk³⁶. In Germany, since 2007 either risk- or health-based OELs have been derived or are still in the process of being derived for more than 40 carcinogens. In the Netherlands, since the mid-1990s, risk-based OELVs have been derived for about 25 carcinogens (Wriedt, 2016).

The questionnaire modules will be affected only if OELs for a substance are so different that certain tasks would be considered tasks with carcinogenic exposure in some countries but not in others, taking into account the level of exposure usually associated with that task and material (for example according to research by safety and health institutes and other scientists). Before applying the OccIDEAS concept to Europe, it should therefore be checked whether or not there is any agent or exposure situation that is not covered by OccIDEAS because it has a considerably higher OEL in Australia and was therefore not considered relevant there.

In our view, an EU-wide worker exposure survey should ignore the country differences with regard to OELs within the EU. Instead, the OEL recommended by the EU should be taken as the basis for possible adaptations in the questionnaire modules or in the algorithms underlying the assessment of the likelihood and intensity of an exposure. These adaptations should best be implemented by the OccIDEAS team, which set up the assessment algorithms and is therefore familiar with the logics and rules behind the application of OELs.

4.4.4 National carcinogen and OEL lists

Germany

The German list of carcinogenic, mutagenic or reproductive toxic substances contains 70 carcinogens classified as Carcinogenic 1A, 1B and 2 (Technical Rules for Hazardous Substances – TRGS 905, BMAS, 2006). The OELs for Germany are laid down in TRGS 900 (BMAS, 2017). There, 438 substances are listed.

The German GESTIS (*Gefahrstoffinformationssystem*, Hazardous Substance Information System) International Limit Values for Chemical Agents Database³⁷ is an information system on hazardous substances run by the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)³⁸. The GESTIS Substance Database contains information about the safe handling of hazardous substances and other chemical substances at work, for example health effects, necessary protective measures and measures in case of harm (including first aid). Furthermore, the user is offered information upon important physical and chemical properties as well as special regulations, for example Globally Harmonised System (GHS) classification and labelling according to the Classification, Labelling and Packaging (CLP) Regulation (pictograms, H-phrases, P-phrases). The database also contains a collection of OELVs for hazardous substances gathered from 30 European and non-European countries.

³⁶ https://oshwiki.eu/wiki/Occupational_exposure_limit_values

³⁷ The available information relates to about 9 400 substances. Data are updated immediately after publication of new official regulations or after the issue of new scientific results.

³⁸ Available at: <http://www.dguv.de/ifa/gestis>

The German list of occupational diseases includes the following carcinogenic substances: asbestos, benzene, aromatic amines, halogenated hydrocarbons, polycyclic hydrocarbons (PAHs), wood dusts, quartz dusts and some metals, for example lead, chromium, nickel and cadmium.

Poland

The Polish list of carcinogenic or mutagenic chemicals in the workplace is open. To carcinogenic or mutagenic substances belong: a) substances with a harmonized classification listed in Annex VI to the CLP Regulation 1272/2008/EC³⁹, b) chemical substances meeting the criteria for classification as carcinogen or mutagen category 1A or 1B, and c) chemical substances meeting the criteria for classification as carcinogen or mutagen category 1A or 1B without a harmonized classification.

The list of carcinogenic or mutagenic substances in the workplace with a harmonised classification contains 917 chemical substances. The list of carcinogenic or mutagenic substances in the workplace without a harmonised classification contains 30 chemical substances. The OELs for Poland are presented by the Central Institute for Labour Protection – National Research Institute (CIOP-PIB)⁴⁰. The list currently includes 441 chemical substances and 19 dust factors. OELVs were established for 27 carcinogenic chemicals and 11 dusts considered carcinogenic.

Romania

Romania has implemented the general EU legislation on chemicals, including the BPR. Therefore, it observes the EU restrictions on carcinogenic compounds. The OELs for Romania are laid down in regulation HG 1218/2006 with amendments⁴¹.

There are 590 OELs in total, of which 93 are for carcinogens 1A, 1B and 2. All OELs in Romania are compulsory (there are no indicative limits). According to legislation, if a substance meets the criteria for carcinogenicity then it should be considered carcinogenic, even if there is no OEL established. There is no published list of carcinogens used in Romania. Article 6 of the CMD is generally not applied.

4.4.5 Examples: materials and substances relevant to farmers and painters

The main chemical hazards to which a **farmer** is exposed include contact with plant protection agents, fertilisers, fuels and lubricants, in all three countries. In addition, farmers are exposed to a series of further carcinogens, including UV radiation, diesel exhausts and a number of dusts (such as dusts from grain harvesting or silica dusts).

No quality differences were found between Polish, German and Romanian products available on the market. Lists of authorised pesticides are published by national authorities, such as the national Ministry of Agriculture in Romania or the Federal Office of Consumer Protection and Food Safety in Germany. The lists include the name of the products, the active substances, the producers and usually also suggestions on their application.

According to our assessment, in most cases farmers and farm workers are not likely to be able to provide information regarding the composition of the materials (chemicals) they use. They are more likely to remember the name of the product itself and possibly the producer. This information is available from the lists of allowed pesticides mentioned, so, based on the lists, free text answers on questions about pesticides could be categorised in accordance with the substances they include.

Chemical products to which a **painter** may be exposed include paint-stripping formulations containing, in particular, methylene chloride, cresol, phenol, potassium hydroxide and/or alicyclic hydrocarbons (for

³⁹ Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

⁴⁰ OELs for Poland, available at: http://www.ciop.pl/CIOPPortalWAR/appmanager/ciop/pl?_nfpb=true&_pageLabel=P20200353841377519103587

⁴¹ OELs for Romania, available at: <https://www.inspectiamuncii.ro/documents/66402/260306/Hotararea+nr.+1218+din+06092006.pdf/5549b6b0-b827-45ab-bbd5-bfa574042ef2>

example methylcyclohexane); paint components including, in particular, cadmium, lead, organotin, mercury and arsenic compounds, chromates, epoxy, polyurethane, acrylate, vinyl and other resins and their constituents; solvents and diluents including, in particular, turpentine, petroleum fractions (naphtha, white spirit, Stoddard's solvent), n-hexane, toluene, xylene, benzene, acetone, methyl ethyl and other ketones, alcohols (methyl, ethyl, isopropyl, amyl, etc.), formaldehyde and phenol; and cleaning formulations including acids (which may contain various organic inhibitors), alkalis, organic solvents, etc.

No quality differences between Polish and German products available on the market were found. There are no lists of chemicals used in paints in Romania, but in our experience they are similar to those mentioned for Germany and Poland. Because of Romania's long non-EU border, it might be possible to find products that contain hazardous compounds (such as naphtha petroleum solvent, which is a carcinogen 1B) acquired in small quantities through illegal trade, especially by small enterprises.

- ▶ The number of identified carcinogens is considerably larger than the selection included in OccIDEAS.
- ▶ OccIDEAS does, however, cover most of the carcinogens considered both measurable and relevant to the workplace. At least seven further carcinogens should nevertheless be added to OccIDEAS, requiring the identification of relevant tasks and exposure circumstances.
- ▶ For many substances, OELs differ between Australia and Europe as well as within Europe. For an adaptation of the instrument to Europe, the OEL recommendations of the European Commission should therefore be used.

4.5 Implementability of the OccIDEAS survey concept in Europe: preliminary conclusions

In the previous sections, differences between selected EU countries regarding tasks, agents, OELs and protective measures were analysed for the selected examples of farmers and painters in Germany, Poland and Romania. The aim of these analyses was to gain information on possible differences between Australia and Europe and between EU Member States. The magnitude and degree of differences will be an important criterion for decisions on further steps if OccIDEAS is implemented in Europe.

For the analysed examples, the portfolio of tasks and technologies used did not show major differences between Australia and the EU or between the EU countries. Most of the differences found were quantitative rather than qualitative, for instance more farmers in a country using manual instead of more advanced tools for tasks involving exposure. The task portfolio itself is similar. Regarding products (fertilisers, pesticides, etc.), no relevant quality differences were found between the three EU countries or between these and Australia.

The JSM for farmers can thus be adapted rather easily for Europe, with just a few modifications, in particular tasks or materials. For construction painters, the differences between the tasks as described in ANZSCO, ISCO-08 and national systems are somewhat larger because of the differences regarding the classification of painters in the national systems. In practice, however, construction painters do not seem to be very different in the selected EU countries and Australia. Thus, for painters too, only slight adaptations in the research instrument would be required.

These sample examinations suggest that the adaptation of the OccIDEAS concept to Europe is generally possible and requires only a moderate amount of adaptations:

- ▶ The quantitative relevance of occupations covered by the OccIDEAS modules needs to be assessed. This should be done based on data from the Labour Force Survey. Existing modules should not be used if the occupations in question do not exist in Europe. For occupations relevant to Europe, but not covered by OccIDEAS, new modules should be created.
- ▶ Although the examined examples have not shown any major qualitative differences in the tasks and exposure circumstances between Australia and Europe, all further job-specific modules need to be scrutinised with respect to such differences before a launch of the survey in Europe.
- ▶ If differences are encountered, the affected questionnaire modules need to be adapted. For this, a number of sources with descriptions of job-specific tasks and exposure circumstances have been identified. In addition, sector-specific experts from different EU countries should be consulted.
- ▶ In a further step, relevant differences between the EU Member States need to be assessed for all modules. Judging on the basis of the results from the examined examples, major qualitative differences between EU countries are not to be expected.

5 Quality of data derived from a worker exposure survey

In what follows, first, the generic quality dimensions of survey research will be briefly introduced. Then, a theoretical concept will be outlined to structure two aspects of quality: accuracy and reliability of a statistic. Thereafter, challenges will be discussed related to the envisaged type of survey with regard to two other quality components: measurement and representation.

5.1 The quality of survey data: dimensions and criteria

According to the definition presented in the European Statistical System (ESS) framework, 'quality is a multi-dimensional concept and encompasses all aspects of how well statistics are fit for their purpose' (Eurostat, 2015, p. 10). In evaluating the quality of survey data, two perspectives can be distinguished: an output perspective and a process perspective.

Output quality components are (quotations from Eurostat, 2015, p. 10):

- relevance, that is 'meet the needs of users', which is particularly important for goals of dissemination;
- accuracy and reliability, that is 'outputs accurately and reliably portray reality';
- timeliness and punctuality, that is 'outputs are released in a timely and punctual manner';
- accessibility and clarity, that is 'outputs are presented in a clear and understandable form, released in a suitable and convenient manner, available and accessible on an impartial basis with supporting metadata and guidance';
- coherence and comparability, that is 'outputs are consistent internally, over time and comparable between regions and countries; it is possible to combine and make joint use of related data from different sources'.

The key process quality components are (quotations from Eurostat, 2015, p. 11):

- costs and burden, that is 'resources are used effectively' and 'the reporting burden is proportionate to the needs of the users and is not excessive for respondents';
- confidentiality, that is 'the privacy of data providers (households, enterprises, administrations and other respondents), the confidentiality of the information they provide and its use only for statistical purposes are absolutely guaranteed'.

In this section, the criteria of 'accuracy and reliability' and 'coherence and comparability' will be discussed in more detail. The other quality criteria listed above either were not subjects of this feasibility study or are tackled in previous or subsequent sections of this report. For the aspect of relevance, see for example section 2.1 on information needs and section 3.4 on the type of information obtainable from the survey.

- Eurostat has developed the European Statistical System (ESS) as a quality framework for cross-national surveys. It defines key quality criteria related to the output quality and the process quality.
- The OccIDEAS survey concept will be checked against the output quality indicators: accuracy, reliability, coherence and comparability.

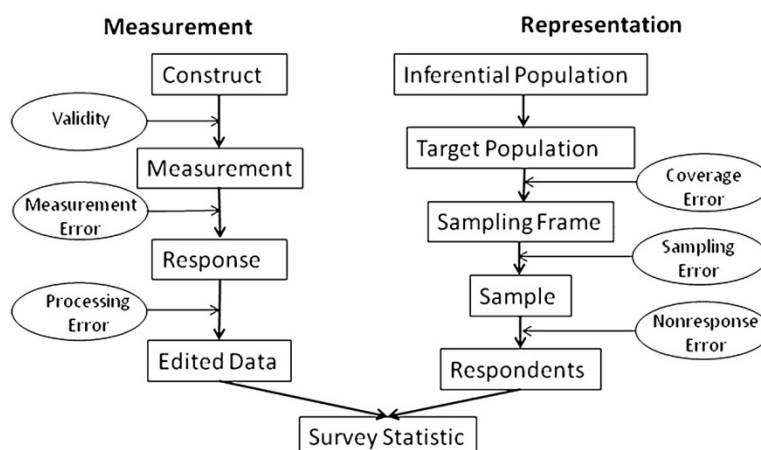
5.2 A systematic approach to accuracy and reliability

5.2.1 The concept of the 'total survey error'

The methodological quality components of accuracy and reliability can be structured using the concept of the 'total survey error' (see, for example, Groves, 2004; Groves et al., 2009; Groves and Lyberg, 2010; Weisberg, 2005). The total survey error approach has the status of a widely accepted and theoretically guided concept that can be extremely helpful in a systematic evaluation of the principal key errors which are inevitable in survey research, but which can be minimised if the design and implementation is guided by this framework. It focuses on the accuracy, that is unbiasedness, precision, validity and reliability, of the data, and thus on the possibility of drawing valid conclusions by extrapolating from samples to target populations and from the answer to an individual question to a true population value.

Groves and Lyberg (2010) identify two paths of inference in surveys that may be prone to error: 'the first inference is from the response to a question for a single respondent and the underlying construct of interest to the measurement. The second inference is from an estimate based on a set of respondents to the target population' (Groves and Lyberg, 2010, p. 856; see Figure 1).

Figure 1: Components of the 'total survey error' according to Groves and Lyberg (2010, p. 856)



Measurement:

1. In the path of measurement, problems of validity may arise, that is in the degree of correspondence between the manifest operationalisation, the survey question and answer and the latent theoretical construct.
2. Measurement issues in the narrower sense, that is the degree to which the response to a question fits to the content targeted by the question, define a further source of potential errors.
3. The path of measurement may be prone to data-processing errors.

Representation:

4. In the path of representation, there is a coverage error, that is the sampling frame usually does not cover 100 % of the targeted population.
5. Each survey based on a sample comes with a sampling error, which means that only a part of the population and not the whole population is chosen.
6. The path of representation is affected by non-response errors, which means that only some of the respondents in the sample can be reached and actually participate.

5.2.2 Measurement component of survey quality

Measurement 'concerns the process of linking abstract concepts to empirical indicants' (Zeller and Camines, 1980, p. 2). This gives rise to the question of how well an empirical indicator, or a set of empirical indicators, represents a theoretical concept.

There are two key properties of empirical measurements at the most general level – validity and reliability (see, for example, Carmines and Zeller, 1979; Zeller and Carmines, 1980):

- 'An indicator of some abstract concept is valid to the extent that it measures what it purports to measure' (Carmines and Zeller, 1979, p. 12).
- 'Reliability concerns the extent to which measurements are repeatable – by the same individual using different measures of the same attribute or by different persons using the same measure of an attribute' (Nunnally, 1967, p. 172).

5.2.3 Validity

Validity of measurement 'concerns the crucial relationship between concept and indicator' (Carmines and Zeller, 1979, p. 12). The basic hypothesis behind the OccIDEAS survey concept is that collecting information on the number of people doing tasks that imply the handling or breathing in of specific substances – in combination with information about protective measures – allows conclusions to be drawn about the number of workers at risk of cancer. In these conclusions, a differentiation can be made between the likelihood of being at risk and the degree of the risk itself.

Whether or not this is actually the case cannot be tested and verified in the framework of this feasibility study. The OccIDEAS team has carried out extensive checks on the validity of the measurement. A new assessment is advisable if the instrument is transferred to an area where environmental, working or legislative conditions differ. This is also supported by the authors of the OccIDEAS concept, who state that the 'extent to which these exposure assessments can be applied to workers in other countries is unclear, particularly where the exposure circumstances are clearly different. For example, estimates of solar ultraviolet radiation exposure obtained from Finland are likely to result in an underestimate of exposure when applied to Australia' (Carey, 2014, p. 56). Also, the working processes in the same jobs, such as manufacturing, may differ between countries, resulting in different exposures to certain agents. Different threshold values may also play a role with regard to the use of protective equipment.

Having these points in mind, it will be necessary to invest time in research on differences in environmental and working conditions between Australia and the EU countries as well as between the EU countries themselves when preparing a Europe-wide survey. If well adapted, the instrument is likely to deliver data with a similarly high validity to that in Australia.

An advantage of AWES compared with other surveys on workers' exposure to hazardous substances is that it provides an expert assessment on the degree to which workers are exposed instead of asking workers for their self-assessment, as has often been done in surveys on working conditions. Although the expert assessment is also fallible to a certain degree, it can be expected to be much more informed and much less influenced by expectations and awareness, and thus more valid.

5.2.4 Reliability

Reliability is a concept embedded in the context of repeatability, in other words administering an indicator repeatedly to a person (or other unit to be measured). It 'concerns the extent to which an experiment, test, or any measuring procedure yields the same results on repeated trials. The measurement of any phenomenon always contains a certain amount of chance error' (Carmines and Zeller, 1979, p. 11). So two questions arise:

1. How reliably does the survey instrument measure exposure?

According to our assessment, the reliability of the OccIDEAS survey concept can be considered high, particularly in comparison with surveys asking about the exposure to hazards in a more subjective way. Assuming that the real exposure of a person has not changed in the meantime, respondents in OccIDEAS are likely to answer a question in the same way if asked again, for instance after some months or years. In a survey asking for the perceptions of hazards, in turn, there is a much higher risk that the person will provide a different answer when asked again, even if the real situation has not changed at all in the meantime. This can, for example, be due to a changed perception. If, for example, the person reads an article about skin cancer resulting from UV radiation, he or she will have much

higher risk awareness and is likely to think about exposure situations at the workplace that he or she did not consider when being asked the first time.

2. How reliable is the algorithm's assessment of the degree to which workers are exposed?

As indicated above, the assessment of the degree to which workers are exposed is based on an expert assessment. The expert assessment procedure as applied in OccIDEAS 'automates some of the assessment steps' (Fritschi et al., 2009, p. 3) and certain rules are specified. With respect to reliability, these features ensure the assessment's repeatability, that is reliability. Insofar as steps are processed automatically and/or the rules are observed, repeated assessments of the same information lead to the same result. Nevertheless, there are limiting factors; for example:

- not all facets of work can be mapped by the questionnaire;
- not all environmental factors can be included;
- information on working conditions or environmental factors is not unambiguous, so a clear mapping to a definite degree of exposure is not feasible.

5.2.5 Measurement error in the narrower sense

The information used in the indicator is collected by asking questions and recording the answers. The first task of the respondent is to understand what information the question is asking for. Secondly, he or she has to retrieve the information. In a third step, the respondent has to evaluate whether or not the information fits the question, is relevant and is complete. In a last step, the respondent has to formulate the response so that it fits the response category or categories⁴². In each of these steps, errors may occur. To minimise error-proneness, attention has to be given to each task in developing a survey questionnaire.

However, attention should not be confined to the development of survey questions. Groves (2004) identifies four potential sources of errors, that is deviations between the observed and the true score, which have to be kept in mind in preparing a survey: interviewer effects, respondent effects, effects of the questionnaire or instrument, and effects of the mode of data collection.

Interviewer effects

'Interviewer effects on survey measurement may occur in different ways' (Groves, 2004, p. 359). Thus, the demographic characteristics of the interviewers, the way they administer the questionnaire, the emphasis put on different words in questions or how interviewers assist the respondent in different ways may influence the answers and thus the measurement dimension. Important ways to minimise the respective effects are thorough training of interviewers and close monitoring of the interviewing process. In the case of an exposure survey, the most critical point in this regard is the process of assisting the respondent in the choice of the appropriate module. Here, interviewer effects are most likely to occur. In the remaining, largely fact-based, questions, the risk of interviewer effects is rather low compared with other survey concepts.

Effects of the questionnaire or instrument

The OccIDEAS questionnaire asks questions in a very objective way, not leaving much room for interpretation on the part of the respondent. The formulation of the questions as such is also quite straightforward, that is the questions should mostly be easy to understand for people who have been doing their current job for a while. Difficulties in answering may, however, arise when it comes to retrieving the information. As pointed out earlier, some questions on materials and tasks require quite good knowledge of the job and might thus be difficult to answer, for example for assistant workers with little training on that job or for people who are new to their job (see section 3.5.2).

While these effects are likely to be restricted to a few occupational groups only, the introduction of time dimensions as discussed earlier would affect more respondents. When asking for time dimensions for the different tasks (frequency and/or duration of the task), deviations between the observed and the true score may occur more often, since this type of information has proven to be very difficult to collect from

⁴² See, for example, Tourangeau et al. (2000) for the identification of these four steps.

respondents, not only in the experience of the OccIDEAS team with this in earlier versions of the survey concept (see section 3.6.4).

Effects of the mode of data collection

The mode of collecting data may also have an influence on the measurement. In general, interviewer-based modes of data collection tend to improve, for example, the representativeness of a survey, but may lead to a higher proportion of socially desirable answers in sensitive questions than online or mail surveys where no interviewer is present. Thanks to the neutral and factual way that questions are asked, errors of this type are likely to be rather few in the envisaged worker exposure survey. Nevertheless, such effects have to be considered and checked, particularly if any type of mixed-mode survey is envisaged.

- ▶ The validity of the OccIDEAS survey concept for Australia is high. It has been thoroughly tested in Australia and results have been shared and discussed with numerous experts.
- ▶ Given thorough adaptation of the questionnaire to the situation in Europe and adequate pre-testing, similarly high validity can be expected for an EU-wide worker exposure survey based on OccIDEAS.
- ▶ The fact-based way of asking questions helps to make the survey concept highly reliable. It also leaves little room for interviewer effects to take place.
- ▶ Although the factual questions keep the risk of mode effects low, in a mixed-mode survey design (computer-assisted telephone interviewing (CATI) combined with online), tests on mode effects would be required.

5.3 Precision of the sample: sampling design and error

Statistical inference from a sample to the target population needs, strictly speaking, random probability sampling. It may be simple proportionate or disproportionate stratified probability sampling, but it has to be at random and the inclusion probabilities have to be positive and known for every element of the target population. Although quota samples are often used in both surveys of individuals and organisations to estimate true population values, from a scientific point of view based on statistical theory, these estimates cause several kinds of problems.

In practice, there are many obstacles to the theoretical ideal of completely randomly drawn samples. Nevertheless, it helps to support the credibility, acceptance and even relevance of survey results if practice and theory coincide as much as possible, bearing in mind the restrictions defined by, for example, budget, time constraints or availability of registers.

What is important in any case is to collect all information available to create the best conditions to calculate or at least estimate the inclusion probabilities. Here, on the one hand, the selection probability with regard to the sampling frame or a combination of several frames has to be considered. On the other hand, this means collecting the relevant information when screening and thereby changing the level, for example going from a household to an individual level or identifying certain target persons such as employed persons or employed persons with certain tasks.

The inclusion probabilities are an outcome of the sample design. Differing inclusion probabilities have to be used to develop design weights to adapt design-based disproportionalities in order to get unbiased estimates. Only by taking into account design effects can correct sampling errors be estimated, which are needed to assess the precision of the estimated statistics.

An important determinant of the precision of an estimate based on a sample is the size of the sample. In determining the adequate sample size, three aspects are important (see, for example, Yansaneh, 2005):

- the time and cost of data collection

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- the quality of the data collected
- the required precision of the estimates.

Firstly, as time and cost increase with the size of the sample, the requirements with regard to delivering results as well as the budget constraints have to be balanced against the number of interviews to be conducted.

Secondly, quality of data is of concern because, for smaller samples, fewer interviewers are needed and so it is more likely that interviewers can be recruited from the experienced staff. With a small number of interviewers, training can better be focused, and relatively more resources and attention can be deployed per interviewer, be it for training or for supervision and maintenance during fieldwork. 'All of this will result in fewer problems in data collection and in subsequent editing of the data collected' (Yansaneh, 2005, p. 28).

Thirdly, the required precision is an important determinant. The precision of an estimate, usually expressed by its standard error, depends on the sample design, the variance of the value in the population, the size of the sample and the size of the population, especially in relation to the sample size.

'A sample design specifies the selection and estimation methods' (Kish, 1965, p. 12). Especially important is disproportionate stratified design. Population surveys by telephone are characterised by two design effects leading to different probabilities of selection and thus to a disproportionate design. The first is the number of telephone connections by which a person can be reached. Both landline and mobile connections are relevant. The higher the number of connections, the higher the probability of being selected. The second is the number of target persons living in the household. The higher the number of target persons in the household, the less the probability of being selected. Besides these features implied by the mode of interviewing by telephone, other stratification schemes, such as by region, age, sex or labour market participation, may apply.

Consequently, the inclusion probabilities differ between the strata because of the sample design. For this reason, design weights have to be developed, which adapt design-based disproportionalities. Only in this way can unbiased estimates be expected, so that the expected value of the sample statistic corresponds to the target population parameter. A consequence is that, 'when disproportionate stratification is used ..., the design effects for total sample estimates will exceed 1 (under the assumptions of equal means and variances)' (Kalton et al., 2005, p. 111). This means that the standard error will be larger than it would be if the sample were based on simple random sampling. The factor is the square root of the design effect. This has to be considered in assessing the precision of the estimated statistics. It also has to be considered that, for analyses within the strata, the design effect might be smaller because there is less variance of the weighting factors, so the standard error might be smaller, too.

The larger the variance of a value in the population, the larger the standard error. The variance of the value in the population is a parameter; it cannot be influenced and has to be accepted. Estimating a sample size, therefore, has to be based on assumptions about this parameter. In surveys, results are often given in the form of percentage values. As a 50-50 split in the population yields the largest variance, this value is the basis for the following estimations.

The larger the size of the sample n is and the larger it is in relation to the population size N , the lower is the standard error (see (1)). We will take this point into account in considering sample sizes with regard to different population sizes. The formula in (1) contains the calculation of the standard error (se) without a design effect. In (2) a design factor with value 2 with regard to the variance, or value $\sqrt{2}$ with regard to the standard error, is included.

$$(1) \quad se(p) = \sqrt{(N - n)/N * p * (1 - p)/(n - 1)}$$

$$(2) \quad se(p) = \sqrt{2 * (N - n)/N * p * (1 - p)/(n - 1)}$$

Table 10 shows what certain decisions on the sample size mean for the resulting precision. The size of the populations presented can be compared with real population sizes, for which examples can be given. Our examples are built on the assumption that for a certain characteristic we find a value of 50 % in the sample, for example 50 % of the persons working in a certain occupation are exposed to certain agents.

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If we draw a simple random sample of $n = 1,000$ in an economy with an employed population of $N = 800,000$ we would find a standard error of 1.6 %. If we choose the confidence level α of 95 % this means in a two-sided perspective a z -value of 1.96⁴³. So we conclude that the population value will vary within an interval of 50 % by ± 3.1 percentage points. Relative to 50 % the value of 3.1 percentage points means about 6.1 %⁴⁴. In a further step we take into account a design effect. We go on the assumption that the design effect means a multiplication of the standard error by the factor $\sqrt{2}$. Therefore, we find a standard error of about 2.2 percentage points, a 95 % interval of about 4.4 percentage points and a relative margin of error of 8.8 %.

Table 10: Estimates of standard error, confidence interval and relative margin of error depending on population and sample size for a 50-50 split

N (universe)	N (int.)	$se(p)$	$se(p)*\sqrt{2}$	$z*se(p)$	$z*se(p)/p$	$z*se(p)*\sqrt{2}$	$z*se(p)*\sqrt{2}/p$
800,000 workers	50	7.1 %	10.1 %	14.0 %	28.0 %	19.8 %	39.6 %
For example SI	100	5.0 %	7.1 %	9.8 %	19.7 %	13.9 %	27.9 %
	500	2.2 %	3.2 %	4.4 %	8.8 %	6.2 %	12.4 %
	1,000	1.6 %	2.2 %	3.1 %	6.2 %	4.4 %	8.8 %
	2,000	1.1 %	1.6 %	2.2 %	4.4 %	3.1 %	6.2 %
	3,000	0.9 %	1.3 %	1.8 %	3.6 %	2.5 %	5.1 %
23 million workers	50	7.1 %	10.1 %	14.0 %	28.0 %	19.8 %	39.6 %
Country group 1	100	5.0 %	7.1 %	9.8 %	19.7 %	13.9 %	27.9 %
	500	2.2 %	3.2 %	4.4 %	8.8 %	6.2 %	12.4 %
	1,000	1.6 %	2.2 %	3.1 %	6.2 %	4.4 %	8.8 %
	2,000	1.1 %	1.6 %	2.2 %	4.4 %	3.1 %	6.2 %
	3,000	0.9 %	1.3 %	1.8 %	3.6 %	2.5 %	5.1 %
10 million workers	100	5.0 %	7.1 %	9.8 %	19.7 %	13.9 %	27.9 %
Country group 1:	500	2.2 %	3.2 %	4.4 %	8.8 %	6.2 %	12.4 %
BG, RO, HR, SI	1,000	1.6 %	2.2 %	3.1 %	6.2 %	4.4 %	8.8 %
	3,000	0.9 %	1.3 %	60.0 %	120.0 %	2.5 %	5.1 %
	8,000	0.6 %	0.8 %	1.1 %	2.2 %	1.5 %	3.1 %
	12,000	0.5 %	0.6 %	0.9 %	1.8 %	1.3 %	2.5 %

⁴³ To simplify matters, we assume that the sample percentage p is normally distributed, which is a 'common practice when determining confidence intervals' (Eurostat, 2013, p. 9; see also Cochran, 1977, p. 72).

⁴⁴ The relative margin of error as calculated here has the disadvantage of not being symmetrical. Although the standard error decreases symmetrically on both sides of 50 %, the relative margin of error decreases with increasing percentage values and increases with decreasing values. This is because the denominator, that is the standard error, decreases in both directions, whereas the numerator increases with increasing percentage values, but decreases with decreasing percentage values.

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N (universe)	N (int.)	se(p)	se(p)*sqrt(2)	z*se(p)	z*se(p)/p	z*se(p)*sqrt(2)	z*se(p)*sqrt(2)/p
40 million workers	500	2.2 %	3.2 %	4.4 %	8.8 %	6.2 %	12.4 %
Country group 2:	1,000	1.6 %	2.2 %	3.1 %	6.2 %	4.4 %	8.8 %
ES, PT, IT, EL, MT,	3,000	0.9 %	1.3 %	1.8 %	3.6 %	2.5 %	5.1 %
	6,000	0.6 %	0.9 %	1.3 %	2.5 %	1.8 %	3.6 %
	12,000	0.5 %	0.6 %	0.9 %	1.8 %	1.3 %	2.5 %
	18,000	0.4 %	0.5 %	0.7 %	1.5 %	1.0 %	2.1 %
75 million workers	500	2.2 %	3.2 %	4.4 %	8.8 %	6.2 %	12.4 %
For example	1,000	1.6 %	2.2 %	3.1 %	6.2 %	4.4 %	8.8 %
NL, BE, LU, FR, DE,	3,000	0.9 %	1.3 %	1.8 %	3.6 %	2.5 %	5.1 %
	6,000	0.6 %	0.9 %	1.3 %	2.5 %	1.8 %	3.6 %
	12,000	0.5 %	0.6 %	0.9 %	1.8 %	1.3 %	2.5 %
	18,000	0.4 %	0.5 %	0.7 %	1.5 %	1.0 %	2.1 %
190 million workers	1,000	1.6 %	2.2 %	3.1 %	6.2 %	4.4 %	8.8 %
EU-28	3,000	0.9 %	1.3 %	1.8 %	3.6 %	2.5 %	5.1 %
	14,000	0.4 %	0.6 %	0.8 %	1.7 %	1.2 %	2.3 %
	28,000	0.3 %	0.4 %	0.6 %	1.2 %	0.8 %	1.7 %
	56,000	0.2 %	0.3 %	0.4 %	0.8 %	0.6 %	1.2 %
	84,000	0.2 %	0.2 %	0.3 %	0.7 %	0.5 %	1.0 %

We also see in Table 10 that, if the sample sizes are the same, there is practically no difference in the standard error between the different population sizes⁴⁵. For example, for a sample of $n = 1,000$ the standard error is always 1.6 percentage points, irrespective of population size.

Eurostat (2016, p. 68) formulates as a precision requirement that the 'estimated standard error for any indicator/variable (in principle proportions) should not exceed 2 percentage points for the overall population'. Table 10 shows that, given the respective population sizes, for a precision of 2 percentage points a sample size between 1,000 and 1,500 interviews is needed if a design effect of $\sqrt{2}$ is assumed.

However, Table 10 also shows that with a decrease in sample size the precision also rapidly declines. Considering a design effect, it can be seen that for a sample of $n = 50$ a confidence level α of 95 % in a two-sided perspective means $50 \% \pm 19.8$ percentage points. That means that, if you find that 50 % of

⁴⁵ For smaller populations, say $N < 20,000$, we would find a greater reduction of the standard error as the sample size grows than we find for larger populations. This is due to the finite population correction factor. For example, in the case of a population of $N = 2,000$ this means that the standard error is 0 if the sample size $n = 2,000$ ($= N$) because then the finite population correction factor $(N - n)/N$ is 0. For larger populations the finite population correction factor is practically irrelevant.

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the sample is exposed to certain agents, the true proportion in the population may vary from about 30 % to about 70 %, based on a 95 % confidence level.

There is another aspect that has to be taken into account. Usually, a sample is drawn and then, based on this sample, analyses of subgroups of the sample are conducted. For example, the target group may be a group of countries with a labour force of about 40 million persons (for example ES, PT, IT, EL, MT, CY). This is the size of the working population. We go on the assumption that a sample of $n = 2,000$ is drawn. Within the sample we identify a subgroup comprising about 2.5 % ($n = 50$) of the workforce, for example ISCO-08 sub-major group 81 (stationary plant and machine operators). The research question may be, for example, how many of the stationary plant and machine operators are exposed to agent Y. Table 11 illustrates this case for two proportions of exposure.

Table 11: Estimates of standard error and confidence interval for subgroups, such as occupational groups

Universe	Sample	Subgroup within the sample, for example certain occupational group			
$N = 40,000,000$	$n = 2,000$	$n = 50$			
Example	Number of persons exposed to certain agents within the occupational group	Percent relative to subgroup size	Percent relative to sample size	Standard error (base: sample)	Standard error * sqrt(2) (base: sample)
A	$n = 10$	20.0	0.50	0.16 %	0.22 %
B	$n = 45$	90.0	2.25	0.33 %	0.47 %
Example	95 % conf. int. percentage points $z*se(p)*sqrt(2)$ (base: sample)	95 % conf. int. percentage points relative to share in subgroup	Absolute size of 95 % CI ie. number of cases in the sample		
A	0.44 %	17.49 %	$n = 9$		
B	0.92 %	36.78 %	$n = 18$		

In example A in Table 11 we go on the assumption that in our sample 10 of the 50 stationary plant and machine operators are exposed to agent Y. This is 20 % of the subgroup of $n = 50$ and 0.5 % of the sample of $n = 2,000$. Based on the sample the standard error is 0.16 percentage points, or, including a design effect of the sqrt(2), 0.22 percentage points. If we choose a z-value of 1.96 for a two-sided confidence level α of 95 % ($z(\alpha/2) = 1.96$) the result is a confidence interval of 0.44 percentage points. That means that, relative to the total sample, the true value is likely to vary between 0.06 % ($0.5 \% - 0.44 \%$) and 0.94 % ($0.5 \% + 0.44 \%$). With regard to the proportion within the subgroup of stationary plant and machine operators, this implies that it is likely to vary between 2.5 % ($20 \% - 17.5 \%$) and 37.5 % ($20 \% + 17.5 \%$)⁴⁶. Expressed in absolute values, the 17.5 % corresponds to nine persons in the sample. In example B, where we assume that 45 of the 50 stationary plant and machine operators in the sample (90 % of this subgroup) are exposed to agent Y, the population value is likely to vary between 100 % (correctly stated $90 \% + 36.8 \% = 126.8 \%$, but more than 100 % is not possible) and 53.2 % ($90 \% - 36.8 \%$).

⁴⁶ As 0.44 % of 0.5 % corresponds to 17.5 % of 20.0 %. Slight deviations are due to rounding errors.

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It is understood that one important aim of sample-based analyses is to get results for subgroups. Therefore, we want to point out that the example just presented should not be understood as an excuse to forgo such analyses. It is presented to focus the attention of the researchers with regard to the precision achievable if small subgroups are analysed.

We have shown that, for an analysis of the total workforce of a country, 1,000 to 1,500 interviews could suffice to meet the precision requirements of Eurostat. However, it should be evident that this sample size should be enhanced to allow the analysis of smaller groups, be it particular occupational groups, sectors of activity, types of workers (such as migrant workers) or something else. Such analyses should be possible with a reasonable degree of precision, at least at the level of country groups, NACE sections (one-digit level) or aggregated occupational groups. Otherwise it would be difficult to, for example, identify groups of workers that need particular attention as regards the design of preventive measures.

The number of modules applied in AWES-cancer, totalling almost 5,000 interviews (see Table 3) gives an indication of the number of interviews to be expected for the different modules and shows for which modules and thus job types a separate analysis would be justified in terms of precision criteria. Five of the modules were asked just once each, many of them referring to jobs or activities with a high degree of exposure to carcinogens (asbestos removal, foundry, metal coating). It is evident that, for these and some other jobs (at least those with fewer than 20 interviews), the available sample size was not sufficient for job-specific extrapolations.

Assuming a similar structure of sectors and occupations in Europe to that in Australia (an assumption which is not really justified – Australia has, for example, fewer people working in the industry sector than Europe), this means that, with national sample sizes of 3,000 interviews, in total 84,000 interviews would be available for Europe. For each of the modules, then, about 17 times as many interviews would be available if analysing the data for Europe as a whole and only just over half of the number of interviews indicated in Table 3 would be available for an analysis by country. At the level of the proposed country groupings, the number of interviews per module would be somewhere in between, depending on the shaping of the groups⁴⁷.

Even with a total EU sample of around 80,000 interviews, confidence intervals for occupational groups that resulted in just one or two interviews in the AWES survey would be very large. It might therefore be worth considering deleting these modules and adding the tasks specific to the groups in question to the modules of other, related, occupational groups. This presupposes, however, that the portfolio of tasks that are specific to these very small occupational groups is not very large. Another aspect to be considered before implementing such a modification is that the incidences in Europe might differ substantially from those in Australia for some of these occupational groups. Some of the modules in question might be selected more often in Europe.

- ▶ For high precision of the sample, random probability sampling allowing the calculation of inclusion probabilities is recommended.
- ▶ For overall analyses of results across all sectors, agents and occupational groups, national sample sizes of 1,000 to 1,500 would be sufficient to fulfil the sample precision criteria recommended by Eurostat. For this survey, national differences in the size of the total population have only a small influence on the required sample sizes, so sample sizes can be similar for smaller and larger countries.

⁴⁷ We would propose six country groups in total, based mainly on geographical criteria and the year of joining the EU. The proposed groupings are: (1) Scandinavia (DK, SE, FI); (2) Southern Europe (CY, EL, ES, IT, MT, PT); (3) South East Europe (BG, RO, HR, SI); (4) Western Europe (AT, BE, DE, FR, LU, NL); (5) Eastern and Central Europe (CZ, EE, HU, LT, LV, PL, SK); and (6) British Isles (UK, IE).

- ▶ The confidence interval is the interval within which the true value of a measurement lies with a certain degree of probability. The smaller the interval, the more precise is the measurement.
- ▶ For more detailed analyses, such as by country and sector or occupational group, considerably larger national samples would be desirable in order to keep confidence intervals to a reasonable limit.
- ▶ National samples of 3,000 are recommended for most countries as a compromise between sample precision and survey costs. The overall net sample for the EU would thus be around 80,000 interviews.

5.4 Underrepresentation of particular groups in a CATI survey

There are certain groups of people who are usually underrepresented in telephone surveys. Focusing on workers, this applies particularly to the following groups:

- young workers
- workers with a relatively low level of formal education
- workers in low-skilled jobs
- workers from urban areas
- male workers
- migrant workers (particularly those not sufficiently familiar with the language spoken at the workplace).

The reasons for the underrepresentation of these groups are manifold. They range from limited accessibility during the usual operating times of call centres to communication problems or inadequate coverage in the available sampling frames. Depending on the reasons for the underrepresentation, there are different measures to improve the representativeness for the abovementioned groups of workers.

1. Modification of the selection key

A common measure for reducing known underrepresentations is modification of the selection key for the random choice of a respondent within the contacted households. Instead of strictly applying a random selection mechanism giving each eligible household member the same chance of being selected, the key could be modified so that it selects underrepresented groups with a certain priority. In any household where more than one eligible person exists, young workers, for example, can be given twice the chance of being selected of older workers. In this way, otherwise underrepresented groups can be included in the sample to a larger degree. In the AWES survey, this method was applied in order to get more men into the net sample.

2. Application of a dual frame sampling approach

One of the key challenges CATI surveys have been facing in recent years is the increasing proportion of residents belonging to the 'mobile only' segment of the population, that is persons living in households that do not have any landline telephone connections. According to the most recent EU-wide data currently available, in October 2015 33 % of all households in the EU had mobile telephone access only, 59 % had both landline and mobile access, and 6 % had a landline only. There are large national differences: the proportion of households still having landline telephone access currently varies from just 13 % in Finland to 93 % in Malta⁴⁸. Only 2 % of all households across the EU-28 have no telephone access at all. A telephone survey can thus in principle reach almost the entire population, but only if using a dual frame approach, that is a sample derived from both landline and mobile phone registers.

Even in countries with a still high proportion of households with landlines, the application of a dual frame design is important to enhance the participation of particular groups such as young people or migrant workers – both groups tend to be underrepresented in landline sampling frames.

⁴⁸ Data on the telephone equipment of households in Europe are taken from Special Eurobarometer report 438, pp.17-18.

Representative inclusion of migrant workers cannot, however, be reached by dual frame sampling alone. Although probably virtually all migrant workers have a mobile phone, some groups of migrant workers are difficult to sample. This holds particularly for those that have concluded their mobile phone contracts in their country of origin and not in the country where they are currently working. These workers can be sampled only in their home country – provided that this country is also participating in the survey. A Romanian worker working in Germany for most of the year, for example, could be called on the mobile phone by the Romanian field institute.

3. Interviewing in multiple languages

It is not only sampling reasons that render interviewing migrant workers difficult. In addition, language barriers often exist. The most obvious measure to overcome these in a telephone survey is to offer the contacted persons additional languages for interviewing. In the larger EU countries, some of the larger fieldwork institutes have multilingual interviewing staff, at least for the most common migrant worker languages (in Germany, for example, Turkish, Russian and Polish).

4. Use of onomastic methods for sampling

Another measure to push the inclusion of migrant workers is the acquisition of additional telephone numbers from commercial address providers that offer sampling frames specifically for migrant populations, with addresses selected from telephone registers by onomastic procedures⁴⁹. Merging these additional frames with the general landline and mobile frames used for the country may lead to some overlaps (double addresses) between the various frames used. These would need to be cleaned as far as possible before starting fieldwork.

5. Online interviewing

Although AWES has so far been carried out as a CATI survey only, with a view to the future, offering an additional online mode to respondents could be an option worth considering. Mixed-mode interviewing brings up the danger of mode effects in the results, but it has also clear advantages, for example in terms of the coverage of otherwise underrepresented groups, in particular younger people and people who are difficult to reach during the normal operating times of call centres.

In view of the lack of any representative online address registers of the population in EU countries, online interviewing of the general population is usually done with samples derived from online panels, that is panels of people who regularly take part in surveys and get some type of remuneration for this. The panels hold information on the basic sociodemographic characteristics of their members, sometimes including basic information on their employment status and their workplace. It is thus possible to target specific types of respondents, for instance for a sample increase in a particularly exposed sector or for groups difficult to reach in the telephone survey (young people, migrants, etc.). Samples derived from online panels are, however, not strict probability samples and the panellists are not necessarily representative of the entire population. It is, for instance, possible that, even if all sectors of activity are well represented in the online panel, workers with office jobs within these sectors are overrepresented while manual workers are underrepresented because they are less familiar with computers.

If online interviewing does not lead to any mode effects in terms of content (different answering behaviour of CATI and computer-assisted web interviewing (CAWI) respondents), CAWI interviewing – including the option for the respondents to use mobile devices for this – could nevertheless be an interesting enhancement, also with a view to future developments. If applying a dual frame sampling approach, questionnaires need to be kept reasonably short and simple. This would also enhance their usability in the CAWI mode.

Another possible way to introduce online interviewing in the worker survey is to contact respondents by telephone, but offer them the choice between the telephone and the online mode. The application of a sequential mixed-mode design in which only persons refusing the telephone interview will be offered the

⁴⁹ Onomastic procedures for the compilation of sampling frames use the names of persons to attribute them to a specific population, based on a linguistic analysis of the first names and surnames. In Germany, for example, the commercial provider Humpert & Schneiderheinze offers sampling frames of migrant populations compiled on the basis of onomastic procedures (<http://www.stichproben.de/frame2.html>). Such providers, however, operate in some countries only. Likewise, the procedure can be applied only for telephone lines listed in a publicly accessible telephone register.

online interview could be a good model. It would allow online interviewing to be introduced and tested for this survey concept, but without the CAWI sampling problems discussed above. The data achieved in both modes could then be analysed for mode effects. Since the proportion of online interviews in this design would be relatively low, the impact of any mode effects on the overall data quality would be limited. The sequential mixed-mode approach would also tend to improve the sample structures because, for example, young people that can be reached by phone might be more willing to answer the survey online than over the phone. For migrants with only limited command of the language of the host country, similar positive effects may occur because it is usually easier to understand a foreign-language written text than to follow a foreign-language telephone call. In addition, the online questionnaire could be sent in another language.

6. Multiple call attempts on different days and at different times

To maximise response rates in general, it is advisable to insist that multiple call attempts be made at each number before considering a number as a non-response. This measure will also improve the coverage of groups of workers that are difficult to reach, for example because of long working hours, shift work or work abroad. As a good compromise between costs and survey quality, a limitation of the call attempts to eight seems adequate.

7. Weighting

While all reasonable efforts should be made to achieve a representative picture of the whole workforce in the unweighted net sample, remaining deficiencies with regard to the representativeness of particular groups can to a certain degree be compensated for by the weighting of the data. This presupposes, however, that the number of interviews obtained for each cell or subgroup to be weighted is large enough and that reliable statistics exist for these subgroups. It also presupposes that statistical data are available for the characteristics on which the sample is deemed to be underrepresented.

Table 12 summarises the measures for improving the representation of otherwise underrepresented groups. It should be taken into consideration that, even if all these measures are applied, selective non-response cannot be totally avoided, so there will be deviations between the (unweighted) net sample and the figures for the whole population. There are, for example, certain occupational groups which are generally more difficult to reach (for instance because they work abroad) and, in spite of all measures applied, a certain undercoverage of these groups will remain.

Table 12: Measures for improving the representation of groups otherwise underrepresented in CATI

Groups likely to be underrepresented/ measures for achieving better representation	Modification of selection key	Oversampling of particular groups	Dual frame interviewing (landline and mobile)	Mixed mode (including online interview option)	Multilingual interviewing	Weighting (ex post)
Young workers	(+) Suitable only for increasing proportion of young people still living in a household with landline telephone	– Not possible in CATI (age information not available from address source)	+	+	O No particular effect on young workers if their proportion in the migrant population does not differ from the proportion in the overall population	+
Workers with a relatively low level of formal education	+	–	?	(+)	(+)	+
	Effective measure, requires asking educational level from all the employed people in the household	Not possible in CATI (information on educational level not available from address source)	Some improvements to be expected, but lower educational level also tends to be underrepresented among mobile users	Possible only if using online panels as sampling frames for CAWI	Indirectly (migrant workers tend to have a lower degree of formal education)	Weighting by ISCED ⁵⁰ level of formal education
Workers in low-skilled jobs	O	–	?	(+)	(+)	+
	Skill level normally not asked at selection stage of household member	Not possible in CATI (information on jobs and skill levels not available from address source)	Unclear (not sufficient empirical experience)	Possible only if using online panels as sampling frames for CAWI	Indirectly (migrant workers tend to work disproportionately in low-skilled jobs)	Weighting by ISCO-08 occupational groups
Workers in particular jobs/occupations (such as jobs in which workers are difficult to reach or refuse more often)	O	–	?	(+)	(+)	+
	Difficult to implement (job/occupation asked at the beginning of the interview, after household screening)	Not possible (no information in address source)	Unclear (not sufficient empirical experience)	Online interviewing is more independent of usual telephone times, so it is for example easier to reach shift workers or workers who often work abroad	Indirectly	Weighting by ISCO-08 occupational groups

⁵⁰ International Standard Classification of Education.

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Groups likely to be underrepresented/ measures for achieving better representation	Modification of selection key	Oversampling of particular groups	Dual frame interviewing (landline and mobile)	Mixed mode (including online interview option)	Multilingual interviewing	Weighting (ex post)
Workers from urban areas	O Selection key applies <u>within</u> selected households (urban or rural households)	(+) Possible for landline numbers only; preselection of numbers by geographical characteristics is not possible for mobile phones	(+) Higher proportion of households of (only) young people in urban areas	(+) Possible only if using online panels as sampling frames for CAWI	+	+
Male workers	+	-	O	(+)	(+)	+
	Effective measure, easy to implement	Not possible (no information in address source)	No clear effect	On average, men tend to spend more time on the computer than women	Indirectly: on average, higher proportion of males among migrant workers	Weighting by the characteristic 'sex'
Migrant workers	(+)	(-)	(+)	(+)	+	+
	Useful for specific part of migrant workers only	Possible only with very high effort and considerable restrictions (application of onomastic methods to oversample landline telephone numbers of assumed migrant workers; feasible only for persons with a name entry in a publicly available telephone book)	Improves coverage of migrant workers with a mobile phone contract from the country of the workplace	Possibility to oversample migrant workers if using online panels for the CAWI part; otherwise only low impact (for example by being better able to offer foreign-language questionnaires in the online version)	Particularly for nationalities that are well represented in the country of the workplace	Weighting by the characteristic 'nationality' (but: only if sufficient interviews with migrant workers are available)

+, measure is appropriate for improving the coverage of workers from this specific group

(+), measure has an indirect impact or an impact on parts of the underrepresented group

O, measure has no or little impact on the coverage of the underrepresented group

-, measure is not possible to apply for this underrepresented group

- ▶ Young, low-skilled, male or migrant workers tend to be underrepresented in telephone surveys among workers.
- ▶ The underrepresentation has various causes, ranging from undercoverage in sampling frames to a generally lower disposition to participate in survey research.
- ▶ Various measures are available to improve the coverage of these groups. The modification of household selection keys and the use of dual sampling frames are highly recommended for the survey.
- ▶ For migrant workers, additional samples selected by onomastic methods, sequential mixed-mode interviewing and the offer of different languages for the interview are measures to enhance their representation. Some of these measures are rather costly.

5.5 Comparability of survey results across countries

The AWES survey has been conducted at a national level, in a country with just one official language and with a quite homogeneous situation as regards education, vocational training, sectoral organisation, legislation on safety and health, etc. For an EU-wide survey, the situation would be different. In spite of a considerable degree of harmonisation reached by EU legislation or guidelines, differences in agents, materials, tasks, etc. are likely to exist. OccIDEAS has never been applied as a cross-national survey. Therefore, there are no experiences or data available allowing a clear judgement on its cross-national comparability. Nevertheless, a critical theoretical assessment of the questionnaire concept with regard to cross-national comparability can deliver some insights into this issue, alongside with a summary of the findings regarding national differences for selected jobs between Romania, Poland and Germany (see chapter 4).

5.5.1 The questionnaire concept and design

Full cross-national comparability is one of the central aims of any cross-national survey. To reach this aim, in best practice surveys a lot of effort is made to ensure the highest degree of comparability that can be reached within the given time and budget restrictions.

Nevertheless, analyses of results even from best practice surveys sometimes reveal country results that are not in line with the expectation of experts in the subject matter. In the fifth EWCS, for example, Finland ranks third highest regarding the exposure of workers to biological and chemical risks, topped only by the workers in the former Yugoslav Republic of Macedonia and Kosovo (see Parent-Thirion et al., 2012, p. 47, figure 19). Taking into account the type of industries present in Finland and the country's well-developed safety and health culture, this result is surprising.

Similarly, in EU-OSHA's European Survey of Enterprises on New and Emerging Risks (ESENER), unexpected differences occur when interviewees (managers and experts in charge of safety and health) are asked about a variety of risk factors present in the establishment. Whereas in the UK, for example, more than 50 % of the establishment representatives report the presence of dangerous substances, only 15 % of the Bulgarian representatives do so. In view of the fact that the UK has a relatively small manufacturing sector and a high proportion of service industries, this is again a surprising result.

Both the EWCS and ESENER are surveys where best practice standards were applied to all stages of fieldwork, including sampling, translation and coding of results. The unexpected differences are therefore unlikely to be related to any methodological differences in the application of the survey across the countries. The main source of the differences is most likely to be found in different risk perceptions, namely of what a dangerous substance is, how far it is present at the workplace and when an exposure situation appears.

It is often very difficult to disentangle the perception of certain hazards from the real existence of them. There is a danger that, the better safety and health instructions at a workplace are, the more risks are perceived and reported in an employee survey. Workers not made aware of and instructed about the risks are in turn likely to report only the most obvious hazards if being asked, for example, about

dangerous substances or harmful vapours present at their workplace. Likewise, culturally influenced perceptions regarding workplace conditions and the duties of an employer or a lack of trust in the full confidentiality of surveys are likely to influence individuals' answers on questions related to working conditions.

The approach of an expert guided interview under the OccIDEAS model has great potential to overcome such weaknesses in terms of cross-national comparability. In the exposure questions, it asks only factual questions about the performance of tasks, about machines and substances used for these tasks and about various protective measures taken. The assessment of whether or not a risk emanates from these activities is not at all up to the worker being interviewed. Instead, this judgement is based on an expert assessment using the objective, factual information provided in the interview. The risk of getting answers that are biased by expectations, perceptions or the individual's mentality (for instance one's general disposition as a rather fearful or carefree person) is thus minimised in this approach. Particularly for a cross-national survey, this is an invaluable advantage.

Given the use of translations according to best practice procedures and the application of adequate and uniform sampling, fieldwork and weighting practices across countries, the likelihood that answers to the OccIDEAS questions on exposure situations may be biased is very low, particularly compared with other survey concepts tackling this type of subjects. The situation is similar for the questions related to the protective equipment set out in OccIDEAS. These questions just ask in a very factual way if specified types of protective equipment are used and how often or how long they are used while performing certain tasks.

Some of the questions proposed in this report as additions to the current OccIDEAS questionnaire could in turn be more susceptible to personal and cultural expectations and perceptions or to social desirability. This holds for, for example, the proposed question(s) on the reasons for not (properly) using protective equipment or an overall question on the awareness of carcinogenic risks. This is not necessarily undesirable – personal risk awareness is, for example, influenced by cultural aspects and it is helpful to know in which countries the awareness is lower than in others, particularly if this awareness can be compared with a largely objective measure of the real risk situation. In fact, this opportunity to compare perceptions and real risks would make the survey quite unique. It offers great potential for analyses. However, it should be clear that these additional proposed questions are less factual and more subjective than the questions from the original OccIDEAS modules and thus more likely to produce unexpected country results. This should be taken into account when deciding whether or not the exposure survey – if conducted at all – should be augmented with further questions.

5.5.2 Level of knowledge of respondents

Comparability across countries can also be limited by the level of knowledge on agents and materials on the part of workers. As shown in section 3.5.2, to answer accurately some of the questions related to the exposure situations and materials on OccIDEAS, a certain level of basic knowledge on the job is required, which is not necessarily available from mere on the job training. In countries where the job usually requires some kind of systematic vocational training that also includes lessons about substances used at work, more workers in that job will have the knowledge required to provide a well-informed answer on such detailed questions. In countries where hardly any worker in the job has received any kind of vocational training on it, there will be considerably more 'Don't know' answers or – even more of a problem – wrong answers. For cross-national comparability, this can be an issue.

An example of possible country differences resulting from this is again the cleaning jobs. For these, questions on materials (cleaning materials and materials existing at the place where the cleaning is done) and questions on exposure situations are quite specific and require a certain level of knowledge. In many EU countries, however, cleaning jobs are mainly done by migrant workers with no vocational training in that job and with language deficiencies.

5.5.3 Harmonisation of background variables

For a high level of cross-national comparability, not only the questions asking about jobs, tasks and materials need to be harmonised as far as possible between the countries. Likewise, the background variables also require a high degree of harmonisation.

While for some of these variables – such as age, sex or current nationality – no harmonisation is needed, for others – such as the educational level – national differences can be large. A way of asking has to be chosen which is on the one hand clear and easy to answer for respondents, but is on the other hand also compatible with classifications used for EU-wide analysis. There are, however, already several EU-wide surveys among individuals and workers available, from which such harmonised background variables can be adopted. For an EU-wide exposure survey, two sources can be recommended for this, namely the Labour Force Survey conducted by the national statistical offices and the EWCS conducted by Eurofound.

It is proposed to use the background variables from the LFS for all characteristics on which the data are meant to be weighted, since universe figures from the LFS will be the basis for the weighting. This ensures a high level of consistency between the data and the weighting base. For variables which are not included in the LFS or where the LFS uses a more complex and time-consuming way of asking, use of the EWCS is proposed. The EWCS could also be the preferred source for variables that are useful for comparisons between the data collected in the EWCS and those to be collected in the exposure survey.

The set of background variables proposed to be included in an exposure survey will be discussed in section 6.2.1.

5.5.4 Practical and methodological aspects of survey implementation

The questionnaire design is not the only factor relevant to cross-national comparability. A series of further factors are likely to have a considerable impact on the comparability of results over countries:

- survey organisation
- sampling
- translation
- fieldwork
- data processing and weighting.

These issues will not be discussed in detail here⁵¹ since, over the last couple of years, cross-national survey research has made great progress in the harmonisation of these survey steps and aspects, and there are best practice models in place that help to ensure a high level of cross-national comparability. Among these are a strongly centralised survey organisation with local interviewing, and the definition of a sampling design that follows comparable rules in all countries⁵² and is ideally even implemented centrally.

5.5.5 National or regional differences in job tasks and in materials used

Another hindrance to ensuring full comparability could be national differences, for example in job tasks, in the applied technology or in substances and materials used.

This type of differences was examined as an example for the job groups 'farmers' and 'painters' in Germany, Poland and Romania (see chapter 4). The results show that, at least for these two job groups, tasks, exposure situations and substances are overall similar in the three countries. The existing differences are mostly of a quantitative rather than qualitative nature, with, for example, more workers still using manual tools and techniques (such as for spraying pesticides) in some countries than in others.

⁵¹ Translation issues will be discussed in section 0, although from another perspective.

⁵² The ESENER-2 establishment survey of EU-OSHA, for example, can serve as a model regarding the five aspects mentioned.

In spite of these positive conclusions regarding the scope of necessary adaptations, for a full cross-national comparability of the survey results it is crucial to have a survey instrument that is able to cover relevant qualitative differences in the national shape of jobs, tasks and exposure situations. In an ideal case, these differences do not require country-specific task modules, but can be handled by the addition of single questions or items required only in some countries and not shown in the others.

- ▶ The fact-based questionnaire concept favours full cross-national comparability of the results of an exposure survey.
- ▶ The most important prerequisite for achieving a high degree of cross-national comparability is a thorough adaptation of the questionnaire modules to the situation in Europe, also taking into account differences between EU countries.
- ▶ Although differences in tasks, materials, agents and exposure circumstances are expected to be limited, this needs to be thoroughly checked in the survey preparation phase.
- ▶ The application of proved best practice methods for translation, sampling, fieldwork organisation and data processing will ensure a considerable degree of cross-national comparability.
- ▶ A further hindrance to a high level of cross-national comparability could be national differences between workers regarding the level of knowledge on details of tasks and materials. This aspect is more difficult to tackle.

5.6 Comparability of survey results over time

EU-OSHA would like to consider repeating a possible exposure survey every few years in order to be able to monitor changes over time, for instance changes in the exposure situation following a modification of legislation.

To enable researchers to observe causal inferences in the longitudinal analysis, it would be best to conduct the survey as a panel survey instead of conducting it with repeated ad hoc waves, using different samples each time. Conducting a Europe-wide survey of this kind as a panel survey would however be a very difficult and costly undertaking. Frequent job changes, for instance, would be a major problem: the development of a person's exposure situation over time and the possible impact of any measures (for instance legislative measures) on the exposure situation can be analysed in a meaningful way only for persons who remain in the same job and ideally also with the same employer. Especially in low-skilled and unskilled jobs, changes between jobs – often also involving changes between sectors of activity – are frequent. Moreover, survey participants may change into another employment status (to unemployed, self-employed, retired, etc.), so the number of persons available for longitudinal analyses would be diminished considerably by such factors. Other general reasons for panel attrition such as refusals to participate in future waves or irretrievable changes in telephone numbers would add to these survey-specific reasons.

Even with a repeated ad hoc survey design, however, some longitudinal analyses will be possible and are likely to render interesting insights. A few restrictions do, however, apply. Partly, they can be avoided by modifications to the survey design.

- One of the barriers to full comparability over time may be the relatively undifferentiated way of mapping exposure situations in OccIDEAS, that is the lack of questions on frequency and duration. In its current form, the OccIDEAS questionnaire is able to map changes over time only in terms of the number of affected workers and (where applicable) the degree to which personal protective measures are taken. If the time or frequency of exposure to a cancer risk factor is drastically reduced, this change will not become visible as long as the number of exposed workers remains stable.
- Another issue to be considered as regards comparability over time is the possible reduction of exposures due to new technical developments or developments in agents. If for instance the potentially carcinogens contained in a widely used pesticide or a thinner used by painters are

reduced substantially, this will reduce the danger emanating from exposure to this product even if the exposure time remains the same as before. Such changes over time due to technical and scientific developments do not have a repercussion on the questionnaire (as long as the product used does not get a totally different name). In the assessment rules underlying the OccIDEAS concept, however, this type of changes should and can be taken into account: To set up assessment rules, the carcinogenic potential of an agent and thus of the task in which the agent is used are among the criteria taken into account in the calculation of the degree of risk for a particular interviewee. If this carcinogenic potential is drastically reduced, this can be taken into account in the assessment of the dimension 'level of exposure'.

- In view of the lack of possibilities to observe causal effects in an ad hoc design, some changes in the degree of exposure may be difficult to evaluate. A reduction in the number of exposed workers in country X could, for instance, be just the result of outsourcing of related activities and not necessarily the result of efforts to limit the exposure to the agent.
- OccIDEAS is an instrument that is constantly being reviewed and improved in details, for instance by taking into consideration new agents, exposure situations or tasks or by a redesign of questionnaire aspects that proved not to work particularly well. While this is certainly beneficial for the quality of the survey, it may have an impact on the direct comparability of results over time. If an EU-wide exposure survey closely followed OccIDEAS, it would be good to have as few changes to the concept as possible (apart from adaptations following changes in tasks, agents, etc.). For this, the instrument should be empirically tested in a pilot study in selected EU countries. This minimises the necessity for changes between the first and subsequent full survey waves.

- The fact-based questionnaire concept favours a high level of comparability over time, if the survey is repeated.
- The lack of information about the frequency and duration of exposure situations in the current OccIDEAS design, however, puts some limitations on the observation of trends over time.
- The set-up of the survey as a panel survey would allow the analysis of causal effects. For practical reasons, an ad hoc survey design is nevertheless recommended.
- Using a well-elaborated and tested instrument already for the first wave minimises the need for changes between waves and enhances comparability over time.

5.7 Main survey errors to be expected

In the two following tables, the main errors in the paths of measurement and representation are summarised and possible measures to minimise these are presented.

Table 13: Possible errors in the path of representation

Possible error source/error type	Consequences	Measures
Coverage errors: Migrants with foreign mobile phone contracts are likely not to be covered	Net sample is not fully representative of the total of workers in the country	possibly: efforts to phone these persons from their home country over the mobile phone (for instance a Czech worker working in Germany during the week would be called in Germany, but by the Czech institute); analysis of the situation of these workers in the data of the country of their current workplace

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Possible error source/error type	Consequences	Measures
Sampling errors: Due to limited sample size per occupational group, some occupational groups might be underrepresented in the sample	Possibilities to analyse results for particular occupational groups are restricted	- Choose a sufficiently large sample size - Draw a disproportionately stratified sample to represent smaller groups of the population with an adequate number of cases in the sample (prerequisite: information on the stratification variable available from the sampling frame) - Weighting of the dataset by sectors and occupational groups, based on LFS data (weighting design needs to consider the number of interviews per weighting cell; summarising of occupational groups might be necessary)
Non-response errors: Higher non-response to be expected for some groups, such as young, low-skilled, urban	Underrepresentation of these groups, sample not fully representative of the working population	- Various measures to improve the coverage of these groups as described in this chapter (dual frame sampling, multilingual interviewers, possibly mixed-mode option, etc.) - Weighting of the data by the criteria assumed to be associated with underrepresentation

Table 14: Possible errors in the path of measurement

Possible error source/error type	Consequences	Measures
Generally: If sticking to OccIDEAS: Generally high degree of validation as regards carcinogenic nature of substances and circumstances and regarding tasks; protective measures tested as being effective; BUT: Validation done for Australia; possible differences for Europe If setting up a largely new exposure survey: possibly higher relevance due to better adaptation to European user needs (coverage of tasks/agents specific for Europe, inclusion of questions on time dimensions, new shaping of modules in close correspondence with ISCO-08, etc.); BUT: lower validity to be expected due to untested instrument		
Carcinogens relevant to Europe missing in the questionnaire modules	Underestimation of the exposure to carcinogens due to the missing substances, overall and in particular for the specific groups exposed to the substances (specific occupational groups, specific countries if omitted substances are used in some countries only)	- Thorough check of all IARC substances currently not covered in OccIDEAS on whether or not they are relevant as risk factors at workplaces in Europe - Check of the lists of agents for completeness by OSH

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Possible error source/error type	Consequences	Measures
		specialists in each participating country
Relevant tasks not covered	Underestimation of the exposure to carcinogens due to missing relevant exposure situations	Check of tasks by comparing task modules with task lists in ISCO-08 and other sources; check of occupations prevalent in Europe on basis of LFS data
Some questions on work processes and substances possibly too specific, particularly for unskilled workers	High item non-response or wrong answers to be expected among particular groups (not enough cases for analyses in these groups, bias in the overall analyses due to lack of data for these – often particularly exposed – groups)	- Try to simplify questions (but: not very likely to find easier terminology) - Train interviewers to assist respondents in the particularly difficult modules (but: interviewers are not and cannot be expert in, for example, foundry) - Where applicable: interviewers insist on naming product brand if substance/agent type is not known
Selection of wrong modules	- Underestimation if respondents that are actually exposed do not get the modules asking about the relevant exposures - Annoyance of respondents if being asked largely irrelevant questions; possibly break-off of interviews due to annoyance	- Train interviewers to assist in selection process (as far as possible with the available type of interviewers) - Thorough piloting and analysis of data from previous surveys (AWES) to see which types of respondents (occupation, sector) are most likely to lead to wrong modules; if necessary, adapt closed questions used for the module selection - Possibly: program automated coding of ISCO-08 and use result for verification of the module selection
Missing time dimension	- Overestimation of exposure situations that an individual is faced with only rarely or only for a short time - As result: difficulty to identify the agents and exposure situations that need to be prioritised in preventive measures etc. (rarely occurring exposures concerning many workers may be prioritised over frequent and intensive exposures concerning only a small number of workers)	Limit the time frame for which exposure is asked about

Possible error source/error type	Consequences	Measures
- Measurement in different languages and different cultural settings - Measurement in the same language in different countries - Measurement in different languages in the same country	- Concepts may be understood differently or may differ in their meanings in different languages - Answering behaviour may differ between cultures, being in some cultures more open or critical than in others	- Thorough translation, inclusion of substantial and methodological expertise - Make sure that the respondent trusts in privacy and data security

5.8 Summary: quality of data to be expected from an EU-wide worker survey

The fact-based questionnaire design ensures a high level of comparability across countries and over time. If the survey instrument is thoroughly adapted to Europe, the survey concept is likely to deliver high-quality data. The adaptation of the questionnaire modules to Europe and the identification of relevant differences between countries are the key challenges.

National sample sizes should be defined that are large enough to allow the analysis of subgroups, for example particular sectors of activity or occupational groups.

Augmenting the questionnaire by the inclusion of questions about the time dimensions of tasks and exposure situations (frequency and duration) is worthwhile from the perspective of the relevance of results and their comparability over time. However, the general difficulties encountered in the measurement of the time dimensions may endanger the measurement quality.

6 Preparatory work and costs related to a worker survey on exposure to carcinogens

6.1 Two scenarios: adaptation of OccIDEAS versus set-up of a customised EU-wide survey

Having analysed the OccIDEAS system in more detail, the authors conclude that an EU-wide worker survey based on or inspired by OccIDEAS can indeed deliver additional, relevant information on the exposure of workers to carcinogens that is currently not available in this form from any already existing survey or other information source at the EU level.

The HazChem@Work initiative launched by the European Commission is also unlikely to deliver this information in the near future. As shown in section 2.2.1, there are still many obstacles related to the set-up or harmonisation of the national exposure databases that would serve as the basis for a harmonised European database on carcinogens following the HazChem@Work recommendations. HazChem@Work is based on measurement data and, once established in a majority of countries, could be a good complement to the EU-wide worker survey oriented to the OccIDEAS concept.

There are two general scenarios for the set-up of an EU-wide worker survey on the exposure to carcinogens (and possibly to other agents). The scenarios differ greatly in terms of the preparatory work they imply.

The **first scenario** consists in applying OccIDEAS to Europe with only slight modifications. These are modifications which do not substantially touch the general OccIDEAS survey concept and which therefore allow the already programmed questionnaire and the underlying analysis algorithms to be used to a considerable extent. Adaptations in this scenario would be confined to the following aspects.

- A critical check of all job modules on their completeness and adequacy for the situation in Europe. This includes an assessment of all agents, tasks, exposure situations and protective measures asked about.
- The addition of single agents, tasks or exposure situations considered relevant to Europe but not covered by OccIDEAS.
- The revision of questions considered too difficult to answer because of the level of job-specific knowledge required regarding, for example, materials used.
- The omission of single tasks or exposure situations considered irrelevant to Europe
- The addition of JSMs for jobs that are relevant to Europe but not tackled in OccIDEAS. The definition and demarcation of 'jobs' would be done in a similar way to the already existing job modules, that is not necessarily with a direct correspondence to a single ISCO-08 code.

This option implies accepting the drawbacks regarding the information gaps that OccIDEAS leaves in terms of the duration and intensity of exposure. It also implies accepting that the jobs distinguished in the questionnaire modules cannot directly be linked to the ISCO-08 classification.

The addition of one or two summarising questions asking about the frequency or duration of the main tasks or exposure situations might nevertheless be possible in this scenario. The introduction of time dimensions in this summarising form would, however, require intensive pre-testing and might not yield satisfactory results in the end.

The **second scenario** is the development of a new, EU-wide survey oriented to the OccIDEAS concept, but with substantial changes to the questionnaire and the analysis concept. These mainly consist in a consequent addition of a time dimension for each task and/or a redesign of the modules so that they correspond to the ISCO-08 classification.

If setting up a JSM for each ISCO-08 group, a much larger number of different JSMs would result than currently exist in the OccIDEAS system. For each of the JSMs, tasks and exposure circumstances that might be relevant to that task would need to be identified and operationalised in the form of concrete questions. Although parts of the existing master questionnaires of OccIDEAS could be used for this

purpose (given the agreement of the OccIDEAS team), many new elements would have to be newly developed.

This scenario would result in an instrument with considerably more modules than the current OccIDEAS questionnaire has. The already programmed OccIDEAS script could not be used in this scenario. Instead, modules would need to be programmed from scratch. Likewise, the algorithms underlying the assessment of certain tasks and scenarios with regard to the likelihood and extent of exposure would need to be newly developed or at least to be substantially revised.

A further substantial change concerns the measurement of the time dimensions (duration and frequency of tasks or exposure situations) for all exposures. If the time dimensions are considered indispensable, questions asking for the duration and frequency would have to be developed and added to all or at least a majority of tasks and exposure situations. Scenario 2 does not necessarily need to combine both elements, namely the differentiation of modules by ISCO-08 and the introduction of time dimensions. It is also possible to set up the survey with just one of these changes.

- ▶ The amount of preparatory work to be done to implement such a survey in Europe depends on the demands regarding the tailoring of the questionnaire to Europe and the importance of introducing further modifications to the OccIDEAS concept.
- ▶ If the addition of a time dimension for each exposure and/or the full compatibility of the survey with the ISCO-08 classification of occupations are considered indispensable for the survey, the set-up of a largely new survey concept is necessary (Scenario 2).
- ▶ If the lack of a time dimension for most exposure situations and the only loose linkage of the OccIDEAS job modules are acceptable trade-offs, the existing OccIDEAS survey concept can be used and will require only occasional adaptations (Scenario 1).

6.2 Preparation of questionnaires

6.2.1 Definition and adaptation of background variables

The background variables used in the AWES studies were tailor-made for the situation in Australia and do not apply in the same way to Europe. There are substantial differences between Australia and Europe, but also between European countries as regards the educational system, the territorial structure, etc. Besides, AWES was relatively sparse as regards the inclusion of background variables. There are a number of additional background variables that could be interesting to include.

There is mostly no need to formulate the background variables for Europe from scratch, as there are already a number of high-quality EU-wide surveys among workers available (for example the LFS or the EWCS). Relevant background questions used in these surveys could serve as a basis for setting up background questions for an EU-wide worker exposure survey (see section 5.5.3). It may even be possible to obtain all national language versions of these variables from Eurostat (LFS) or Eurofound (EWCS).

Table 15 below shows background variables which could be worth including in a worker exposure survey. The list includes the variables already asked about in OccIDEAS as well as a number of additional variables that would allow more differentiated analyses of the data. The results would for example allow the identification of the groups that should be targeted as priorities in preventive campaigns and other measures. The table differentiates between variables considered essential to include and others considered optional, that is useful but not essential.

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Table 15: Recommended background variables

Variable	Form of question/answer	Purpose	Recommended source	Importance
Age	Preferably numerical	Identification of particularly exposed groups; weighting variable	No source needed	Essential
Sex	Male/female	Identification of particularly exposed groups; weighting variable	No source needed	Essential
Educational level	Country specific; in a simplified form	Identification of particularly exposed groups; weighting variable	EWCS	Optional
Occupational group	Free text question, to be coded into ISCO-08	Identification of particularly exposed groups; for weighting and analysis	OccIDEAS	Essential
Nationality	Country of interview/other EU country/other country	Identification of particularly exposed groups; possibly weighting variable	EWCS (simplified)	Optional
Size of the workplace	Size bands	Information relevant to targeting of campaigns etc. (for example related to the use of PPE)	LFS, although with modified categories	Essential
Sector of the workplace	Free text and closed questions	For steering of JSMS	Closed questions to be newly drawn up (to fit best with existing JSMS)	Essential
Type of employer	Private versus public	Check on possible differences between public and private sector	EWCS	Optional
Employment status	Self-employed/employed /family worker etc.	Screening if only employed are to be asked; separate analyses if all groups are to be included	LFS	Essential
Full-time/part-time	Number of hours worked in an average week	For questions asking about the duration of exposure (for UV radiation and possibly other factors)	No source needed	Essential
Type of contract	Indefinite/fixed/temporary employment agency	Identification of particularly exposed groups	EWCS	Optional
Years working in the same (type of) job	Preferably numerical	Allows further analysis of how much at risk of cancer the person is	No source needed	Optional
Number of landline and mobile telephones in the household	Numerical	Needed for weighting (correcting for different selection probabilities)	Standards used by survey institute in charge of survey implementation	Essential

6.2.2 Checking, revision and augmentation of exposure matrices

The exposure matrices are at the core of the OccIDEAS concept and decisive for the success of the survey. Therefore, it is essential to have complete, consistent and accurately fitting exposure matrices available.

The job exposure matrices developed for OccIDEAS have a high degree of maturity, achieved through intensive previous research, extensive empirical testing and validation, and constant further development. Judging on the basis of the selected examples examined in this report (farmers and construction painters), they can largely be used for Europe without major adaptations. Nevertheless, all existing exposure matrices need to be thoroughly checked against the situation in Europe.

In the analyses of OccIDEAS done as part of this feasibility study, a few issues have already become apparent where the situation in Europe requires additions to the existing OccIDEAS questionnaires. The list of issues is by no means complete, since it does not follow a systematic examination of all modules. Nevertheless, the following examples show the type of additions expected to be necessary.

- Some modules could be extended. The module 'construction trades' could, for example, be augmented with specific questions about tasks, substances and materials used for 'mason and roofer (non-metal)'.
The module 'rubber industry' could be extended with specific information for 'tyre vulcaniser'. Depending on the country situation, there could also be a need to create a special module for 'roofers (non-metal)', 'steel workers' or 'tyre vulcanisers'.
- A type of jobs often associated with carcinogen exposure is those related to the production of nuclear energy. Specific questions related to radioactivity could not be found in the module 'line worker/power station worker' or elsewhere in the sections of the questionnaire on energy production. Australia has to date no atomic reactor in operation. This form of energy production is therefore not relevant to the Australian context. For Europe, however, it is highly relevant in some countries, for example France (58 atomic reactors in operation⁵³), the United Kingdom, Sweden or – still – Germany.
- Another difference between Australia and Europe is the climate. In much of Australia, there are usually no severe winters; even in winter, in large parts of the Australian territory, the daytime temperatures are mostly above 10 °C. Some problems with ventilation therefore do not exist in Australia and are therefore not necessarily taken into account in OccIDEAS⁵⁴. Likewise, many buildings do not have central heating, therefore the typical work profile of plumbers, for example, differs from Europe. Within Europe, climatic differences have also be taken into account when checking and amending the questionnaire modules.
- Some specific industries such as the automotive industry or the production of specific chemicals virtually do not exist in Australia. Tasks and exposure circumstances typical of jobs in only these industries may not be included in OccIDEAS.

In short, the steps for revising and adapting the concept for its application in Europe following Scenario 1 could be as follows.

1. Establish correspondence between the job modules and ISCO-08 for all modules and all ISCO-08 unit groups. To which module would workers of a particular ISCO-08 unit group probably assign themselves?
2. Check differences in the industry structure and the array of relevant occupational groups between Australia and Europe and – in a second step – within Europe. To this end, LFS data showing the number of workers per occupational group and per sector could be compared with corresponding data about the Australian workforce.

⁵³ <https://www.euronuclear.org/info/encyclopedia/n/nuclear-power-plant-europe.htm>

⁵⁴ An example of this mentioned by Lin Fritsch is car repair workshops. In Australia, the doors of such workshops are always kept open if engines are run, whereas, in many regions of Europe, the doors are closed for parts of the year, so proper ventilation systems are required.

3. Systematically check the completeness of the task questions used in OccIDEAS against the task lists shown in ISCO for all ISCO unit groups relevant to Europe (according to the statistical analysis).
4. For all tasks not covered: develop new questions, in close cooperation with the OccIDEAS team.
5. Systematically check and clarify which additional agents (if any) that are not covered by OccIDEAS should be included.
6. Identify jobs and tasks where these additional agents are relevant.
7. Set-up task-related questions for these agents where necessary, using among other tools ISCO-08 task descriptions.
8. Send the revised OccIDEAS questionnaire modules to sectoral safety and health experts from different countries for a further check on adequacy and completeness.
9. Include the feedback of the experts as far as is useful and feasible.

6.2.3 Adaptations to the selection of the appropriate job module

As discussed in section 3.5.5, the selection of the most appropriate JSM for each respondent is a crucial moment for the success of the survey. In OccIDEAS, this is done by a sequence of open and closed questions related to the industry, the occupation and the main task of each worker.

1. In your main job, what is the industry of your employer? [free text]
2. In your main job, what is your occupation? E.g. child care worker, maths teacher, apprentice toolmaker etc. [free text]
3. What are the main tasks you do in your job? [free text]
4. Which of the following best describes your job category? [given categories]
5. You chose [sector xy]. Which of the following best describes your job role? [given categories]
6. Only for some job categories: Which occupation do you work in? [given categories]

This procedure has worked quite well in AWES; the broad majority of respondents could be assigned to the most relevant occupational groups. Nevertheless, this step requires intensive previous testing and possibly some modifications for application in Europe.

1. In the closed questions leading to the JSM selection (see steps 4 and 5 above), the differentiation of sectors and occupations applied is adapted to Australian classifications. Adaptations to NACE and ISCO-08, the classifications used in Europe, might be necessary.
2. The Australian AWES survey was done by a small, well-trained team of interviewers from a call centre attached to a university, and almost exclusively dedicated to AWES at the time of the fieldwork. In Europe, fieldwork can hardly be organised in that way, since only a few countries have such academic teams of interviewers. Even where they exist, it would be difficult to coordinate them and to ensure that they are all working according to the same standards. The survey would therefore be done instead by a commercial survey company with its own offices or cooperation partners in the countries involved. Although they work with experienced and generally well-trained interviewers, it might be difficult to train them sufficiently well to assist effectively in assigning the JSMs. This assistance requires a profound knowledge of sectors, occupations and the available modules on the part of the interviewers. The necessity of interviewer intervention in this step should therefore be reduced to a minimum.
3. For the future, the set-up of the survey as an online or mixed-mode survey might be an option to save money or enhance the size of the net sample. In the online mode, there is no interviewer available to assist in assigning the correct occupational group. The filtering to the JSMs would therefore have to be set up so that respondents are reliably led to the correct module.

If Scenario 2 is applied, the entire selection mechanism will require a thorough revision. In this scenario, questionnaire modules will be developed that directly correspond to ISCO-08-categories. If ISCO-08 is used for the modules and their assignment, free text questions about the occupation and subsequent automated online coding of the free text answers could be a more efficient and reliable solution than routing by way of closed questions showing ISCO-08 categories. In recent years, several institutions and scientists have tried to develop computer-assisted systems for the assignment of sector and occupation codes to respondents within an interview. Some of these systems have reached a considerable degree of maturity and have been thoroughly tested in practice. In particular, there are two

systems which may have the potential to be used for on-the-spot application of ISCO-08 on the basis of a free text description: the occupational self-coding automatic recording (OSCAR) system developed in the UK (De Matteis et al., 2017) and the automated coding process developed by M. Schierholz in Germany (Schierholz et al., 2017). Both online coding systems are still rather new and would require further adaptation for use in a potential EU-wide exposure survey, but they would probably be available for the survey.

6.2.4 Pre-testing

The OccIDEAS concept has been thoroughly tested and validated in Australia in the large-scale survey on carcinogens in AWES 2011/2012. Problems encountered in the process have been analysed by the OccIDEAS team and have led to a number of smaller changes to the concept. The survey concept can thus be considered a quite mature measurement instrument. Nevertheless, we recommend planning a thorough pre-testing phase before eventual implementation as a full survey in Europe, for a number of reasons.

- Applying it in the various EU countries may present difficulties that did not arise in Australia.
- The suitability of some of the questions on agents and exposure situations asked to job groups with mainly unskilled workers needs specific attention in empirical tests.
- All newly developed or revised modules or single questions should be empirically tested before their large-scale implementation. The selection process/filtering for these new modules should also be tested in practice in order to ensure that the module is selected by the intended occupational groups.
- The technical set-up, with an outline script prepared by the survey company in Europe and an online web connection of the call centre to the OccIDEAS server, requires testing in order to ensure a smooth interviewing process for the main survey.
- If the survey is set up as a mixed-mode survey with a CATI and a CAWI option, this requires intensive testing of the CAWI version. OccIDEAS has never been implemented in a CAWI environment, so this design would require thorough testing. The most critical points to be tested are the technical implementation (linkage from the framework questionnaire to the web-based core questionnaire at Curtin University) and the filtering to the most appropriate JSM without the assistance of an interviewer.
- In the event of mixed-mode interviewing, analysis of pre-test results might give first hints regarding possible mode effects. For this, we recommend conducting pre-test interviews with both the CATI and the CAWI mode in at least two or three countries. The data derived by both modes can then be tested on mode effects by applying multivariate analysis methods. This type of analysis does, however, require a substantial number of pre-test interviews.

Bearing the above in mind, the design in Table 16 is recommended for the piloting of the survey.

Table 16: Recommended pilot design for Scenario 1

Number of countries:	3 to 5 as minimum, from different regions (min.: 1 Western European, 1 Eastern European, 1 Southern European) and from economies with different characteristics in terms of, for example, the degree of industrialisation and mechanisation
Mode:	CATI; Additionally , CAWI interviews in at least 2 countries if CAWI or mixed mode is considered an option
Number of interviews:	1,000 or more per country and mode (due to large number of different modules; 1,000 interviews/60 modules = ca. 17 interviews per module on average)

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Sample:	Random telephone samples of both landline and mobile phone numbers Possibly additional sample of prequalified addresses for sectors/occupations where the newly added agent modules are most likely to be relevant For cost reasons, the use of prequalified addresses for the entire sample could be considered as an option
Form:	A standardised pre-test is likely to be sufficient for Scenario 1 in view of the practical experiences from Australia; for new questions, some form of cognitive pre-testing would nevertheless be desirable, particularly if the new questions have not been asked and validated elsewhere in the same or a similar form

6.2.5 Translations

For studies with a limited geographical scope, the OccIDEAS team also offers to organise translations into other languages. For an application to the survey concept to the European Union with its large variety of different languages, a different approach to translations is recommended, following the best practice models with double translation and adjudication as applied to other best practice EU surveys (such as ESENER or the surveys of Eurofound).

For the translations, the English master texts can be exported into a databank (such as Excel) and can then be re-imported into the OccIDEAS script. Parallel language versions can then be created for the English master questionnaire modules.

In view of the large number of different modules existing for OccIDEAS and thus the large number of words to be translated, sufficient time and budget has to be allowed for the translation process. In total, the final number of translatable words in the questionnaire could be roughly in the range of 6,500 to 8,000 words⁵⁵. This is still a manageable number of words, resulting from the short and fact-based formulation of questions and items. Translation costs will nevertheless be considerable if following best practice models. The main difficulties in the translations will be correct, although not too technical, translation of the numerous specialist terms (agents, work processes, protective equipment).

⁵⁵ This estimate is based on a rough count of words done by the OccIDEAS team, but takes into account some modifications that might be necessary. If the survey is to be amended by adding a series of questions that are currently not part of OccIDEAS, the number of words will rise.

- ▶ Regardless of the preferred scenario, the background variables set out in OccIDEAS should be not only adapted to Europe, but also considerably augmented. Additional background variables will enable better identification of particularly vulnerable groups. This improves the targeting of preventive measures.
- ▶ Scenario 1 requires a thorough check of all exposure matrices and job-specific questionnaire modules. Where necessary, adaptations for application in Europe need to be made. Adaptations may result from differences in climate, in industries, in jobs or in materials used.
- ▶ Scenario 2 requires the set-up of new exposure scenarios and questionnaire modules almost from scratch, customised to ISCO-08 occupational groups and augmented with questions on the time dimension of the exposure.
- ▶ The mechanism for selecting the most appropriate questionnaire modules also requires adaptation. Correct attribution is key for the success of the survey.
- ▶ Before it is implemented in a large-scale survey in Europe, the adapted questionnaire needs to be thoroughly tested in a few EU countries. For this, a selection of countries from different regions, with different industry structures and different degrees of mechanisation should be chosen.
- ▶ High-quality translations are key for full cross-national comparability of the survey results. In spite of the numerous questionnaire modules to be translated, the overall number of words to translate is moderate and manageable.

6.3 Further practical aspects of survey preparation and implementation

6.3.1 Training requirements for interviewers

The main training requirement for interviewers working with OccIDEAS is choosing the appropriate job-specific questionnaire module. This task requires intensive training of interviewer teams. Interviewers need to be familiarised with how the selection of the appropriate module is done. In order to be able to support respondents in this step, interviewers must have a good overview of the questionnaire modules and need to be familiar with the main features of the NACE and the ISCO-08 classifications. Because of these training requirements, it is advisable to form relatively small and stable teams of interviewers for this survey.

An issue that did obviously not require specific training in Australia, but might require training in the European context, is the terminology for substances and exposure situations. As shown above, questions for some low-skilled workers are quite specific. Workers with hardly any training in the job they are performing might have difficulties with these questions. Providing interviewers with some basic knowledge about these issues might enable them to help in the interview situation.

Apart from this, the survey is unlikely to present any particular difficulties to interviewers. Questions in the original OccIDEAS modules are mostly very short and easy to understand, except for some technical terms related to tools or agents (for example cleaning agents or types of metal being handled), which sometimes may present problems, particularly to respondents who have had only little or no vocational training for that job.

6.3.2 Statistical information about occupation and sector of activity

The availability of statistical information on the universe is an important prerequisite for the envisaged representative worker exposure survey in Europe. In addition to the standard demographic information needed for the weighting of any representative survey among employees (age, sex, employment status), information on occupation, sector of activity and – ideally – also the size of the workplace are important. This information is needed at two stages of the process:

- knowledge of the distribution of employees by occupational groups and by sector allows the identification of occupations that are so rare that the development of a job-specific questionnaire module for them is not justified;
- weighting of survey results by NACE and ISCO-08 can correct for disproportionate non-response by sector and occupational group⁵⁶ and thus improve the accuracy of the analyses made on the basis of the data.

Statistical information about the distribution of employees by occupations is easily available for all EU countries. The LFS coordinated by Eurostat and carried out by the national statistical office in each Member State provides detailed and comparable information on the distribution of occupations by country, sector of activity and other criteria. The LFS collects data on the sector of activity a person's workplace belongs to and on the occupation he or she has there. Both the ISCO-08 and the NACE codes are available from the LFS up to the three-digit level (minor groups), which is the second-finest differentiation that exists in these systems. For some (larger) countries, even the four-digit level (unit groups) is available. The survey has been happening for a very long time and is conducted at least annually, with very large sample sizes. The statistical data produced on the basis of the LFS can therefore be considered very accurate.

6.3.3 Clarification of usage rights and modes of cooperation with the OccIDEAS team

OccIDEAS has been developed over several years by the research team of Professor Lin Fritschi at Curtin University in Perth, Australia. Although no general copyright regulation is valid for questions from survey questionnaires, the adaptation of OccIDEAS for Europe would be a different case, since OccIDEAS is not only a questionnaire, but a highly developed integrated data collection and analysis system. Therefore, any use of OccIDEAS requires consent on part of its authors – be it direct use according to Scenario 1 or as a model survey and starting point for a modified survey according to Scenario 2.

Regardless of the scenario finally chosen, the authors of OccIDEAS are generally open to the application of the system in Europe and even offer their support for it. The precise mode of cooperation would depend on the scenario chosen. In Scenario 1, the OccIDEAS team needs to be very closely involved in any modification of OccIDEAS, since, in this case, the OccIDEAS programmed master script and the server of Curtin University would be used. Likewise, the agreement of any modifications with the OccIDEAS team would ensure that none of the modifications introduced for Europe hampers the concept (for instance the underlying algorithms) in any way. Although OccIDEAS has not been developed for commercial purposes, it is obvious that the work invested in adaptation to Europe would need to be compensated for.

- For any adaptation of the OccIDEAS concept to Europe, usage rights have to be clarified with the OccIDEAS team. The team is happy to provide support in the adaptation of the survey to Europe. Since OccIDEAS has not been set up for profit sales purposes, only moderate costs are to be expected for this.

⁵⁶ If necessary at all, weighting by occupational groups should be done on only the highest level of ISCO-08. For the finer differentiations, the number of interviews in the net sample will be too small. Weighting on the highest level can be useful if, for example, workers from a particular skill level (such as managers or low-skilled workers) are clearly underrepresented in the survey. To a certain degree, this type of underrepresentation will, however, automatically be corrected for in the weighting by the criterion 'level of education'.

6.4 Cost estimates

6.4.1 Fieldwork costs

The costs related to fieldwork are based on a cost estimate drawn up by the private survey research group Kantar and by Kantar Public Germany. The price estimates are derived from costs of other recently conducted best practice CATI surveys among the general population. They are based on the following assumptions.

- The target population is defined as the economically active population aged 15 to 64 years. If this definition is narrowed down, for instance by modifying the age band or by excluding family workers or self-employed persons without employees, costs will increase slightly because of the greater effort needed to screen calls. Sampling frames for CATI surveys usually do not provide any information on the age composition or employment status of the household members.
- The indicated interview duration is an average value. Based on the experiences from AWES in Australia, it can be expected that roughly half of all respondents are asked only very few questions because they are working in jobs where they are unlikely to be exposed to any carcinogens. Assuming a screening questionnaire taking on average 10 minutes for jobs without exposure and an interview of 25 minutes for jobs with exposure, the average duration would be 17.5 minutes in the assumed ratio of 50 % screening interviews and 50 % full interviews (for jobs with likely exposure).
- The calculation goes on the assumption that multiple calls are made at each selected household (up to 8 or 10 calls) and that the survey is treated as a best practice CATI population survey, aiming for high response rates. This also includes the application of a best practice translation procedure (double translation and adjudication) and a preparation seminar for local CATI supervisors. Lowering the quality level would save some costs.
- The cost estimates are based on current fieldwork prices. Since a full survey is unlikely to be carried out before the year 2019 or even 2020, annual cost increases should be considered in the definition of the budget for such a survey. While usual increases are in the range of 2 %-3 % per year, they may be larger for this survey because the proportion of mobile phones to be called is likely to increase from year to year. Interviewing respondents with mobile phones is considerably more expensive than landline interviewing.
- In the cost estimate, it was assumed that the same number of interviews (1,000, 2,000 or 3,000) would be conducted in each country, including the very small ones. If EU-OSHA wishes to have more interviews in the larger countries and fewer in the smaller ones, this is likely to have some impact on the prices because the larger countries tend also to be among the more expensive ones in terms of fieldwork.
- For the calculation, it was assumed that the pre-test would be coordinated centrally, but carried out locally. Costs for central coordination, for sampling and for technical reporting are included.
- The costs include pre-test interviews in five countries, with samples of 1,000 CATI interviews per country and an analysis of the pre-test results.
- Costs for programming questionnaire modules are not included. The calculations include only the costs for the programming of the framework questionnaire with the sample management and household selection features. The script itself would have to be adapted by Curtin University (language versions, adaptations of questions, inclusion of new background variables); costs for the team at Curtin University are not included.

Table 17: Price estimate for a CATI worker survey following the AWES/OccIDEAS model

Variant	Interviews per country	Interviews in total (EU-28)	Average duration (minutes)	Estimated price (2017) (EUR)
1	1,000	28,000	15	2,400,000
2	1,000	28,000	20	2,600,000
3	2,000	56,000	15	3,300,000
4	2,000	56,000	20	3,700,000
5	3,000	84,000	15	4,100,000
6	3,000	84,000	20	4,800,000

The costs give an indication only. Actual costs at the time of launching a call for tender may vary between survey institutes and they also depend on the detailed survey requirements defined for the call for tender.

6.4.2 Overall costs

The overall costs of this approach, that is the costs including the adaptation of the questionnaires to Europe and possible national adaptations to take into account differences between EU countries, are difficult to assess at the current stage. For this, more clarity on the design (Which scenario would be most likely? How meticulously does the instrument need to be adapted to Europe?) and on the task allocations (Who would do the adaptations?) would be needed. Also, the kind and modalities of the cooperation with the OccIDEAS team at Curtin University would need to be clarified.

- For the implementation of a full-scale survey in Europe, fieldwork costs of about EUR 2.4 million to EUR 4.8 million are to be expected, depending on the duration of interviews (15 or 20 minutes) and the sample size. For the estimate, overall sample sizes ranging from 28,000 to 84,000 interviews were assumed, reflecting national sample sizes between 1,000 and 3,000 interviews.
- The price estimate includes translations and a large-scale pilot of the survey in five countries, with 1,000 interviews per country.
- Costs of the adaptation of the survey in terms of questionnaire content and costs for the cooperation with Curtin University are not included. For the first wave of the survey these costs will be considerably higher than for any repetition of the survey.

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7 Final conclusions and recommendations

The feasibility study has shown that a task-based EU-wide worker survey on exposure to carcinogens can fill important information gaps. The Australian OccIDEAS survey concept and the AWES survey, its most comprehensive practical implementation, could serve as a model for an EU-wide exposure survey. This concept is well validated and has been prepared according to high scientific standards. Its fact-based approach leads to results that are largely independent of the (often culturally influenced) risk awareness, risk perception and expectations of individuals. The results will therefore have a high degree of cross-national comparability.

The OccIDEAS concept is able to deliver accurate, reliable and representative information on the level and likelihood of exposure to carcinogens (and other hazards) for all kinds of workers. It allows differentiation between sectors of activity and occupational groups. Groups of workers that are particularly affected by exposure to carcinogens can be identified and targeted more effectively with campaigns and other preventive measures.

The work done in the course of this feasibility study has shown that OccIDEAS can be adapted to Europe with reasonable investments in terms of time and money. The information required for the adaptation is largely available. Task descriptions for occupational groups, the description of job-specific hazards and statistical figures on the number of workers in particular jobs and sectors can be derived from a variety of national and international sources.

OccIDEAS is a very mature, well-tested and constantly improved survey and assessment instrument. The most serious drawback of the concept regarding the information needs existing at the EU level is its lack of a time dimension in the exposure measurements. The current version does not measure the frequency and duration of each exposure situation. Collecting this kind of additional information has proven to be error-prone and very demanding for respondents and has therefore been abandoned. Another (minor) caveat is that the job differentiation used in the questionnaire modules is not directly linked to ISCO-08 or any other official classification of occupations. This may lead to some inaccuracies in extrapolations of exposure data for particular occupational groups.

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9 Annex

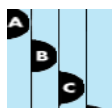
Figure 2: Excerpt from ILO Guide to Occupations (ILO, 2012) for the example of painters

PAINTER (NON-ART)

Synonyms: Brusher; lacquerer; paint sprayer; paint worker

Job profile

- **Definition and/or description**



Applies paint to surfaces. Prepares walls, metal, wood or other surfaces for painting. Spreads dropcloths over floors, machines and furnishings. Erects scaffolding or sets up ladders for work above ground level. Removes fixtures (such as pictures, nails, and electric switch covers). Removes old paint using paint remover, scraper, wire brush or blow-torch. Fills holes, cracks and joints with caulk, putty, plaster or other filler. Smooths surface using sandpaper, steel, wool and/or brushes. Washes and treats surfaces with water or other cleaning media. Selects premixed paint or mixes paint components. Applies coats of paint, varnish, stain, enamel or lacquer to surfaces using brushes, spray guns, rollers or electrostatic equipment. May dry or bake paint in special ovens. May cut stencils and brush or spray decorations and lettering on surfaces.

- **Tasks**



Air-drying; applying (paint); blowing (dry air); bolting; bonding; brushing; burning; calculating; carrying; caulking; cementing; cleaning; climbing; coating; cutting; decorating; dissolving; drying; depositing (electrostatically); enamelling; erecting (scaffolds); filling; filtering; finishing; gluing; grinding; hauling; lacquering; lettering; loading and unloading; marking; masking; matching; measuring; mixing; moving; operating (spray gun etc.); painting; pasting; patterning; plastering; pouring; preparing (surfaces); purchasing; puttying; regulating (flow); removing (paint, rust, fixtures, etc.); repairing; rolling; rubbing; sanding; scraping; screwing and unscrewing; sealing; selecting; setting-up (ladders, etc.); shot blasting; smoothening; spraying; spreading; staining; stamping (patterns and designs); stripping; taping; touching up; tracing; transferring; transporting; varnishing; washing; waxing; whitewashing; wiping; wrenching.

- **Primary equipment used**



Hand brushes; rollers; spraying equipment (air pressure or airless; hand-held or automated); electrostatic painting equipment; paint-drying ovens, lamps or hot-air blowers; paint mixing equipment; paint-stripping tools (manual or electric).

Hazards

▪ Accident hazards



- Falls from height (falls from ladders, from fixed and mobile elevated platforms, from scaffolds, from roofs, from tank tops, through opening in roofs, etc.);
- Slips and falls on level surfaces, in particular on slippery floors;
- Electrocution or electric shock (from faulty electrical equipment, through contact of metallic ladders with electric lines, during work with high-voltage electrostatic painting equipment, etc.);
- Hypodermal injection of paint into fingers, hands and (less frequently) other parts of the body when working with high-pressure airless spraying equipment. Such injection may cause deep penetration and amputation of affected fingers;
- Severe mechanical damage to eyes by high-pressure paint jets;
- Fire and explosions of flammable paint solvents and other constituents, especially when working (painting or mixing paints) in confined spaces with poor ventilation. Furniture lacquers may contain nitrocellulose, which is an explosive substance and may explode on impact or heating, if residues of the lacquer are allowed to dry;
- Fire and explosions as a result of electrostatic discharges during electrostatic painting with powdered paints, or as a result of sparks generated when metal particles (e.g., in paints containing metal powders) impact on the painted metal surface, or as a result of ignition of paints with binders which oxidize on contact with air;
- Clothes catching fire, within or outside the painting zone, when impregnated with paints or oil;
- Paint-splashing accidents from burst piping or when trying to unclog clogged spray nozzles;
- Penetration of foreign particles into the eyes during surface preparation for painting (e.g., by shot-blasting or sanding);
- Cuts, stabs, abrasions, etc. in fingers and hands during surface preparation by mechanical means;
- Penetration of skin by wood splinters when preparing wood surfaces for painting;
- Crushing of limbs or blows to other body parts when working in a suspended position;
- Skin abrasions from ladder rungs;
- Eye irritation or damage to the cornea from solvent droplets splashed into the eyes;
- Asphyxiation in confined spaces as a result of oxygen deficiency aggravated by the presence of solvent vapours.

▪ Physical hazards



- Noise from spray guns or shot-blasting equipment;
- Exposure to UV or IR radiation, or heat, from paint-drying equipment;
- Exposure to cold, rain, snow and winds in winter, or to heat and sunrays in summer, particularly in outside work;
- Exposure to draughts in unfinished buildings.

▪ Chemical hazards



- Occupational contact dermatitis as a result of exposure to various paint components or solvents, in particular to aliphatic and aromatic hydrocarbons and organohalogen compounds;
 - Irritation of the eyes (with possible permanent damage to vision) and the respiratory tract by various paint components, in particular toluene and methylene diisocyanates;
 - Acute intoxication, mainly as a result of inhalation of solvents, especially in confined spaces with inadequate ventilation. Mild intoxication has a narcotic effect which reduces vigilance and markedly increases the risk of falls or other accidents, sometimes with severe consequences. Severe intoxication may be fatal;
 - Poisoning by phosgene formed from various chlorinated solvents in contact with a heat source under partial combustion conditions;
 - Poisoning by lead in primers and by other metal constituents of paints (e.g., mercury and arsenic compounds used as fungicides in latex paints, organotin compounds in marine antifouling paints, zinc chromate in various lead-free primers, etc.);
 - Poisoning by paint strippers such as methylene chloride or mixed solvents;
 - Poisoning by hazardous paint constituents, depending on the type of paint used (e.g. formaldehyde in melamine/formaldehyde paints, epoxy resins in epoxy paints, toluene diisocyanate and methylene diisocyanate in polyurethane paints, etc.);
 - Neurotoxic effect as a result of work with paints containing n-hexane solvents or lead pigments.
- **Ergonomic and social factors**



- Neck or shoulder pains, sprain and strain of upper limbs, and musculoskeletal disorders, as a result of awkward postures, in particular during the painting of ceilings;
- Eye strain in painters of small articles;
- Knee pains and injuries to cartilage of the knee joints;
- Cardiorespiratory strains when using respiratory-protection equipment.

Addendum

- Notes



1. Reports have been published according to which painters may be at increased risk of cancer of the lungs, the bladder, the stomach, the kidneys, the oesophagus and the large intestines; of leukaemia, if using paint containing benzene; of presenile dementia as a result of exposure to solvents; of endocrinal disorders; of chronic bronchitis and respiratory obstructions diseases; of mixed-dust pneumoconiosis; of renal failure; and of chronic eye-lens damage as a result of long-term solvent exposure.

2. A special risk exists in the mechanical or chemical stripping or burning of old paints. The use of pigments containing lead, arsenic or mercury in modern paints is now severely restricted and in many countries it is prohibited by law (except for some specialized applications); old paints, however, may contain substantial amounts of such pigments, and during their stripping or burning the pigments are released into the air as dust or fumes, exposure to which may cause lead, mercury or arsenic poisoning.

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3. It has been reported that exposure to ethylene glycol ethers and acetates present in paints may have an adverse effect on the reproductive system.

Table 18: Job-specific modules and their correspondence to sector and occupation

No	Job/occupation	Description	NACE	Compatibility to ANZSCO and ISCO-08
1	Air transport worker (incl. pilots, attendants, etc.)	Air transport including airport ground staff, flight attendant, pilot, etc.	H	Various (ISCO-08 4323 Transport clerks; 5112 Transport conductors; 3153 Aircraft pilots and related associate professionals; 3154 Air traffic controllers; 3155 Air traffic safety electronics technicians)
2	Animal worker	Work with animals as part of their jobs: zoo keeper, farrier, horse rider, wildlife, petshop etc. DOES NOT include veterinarians or vet nurses	A, R	Various
3	Artist/film processor	Professional artists, photographers or process film	R	Various
4	Care taker/janitor	Janitors, handymen, building maintenance	N	Various, difficult
5	Ceramics	Ceramics industry including brick, tile and pipe making, glass, pottery and sanitary ware	C, F	Various
6	Cleaner	Domestic, commercial and industrial cleaners	N	Various
7	Construction trades	Construction trade workers including electricians, painters, carpenters, plumbers, plasterers, labourers	C, F	Various (ISCO-08 9313 Building construction labourers; 1323 Construction managers; 3123 Construction supervisors; 7411 Building and related electricians; 7412 Electrical mechanics and fitters; 7413 Electrical line installers and repairers; 7421 Electronics mechanics and servicers; 7422 Information and communications technology installers and servicers; 7131 Painters and related workers; 7316 Sign writers, decorative painters, engravers and etchers; 7115 Carpenters and joiners; 7125 Plumbers and pipe fitters; 7123 Plasterers)

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No	Job/occupation	Description	NACE	Compatibility to ANZSCO and ISCO-08
8	Driver	Drivers and transport workers	H	Various
9	Dry cleaning	Retail dry cleaning and dry cleaning plant workers	S	Term not found in ANZSCO or ISCO-08
10	Farmer	Crop and livestock farm workers	A	Various ISCO-08 and ANZSCO codes (ISCO-08 6310, 6320, 6330 and 6340 have no equivalents in ANZSCO)
11	Firefighter	Firefighters	O	OK
12	Fitter and maintenance mechanic	Maintenance tradesperson in factories, hospitals etc.	C, F	OK
13	Florist	Retail or wholesale florists	G	OK
15	Food workers	All food related jobs including, chef/cooks, bakers, butchers, food processing plants or food retail outlet.	G, I	Food + various
16	Forestry/timber mill	Forestry, timber mill and lumber workers	A	Branch; job would be Forestry worker
17	Foundry	Production workers in the foundry or metal casting industry.	C, F	Branch; term not found in ANZSCO or ISCO-08
18	Gardener/groundskeeper	Gardeners, landscapers, sports ground maintenance	G	Various
19	Hairdresser/beauty therapist	Hair salon workers/beauty therapists	S	OK, ISCO-08 5141
20	Health worker	Health professionals, includes veterinarians, vet nurses, dentists, dental assistants, nurses including home care, doctors, surgeons	Q	Various
21	Industrial manufacturing, assembly and repair	Manufacture, assembly or repair items	C, F	Branch; term not found in ANZSCO and ISCO-08
22	Laboratory worker chemist	Workers in all types of scientific laboratories	G	Various laboratory
23	Leather tanning	Leather tanning, including beamhouse operations and tanyard processes	C	Term in ANSCO and ISCO-08: Leather goods maker
24	Linesman/power station worker	Power station or power line workers	G	Branch; term not found in ANZSCO or ISCO-08
25	Machinist	Machining parts, fabrication, forging, fitter and turner	C	Various
26	Mechanic/panel beater	Mechanics and panel beaters	C, G	Various

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No	Job/occupation	Description	NACE	Compatibility to ANZSCO and ISCO-08
27	Metal finishing and coating	Metal plating, coating or other finishing	C	ISCO-08 yes, term not found in ANZSCO
28	Military	Army, navy, airforce troops, NOT tradesworkers	O	ISCO-08 Group 0
29	Miners/quarrymen	Miners or quarrymen	B	OK
30	Musician/entertainer	Play or teach music	P, R	Various
31	Office worker	Office or administration workers	various	Various
32	Pesticide user	Main task is to use pesticides including crop sprayers, pest control workers	A, N	Subgroup of listed jobs
33	Petrol station attendant	Petrol and gas station attendant	G	Term not found in ANZSCO or ISCO-08
34	Petroleum/oil industry	Oil or petroleum industry	D, G	Term not found in ANZSCO or ISCO-08; job would be Petroleum engineer
35	Police	Police officers	O	OK
36	Metal refining/smeltering	Production workers in metal smelters and refineries or rolling and drawing mills	C	Branch; term not found in ANZSCO or ISCO-08
37	Printing	Printers and printing workers	C	OK
38	Railway	Rail station, depot, signal box, train repair facility, track maintenance	H	Various
39	Retail worker	Retail stores other than food retail	G	Diverse
40	Road construction	Constructing and maintaining roads	F	Branch; term not found in ANZSCO or ISCO-08
41	Roadside worker	Work alongside roads but NOT in road construction (for example toll booth, street vendors, traffic control)	H, N, O	Term not found in ANZSCO or ISCO-08
42	Rubber industry	Rubber manufacture or rubber goods manufacture	C	Branch; diverse
43	Sewage and water worker	Sewage plant and water workers	E	Term not found in ANZSCO or ISCO-08, only waste water
44	Shipping/fishing	Shipping industry workers, merchant seamen and fishermen	A	Diverse
45	Shoes and leather goods	Manufacture and repair of shoes or finished leather goods	C	Diverse
46	Storeperson	Store person and fork lift drivers	G	OK

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No	Job/occupation	Description	NACE	Compatibility to ANZSCO and ISCO-08
47	Teaching	Teachers	O, P, R	OK
48	Textiles	Manufacture of natural or synthetic textiles, fabric, yarn, or finished goods such as clothes	C	Branch, diverse
49	Upholstery	Upholstery industry including auto and furniture	C	OK
50	Waste management	Tip/landfill site workers, waste truck drivers	E	Term not found in ANZSCO and ISCO-08; subgroup of 44
51	Welder	Welders, boiler makers	C	Diverse
52	Generic module	For jobs that do not have a specific module		

Table 19: Chemical substances and their OELs found in agricultural products

Substance	CAS No	German MAK/AGW (mg/m ³)	Polish NDS (mg/m ³)	Romanian OEL (mg/m ³)
2-Ethylhexan-1-ol	104-76-7	54	160	-
Diatomaceous silica, flux-calcinated	68855-54-9	0.3	-	-
Silica, amorphous	112926-00-8	4	-	-
2-Methylpropan-1-ol	78-83-1	310	100	100
Gasoline	86290-81-5	-	-	-
Diesel fuel (vapour and aerosol), in total hydrocarbons	68334-30-5	-	-	-
Toluene	108-88-3	190	100	192
Methyl tert-butyl ether	1634-04-4	180	180	183.5
2-Methylpropan-2-ol (tert-butyl alcohol)	75-65-0	62	300	-
Ethanol	64-17-5	960	1,900	1,900
Benzene	71-43-2	1.9	1.6	3.25
Di(tert-dodecyl) polysulfide	68425-15-0	100	-	-
Ammonium chloride, fume or respirable dust	12125-02-9	-	10	5

Substance	CAS No	German MAK/AGW (mg/m ³)	Polish NDS (mg/m ³)	Romanian OEL (mg/m ³)
Magnesium oxide	1309-48-4	4	5	5
Boric acid and sodium borate	10043-35-3	AGS 0.5; DFG 10	-	-
Glutaraldehyde	111-30-8	AGS 0.2; DFG 0.24	0.4	-
Formic acid	64-18-6	9.5	5	9
Propan-2-ol	67-63-0	500	900	200
Hydrogen peroxide	7722-84-1	0.71	-	-
Orthophosphoric acid	7664-38-2	2	1	1
Nitric acid	7697-37-2	-	1.4	-

-: no defined value for the respective agent.

AGW, Arbeitsplatzgrenzwert (workplace limit value); MAK, Maximale Arbeitsplatz-Konzentration (maximum workplace concentration); NDS, Najwyższe Dopuszczalne Stężenie (highest acceptable concentration); AGS: Ausschuss für Gefahrstoffe (Committee on Hazardous Substances); DFG: Deutsche Forschungsgemeinschaft (German Research Foundation).

Table 20: Chemical substances and their OELs found in painting products

Substance	CAS No	German MAK/AGW (mg/m ³)	Polish NDS (mg/m ³)	Romanian OEL (mg/m ³)
Diethylene glycol monobutyl ether	112-34-5	67	67	67.5
Kathon – mixture (3:1) (5-Chloro-2-methyl-2,3-dihydroisothiazol-3 one and 2-Methyl-2,3-dihydroisothiazol-3 one)	55965-84-9	0.2	-	-
n-Butyl acetate	123-86-4	AGS 300; DFG 480	200	715
Acetone	67-64-1	1,200	600	1,210
Methanol	67-56-1	270	100	260
Xylene	1330-20-7	440	100	221
Butan-2-one	78-93-3	600	450	600
Butan-1-ol	71-36-3	310	50	100

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Substance	CAS No	German MAK/AGW (mg/m ³)	Polish NDS (mg/m ³)	Romanian OEL (mg/m ³)
Propan-1-ol	71-23-8	-	200	200
2-Phenoxyethanol	122-99-6	AGS 110; DFG 5.7	-	-
2-Metylo-4-isotiazolin-3-on	2682-20-4	0.2	-	-
Kathon – mixture (3:1) (5-Chloro-2-methyl-2,3-dihydroisothiazol-3 one and 2-Methyl-2,3-dihydroisothiazol-3 one)	55965-84-9	0.2	-	-
Lacquer naphtha	64742-48-9	-	300	-
2-Butanone oxime	96-29-7	1	-	-
Distillates (petroleum), hydrotreated light	64742-47-8	350	-	-
Titanium dioxide	13463-67-7	-	10	10

-.: no defined value for the respective agent.

AGW, *Arbeitsplatzgrenzwert* (workplace limit value); MAK, *Maximale Arbeitsplatz-Konzentration* (maximum workplace concentration); NDS, *Najwyższe Dopuszczalne Stężenie* (highest acceptable concentration); AGS: *Ausschuss für Gefahrstoffe* (Committee on Hazardous Substances); DFG: *Deutsche Forschungsgemeinschaft* (German Research Foundation).

Table 21: Comparison between the results of Dares, IOM and Wriedt studies regarding the most relevant EU carcinogens and those in AWES (excluding radiation agents and shiftwork)

	Dares (2013)	IOM (2011)	Wriedt (2016)	AWES
1	Natural mineral oils	Mineral oils as used engine oils	Benzo(a)pyrene (mineral oils, used)	PAHs including Mineral Oils and Benzo(a)pyrene
2	Wood dust	Hard wood dust	Wood dust	Wood dust
3	Crystalline silica	Respirable crystalline silica	Quartz (crystalline silica)	Silica
4	Formaldehyde		Formaldehyde	Formaldehyde
5	Diesel exhaust fumes	Diesel exhaust	Diesel engine exhaust emissions	Diesel exhaust
6	Lead and its derivatives		Lead compounds, inorganic	Lead

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	Dares (2013)	IOM (2011)	Wriedt (2016)	AWES
7	Coal tar and its derivatives		Coal stream substances: Benzene, Benzo(a)pyrene, 1,3-Butadiene	PAHs including coal tar pitch
8	Aromatic hydrocarbons			PAHs
9	Halogenated and nitro hydrocarbons	1,2-Dichloroethane Nitroporpane	1,2-Dichloroethane	Chlorinated solvents
10	Chromium and its derivatives	Chromium VI	Chromium (VI) trioxide and other compounds	Chromium VI
11	Nickel		Nickel monoxide and other compounds classified as 1A/1B	Nickel
12	Asbestos and refractory ceramic fibres		Asbestos (chrysotile)	Asbestos
13	Metallurgical and electrometallurgical fumes			
14	Cobalt and its derivatives		Cobalt compounds classified as 1B	Cobalt
15	Trichloroethylene	Trichloroethylene	Trichloroethylene	Trichloroethylene
16	Aromatic amines		For example o-Toluidine	For example o-Toluidine
17	Various cytostatic agents			
18	Cadmium and its derivatives		Cadmium and compounds	Cadmium
19	Sintered metal carbides			
20	Benzene, perchloroethylene		Benzene Tetrachloroethylene	Benzene Tetrachloroethylene
21	Acrylamide	Acrylamide	Acrylamide	Acrylamide
22	Phenol-formaldehyde resins			
23	Vulcanisation fumes			
24	Arsenic and its derivatives		Arsenic trioxide and other compounds classified as C1A/1B	Arsenic

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Dares (2013)	IOM (2011)	Wriedt (2016)	AWES
25	Benzo(a)pyrene	Benzo(a)pyrene	PAHs including Benzo(a)pyrene
26	Hydrazine	Hydrazine	
27	4,4-Methylenedianiline (MDA)	4,4-Diaminodiphenylmethane (4,4-Methylenedianiline, MDA)	
28	Beryllium and compounds	Beryllium and compounds	Beryllium
29	Rubber process fume and dust	Rubber dusts and fumes: 1,3-Butadiene, <i>N</i> -Nitroso diethanolamine, <i>N</i> -Nitroso diethylamine, <i>N</i> -Nitroso dimethylamine, <i>N</i> -Nitroso di- <i>n</i> -propylamine	
30	1-Chloro-2-3 epoxypropane	1-Chloro-2-3 epoxypropane (epichlorohydrin)	Epichlorohydrin
31	1,3-Butadiene	1,3-Butadiene	1,3-Butadiene
32	Vinyl chloride monomer	Vinyl chloride	Vinyl chloride
33	Ethylene oxide	Ethylene oxide	Ethylene oxide
34	Refractory ceramic fibres	Aluminium silicate fibres (refractory ceramic fibres)	
35	o-Toluidine	o-Toluidine	o-Toluidine
36	1,2-Dibromoethane	1,2-Dibromoethane	
37	4,4-Methylene bis 2 chloroaniline (MbOCA)	2,2'-Dichloro-4,4'-methylenedianiline (4,4'-Methylene-bis(2-chloroaniline), MOCA)	MOCA
38	1,2-Epoxypropane	Propylene oxide (1,2-Epoxypropane)	
39	Bromoethylene		
40	Hexachlorobenzene		
41			Acid mists
42			Carbon disulphide
43			Diethyl/dimethyl sulphate
44		N-Nitrosamines: N-Nitroso diethanolamine, N-Nitroso diethylamine, N-Nitroso dimethylamine, N-Nitroso di- <i>n</i> -propylamine	Nitrosamines: N-Nitrosodimethylamine N-Nitrosodiethylamine
45		Polychlorinated biphenyls (PCB)	PCBs
46			Mercury
47		Leather dust	Leather dust
48			Environmental tobacco smoke

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Dares (2013)	IOM (2011)	Wriedt (2016)	AWES
49			Alcohol
50			Aliphatic solvents
51		Acetaldehyde (ethanal)	
52		Acrylonitrile	
53		Anthraquinone	
54		Butanone oxime	
55		tert-Butyl-4-methoxyphenol	
56		2-Chloro-1,3-butadiene (Chloroprene)	
57		α -Chlorotoluene	
58		C.I. Basic Violet 3	
59		C.I. Solvent Blue 4	
60		Poly[(aminophenyl)methyl]aniline (technical MDA)	
61		Dichloromethane	
62		1,2-Dichloropropane	
63		N,N-Dimethylhydrazine	
64		1,4-Dioxane	
65		2,3-Epoxypropyl methacrylate (glycidyl methacrylate)	
66		Gallium arsenide	
67		Glycidol (2,3-Epoxypropan-1-ol)	
68		Isoprene (2-Methyl-1,3-butadiene)	
69		Methylhydrazine	
70		2-Nitropropane	
71		2-Nitrotoluene	
72		2,3,4,7,8-Pentachlorodibenzofuran	
73		Phenolphthalein	

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Dares (2013)	IOM (2011)	Wriedt (2016)	AWES
74		Potassium bromate	
75		1,3-Propanesultone	
76		Quinoline	
77		Silicone carbide fibres	
78		Styrene oxide ((Epoxyethyl)benzene)	
79		2,3,7,8- Tetrachlorodibenzopara-dioxin	
80		Tetrafluoroethylene	
81		Titanium dioxide	
82		Tributyl O-acetylcitrate	
83		1,2,3-Trichloropropane	
84		Vinyl fluoride	
85			Alpha-Chlorinated toluenes

blank cells: not covered in study.

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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