EPHOR

Exposome tools for a healthy working life

Report on dynamic coding into for more meaningful categories for exposure assessment

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Summary

The present deliverable summarizes the work undertaken as part of WP4 of the EPHOR research project with the aim to develop more meaningful codes for exposure assessment when developing and using Job Exposure Matrices. This is performed by exploring the usefulness of two newly developed classifications by the European Commission: a) a classification that identifies and categorises the skills and competences that are relevant for the occupations of the EU labour market, the ESCO (European Skills, Competences, Qualifications and Occupations) classification and b) an updated and more detailed version of theISCO-08 (International Standard Classification of Occupations 2008 edition), the classification used to systematically identify and categorise occupations, against which the skills and competencies of a) have been mapped upon.

To achieve the above a stepwise approach has been developed which explores whether the information of skills included in ESCO can be used to identify the exposed job codes of ISCO-08. Two substances with different workplace exposure prevalences at a general population level are used as case studies: a) welding fumes and b) diesel exhaust exposure. The approach uses expert evaluations to first identify the skills/activities included in ESCO that are potentially exposed to the above agents. The developed list with the exposure assignments is then used to identify the jobs included in the updated ISCO-08 classification that are exposed to each of those agents. To allow an assessment of the usefulness of tasks in identifying exposed jobs, the results of this exercise are compared with those from exposure evaluations performed by the experts at the job categories included in the original and updated ISCO-08 coding systems blind to the underlying skills and their exposure status. The usefulness of the two new classifications on developing more meaningful job codes for exposure assessment is explored by their ability to identify sub-categories of the occupations included in the original ISCO-08 classification which by other means would be considered as unexposed. In a parallel approach the possibility of reducing the burden of the involved work by using only the tasks to identify exposed jobs is also explored. This involves removing an expert evaluation step that follows the linking of the exposed skills to the jobs and which intends to remove any arbitrary and inappropriate (i.e. non-exposed) entries.

Data analysis is performed using standard method agreement statistics including absolute proportions of agreement and weighted kappa coefficients.

All steps of the approach were implemented for welding fumes whereas for diesel exhaust only the evaluations using the ESCO classification system have been completed and are presented in the present deliverable. The results obtained thus far suggest that the newly classification systems may have the potential of contributing to the development of more meaningful codes for exposure assessment using JEM in general population studies. Some limitations of the system including the lack of information on skills required by the traditional 1-4-digit job codes included in the original ISCO classification and high labour requirements for developing the classifications are highlighted. However, since differences in the prevalence of exposure among job categories are important, the results of the evaluations for diesel exhaust will also be needed to draw more appropriate conclusions. Once obtained, the combined analyses results will be used to develop relevant lessons learned material with the results being communicated further through publication in the peer reviewed literature.

1. Introduction

Occupational exposures are major contributors of non-communicable diseases (NCDs), particularly cancer, cardiovascular, respiratory, musculoskeletal and neurodegenerative diseases (1). It is estimated that the contribution of occupational exposures to these diseases is of a similar magnitude to general environmental risk factors, such as urban air pollution and obesity (2, 3). The *working-life exposome* is a recently introduced concept in exposure science that refers to the totality of occupational and non-occupational exposures of individuals during their lifetimes, and how those exposures relate to their health.

The EPHOR project aims to develop methods that can be used when applying the exposome concept to improve working-life health through research. Among these methods is the development of a toolbox which will essentially provide researchers and policy makers with a) innovative methods for collection, storage and interpretation of working-life exposome data, including its economic and societal impact, b) tools for expanding the current knowledge base on the exposome in relation to health, c) tools for obtaining data and information to develop evidence-based and cost-effective preventive actions and policies and d) better and more complete knowledge on how multiple exposures within the working-life exposome are related to the occurrence of NCDs.

The establishment of innovative methods for collection, storage, and interpretation of working-life exposome data (covered in WP1-4) includes the development and adoption of a data management and analytics platform capable of storing, bringing together and analysing data from multiple locations/countries and exposome technology platforms (WP4). As part of this process new data interpretation methods are also to be explored and developed including more flexible approaches for coding of jobs (T4.2.5). The objective of this activity is to develop more meaningful codes for exposure assessment using Job Exposure Matrices. The present document provides an overview of the underlying issue, summarizes the methods, and presents and discusses the first analysis and results of the work that has been thus far performed of the scientific team towards achieving this objective. A summary of the remaining steps is also provided.

2. Aims and objectives

The overall aim of WP4 is to develop a data management and analytics platform capable of storing, bringing together and analysing data from multiple locations/countries and exposome technology platforms, in accordance with the FAIR guidelines (findable, accessible, interoperable and reusable). This is to be achieved through the following sub-objectives:

a) By adopting a data management and analytics platform for bringing together and storing existing and new data (T4.1),
b) By developing new methods for handling multiple exposures in exposure response analyses (T4.2.1),
c) By compiling an inventory of existing exposure time response models (T4.2.2),
d) By adopting, further developing and applying to the mega cohort hierarchical regression methods (T4.2.3),
e) By improving methods for automated coding of free text fields in occupational histories into job coding through the use of Artificial Intelligence (AI) approaches (T4.2.4),
f) By developing improved coding systems for more flexible coding that allows for different coding structures depending on the risk factor (T4.2.5), and
g) By quantifying the internal biological pathways in relation to the external exposome (T4.2.6).

The present deliverable deals with objective (f) above and summarizes work undertaken to explore whether information on working activities/skills can improve exposure assignment for the purpose of the development of JEMs. This is performed by exploring the usefulness of two newly developed classifications by the European Commission: a) a classification that identifies and categorises the skills and competences that are relevant for the occupations of the EU labour market and b) an updated and more detailed version of the International Standard Classification of Occupations 2008 edition against which the skills and competencies of a) have been mapped upon.

Within the present deliverable we provide details of the data resources involved, the methods implemented, the individual steps taken to achieve this and the results until to date. A discussion surrounding the usefulness of the approaches, its limitation and any future implementation is included as it is also a description of the remaining and future steps.

3. Job Exposure Matrices (JEM) - an introduction

3.1 Definition

Job exposure matrices (JEMs) are a useful, efficient and generally unbiased method for assessing exposure, particularly when no individual level exposure data are available. JEMs are essentially cross-tabulations of job titles with indices of exposure to one or more exposure factors (5). In their simplest form, JEMs include only two axes, one consisting of job titles and the other providing parameters that indicate in a binary format (yes/no) whether or not people who have a certain job title are exposed to a specific substance or a physical, musculoskeletal or psychosocial factor. In more complicated forms this binary exposure metric can be replaced by estimated levels of intensity that are experienced by workers that are expressed either in a semi-quantitative (e.g., using a fixed set of values such as no, low, medium or high) or fully quantitative (e.g., by providing exposure concentrations of each substance) manner. Further axes accounting for parameters which may influence the levels of exposure between jobs – e.g. the probability of exposure, the uncertainty surrounding an exposure level estimate or a multiplier that accounts for changes in exposure levels across time. An example of a JEM is shown in Table 1.

Table 1. Example of a simple theoretical JEM that covers different exposure factors and exposure metrics

Job title	**Exposure factor**					
	X	**y**	**z**	**e**	**f**	**g**
Welder	7.2	100.1	565	High	Yes	55
Joiner	3.6	256.5	846	Medium	No	58
Process operator	2.1	356.3	253	High	No	68
Secretary	0.7	17	0	Low	No	0
Chief executive	0	15	0	Low	No	0
Brick layer	2.1	563.6	963	Low	Yes	69

Typically, JEMs are developed using expert judgement, self-reported data, exposure measurements, statistical modelling or a combination of these. The choice of the type of exposure estimate and/or metric used in the JEM will commonly depend on the data and resources available to its developers. In absence of quantitative exposure measurements, a JEM will usually be developed based on either self-reported information or a case-by-case assessment of the job categories by domain experts, ideally using standardized protocols that involve multiple assessors. It is highly desirable to seek agreement between the assessments of the experts involved through a consensus process, as this will usually improve the quality of the JEM.

3.2 Job and industry classification systems and the issues that raise from their use

In JEMs that are intended to be used in general population studies it is typical that job titles (i.e. the *y* axis on Table 1) consist of broad occupational categories. Usually these categories are coded according to a well-defined a coding system of job classifications, such as the International Standard Classification of Occupations (ISCO) or the Standard Occupational Classifications (SOC) (4, 5) Occasionally, JEMs may also include industry information, which is classified using coding systems such as the International Standard Industrial Classification of All Economic Activities (ISIC) or the European Nomenclature of Economic Activities (NACE). These classifications are essentially tools for organizing existing occupations or industries into clearly defined groups according to a series of specific characteristics.

Within such coding systems occupations are typically first grouped into some major categories based on the level of skills (i.e. level of formal education, nature of work, underlying training) required to perform a job. Normally 8-10 major categories are defined at this level. Then and within each of those major categories, occupations are categorised into more specific categories (usually 3 to 4 more levels) based on certain aspect of the skill specialisation required. This may reflect to the typical tasks performed, their nature and requirements (e.g. need for physical strength), the material involved and/or the resulting product. An example of the hierarchical system implemented within ISCO-08 is provided in Table 2 below.

Table 2. Example of the hierarchical structure of classifications systems using codes from the ISCO-08 coding system.

Goup	Job code	Label
Major group	3	Health Associate Professionals
Sub-major group	32	Medical and Pharmaceutical Technicians
Minor group	321	Medical Imaging and Therapeutic Equipment Technicians
Unit group	3211	Health Associate Professionals
	3212	Medical and Pathology Laboratory Technicians
	3213	Pharmaceutical Technicians and Assistants
	3214	Medical and Dental Prosthetic Technicians

3.3 Issues raising from using standardized classification systems in JEMs

Amid their intended purpose of development, occupational classification systems are used to register job titles of individuals persons or businesses within records of their employers, tax offices, statistical or labour services, and/or other government registers. Their existence is very beneficial for services as it allows linkage to other registered data such as but not limited to income, mortality, production characteristics etc allowing thereby the description of ongoing or previous trends in economic, social and/or health characteristics.

In occupational exposure assessment the grouping included in these classification systems are typically linked with specific exposures in a standardized way. This could involve for example

the assignment of a level of exposure for specific agent per occupation on the basis of the opinion of experts or the results of empirical statistical models that involve the collection and analysis of measurements in the workplace. Although this exposure assignment is generally unbiased when applied to occupational histories and enhanced by the transformation of classical measurement errors to Berkson's errors (5), the approach bears several limitations.

First, due to the concepts underlying the development of those classification systems the resulting occupational groups tend to frequently comprise of a large number of diverse occupations in terms of the activities and processes involved. Such occupations are frequently performed as part of very heterogeneous settings across different sectors or under processes that involve different materials, substances, and/or technologies. For example, code 8223 "Metal finishing-, plating and coating machine operators" of ISCO-88 contains more than 25 listed jobs including anodisers, fetters, painters, sprayers, caster operators, polishers, laminators, and sandblasters; occupations that though part of finishing activities they involve different exposure scenarios including tasks, processes and substances involved. Such differences are among well documented important determinants of the exposure resulting in the ISCO defined occupational groups being heterogeneous in terms of the exposure profiles of the workers their correspond upon (i.e. containing jobs that are both exposed and non-exposed to an exposure agent of interest). Thereby JEMs that are based on occupational classifications generally ignore these differences in exposures within jobs.

Moreover, periodic innovation, legislation and technological changes lead to alternations on the job and industry landscape with new materials, processes and jobs being introduced. Similarly, due to the same changes processes and occupations can become less prevalent or even obscure. To account for such labour market changes coding systems need to be updated periodically (usually every ~10-20 years). However, such updates are not made with the underlying exposure profiles in mind and thereby jobs which are important for a substance-specific JEM may end up being combined in much broader occupational groups with completely different exposure profiles. Because of this and the improved granularity for occupational exposure assessment offered compared to subsequent ISCO versions, the ISCO 1968 edition is still largely used for coding occupations in epidemiological studies.

Essentially the above complicate the assignment of exposure during estimation and increase the risk for misclassification of the exposure. This misclassification, although non-differential, when present will tend to bias risk estimates towards the null.

4. An alternative approach

When assigning exposure estimates at a group level, such as a job title, we assume that all the persons belonging to the group have the same profile of exposure. This is not always right and in exposure assessment it is broadly recognised that the variation in exposure between individuals belonging to a specific group will increase with an increased level of aggregation. This means that the exposure variation will be expected to be higher among workers belonging to the same industrial sector group than among workers belonging to the same job title group. Still, as noted earlier, job titles do not form ideal grouping parameters since workers with the same job title may work in different sectors, in different processes that involve different raw materials, intermediates, exposure sources and working activities (i.e. tasks).

Working activities are well-documented strong predictors of chemical and physical workplace exposures. In exposure assessment for epidemiological studies use of activities for assigning exposure has been suggested as an alternative approach to job classifications that can lead to reduced variability and misclassification in exposure characterisations (6, 7). Thereby efforts to develop tools for exposure assessment based on activities have been previously undertaken albeit on a very limited scale and without the use of standardised approaches (6-10).

The recent development and availability of the European Skills, Competences, Qualifications and Occupations (ESCO) classification by the European commission offers a unique opportunity to try to improve the classification system used within new and existing JEMS for epidemiological analyses in a standardised and systematic manner. ESCO provides a systematic categorisation of skills, knowledge and competences which are linked to an updated version of the ISCO-08 job coding system. Provided that skills and competences are inherently linked to the ability to perform specific activities during work the presence of a systematic classification of skills/activities that are directly linked to a more detailed classification list of job titles may enable a much more refined, straightforward, and unbiased approach for assessing exposure within general population studies.

4.1. The European Skills, Competences, qualifications and Occupations (ESCO) classification system

The European Commission has created ESCO (European Skills, Competences, Qualifications and Occupations), a classification for describing, identifying and classifying professional occupations and skills relevant for the EU labour market and education and training (https://esco.ec.europa.eu/en). ESCO provides descriptions of 3,007 occupations alongside 13,890 skills linked to these occupations, translated into 28 languages (all official EU languages plus Icelandic, Norwegian, Ukrainian, and Arabic).

Each of the 3,007 ESCO occupations is mapped to exactly one ISCO-08 code. ISCO-08 can therefore be used as a hierarchical structure for the occupations pillar. ISCO-08 provides the top four levels for the occupations pillar whereas ESCO occupations provide further refinement with two to four additional levels added to the ISCO-08 codes (i.e. 5-8 digit codes provided instead of 4 digits as in the original ISCO-08) – hereafter this updated version of the ISCO-08 classification will be called the ISCO-08+ classification.

The 13,890 skills are individually mapped as either essential (i.e. those that are usually relevant for an occupation, independent of the work context, employer or country) or optional (i.e. those that may be relevant or occur when working in an occupation depending on the employer, working context, or country) for relevant ESCO occupations. For instance, the skill “drive vehicles” is labelled as an essential skill for occupations including parking valet and private chauffeur, and an optional skill for occupations such as street sweeper and vehicle technician.

An example of the hierarchical classification of jobs including the relevant skills, knowledge and competences is shown in Figure 1 below.

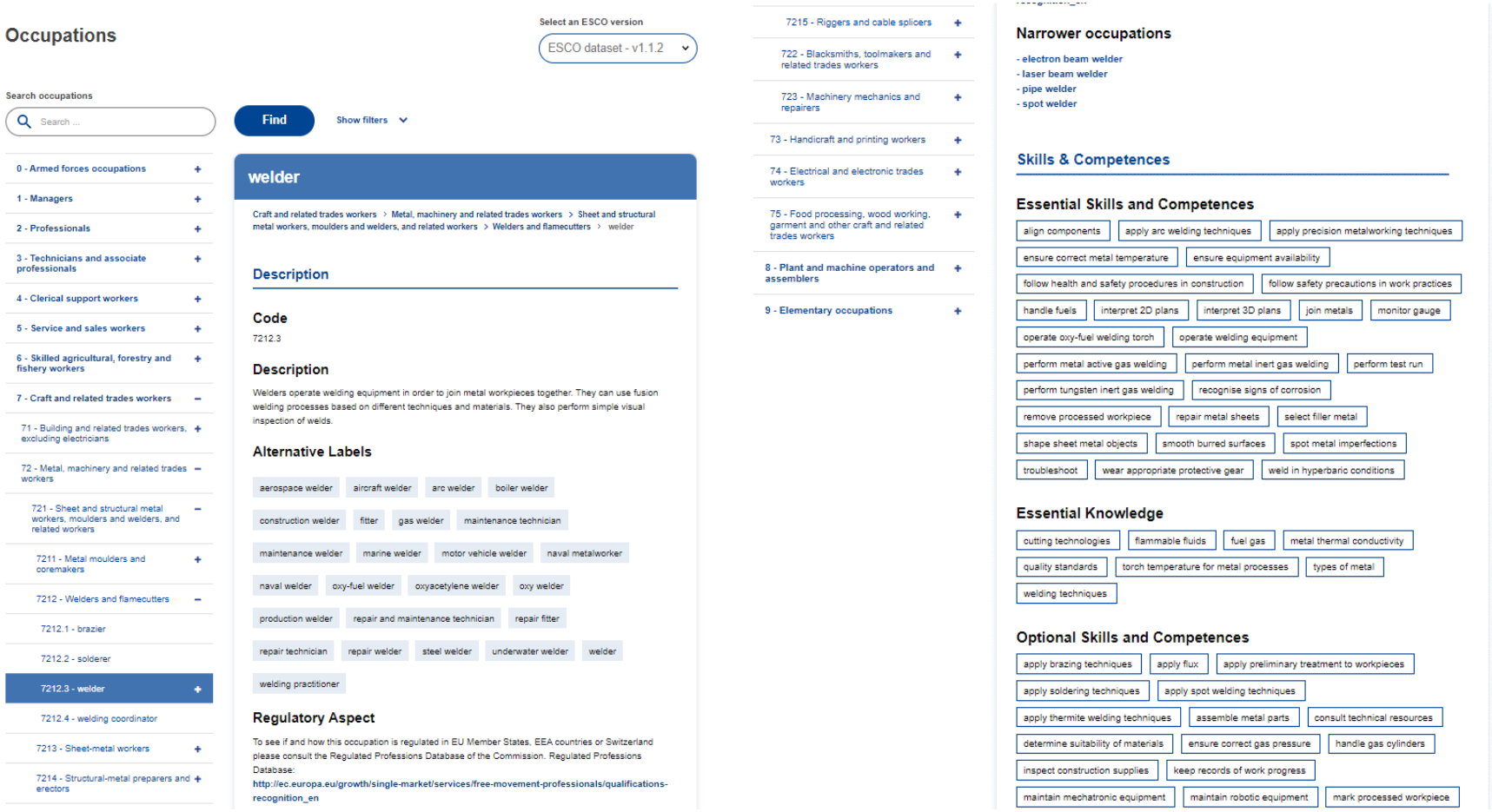

Figure 1. Example of the hierarchical classification of occupations and relevant skills within ESCO .

4.2 Using the ESCO classification system to refine JEMs

As noted above, the presence of ESCO offers a unique opportunity to try to improve the classification system used within new and existing JEMS for epidemiological analyses. More specifically, by looking for specific skill requirements relevant to a specific workplace exposure one can identify job codes or listed jobs within codes of the classification system that otherwise would be considered as unexposed. Similarly, by looking for the absence of relevant skills to the exposure of interest one can identify any non-exposed listed jobs within a job code.

In a more simplistic way the above can be described as two individual but closely linked working approaches:

a) Skills/activities are used as the basic unit for exposure assignment and/or JEM development/refinement. In this approach, skills where exposure to a specific agent is relevant are first identified. Occupations for which the skill/s is/are relevant can then be identified and clustered as required. For existing JEMs a comparison of the results of this exercise with the assigned as exposed categories of the JEM can show us whether refinement of the JEM is required. Exposure levels/scores can also be assigned either at the skill level or by using an algorithm where contributions from different skills can be taken into account into an occupation level (4-8th digit). This approach we defined as the "bottom-up JEM development /refinement approach" and can be also very useful in identifying exposed jobs that otherwise may have been missed or hidden within larger unexposed job codes.
b) Occupations are first used as the basic unit for exposure assignment and/or JEM development/refinement. In this approach you start from the ISCO 4-digit codes and whenever available their refined 5 to 8 digit codes. Skills attached to each job code are used to further refine the exposure assessment grouping and subsequently, if desirable, to also assigned exposure level/scores. If results are compared with an existing JEM through this approach we can identify the need for splitting exposed JEM codes due to the presence of unexposed jobs within them or due to differences in exposure. This approach we defined as the "top-down JEM development /refinement approach".

Although that each of those approaches can be implemented as stand-alone, maximum benefits can likely be achieved when both approaches are implemented together as part of the JEM development or refinement process. When concerning the refinement process the results of the two approaches when combined can be used to decide whether the JEM needs be updated or not.

It also needs be noted that any refinement according to one of the above approaches can be useful only if the resulting modified coding system and/or JEM is applicable to the job histories of cohort study participants. This implies that any JEM or Task Exposure Matrix (TEM) resulting from the process can be used in existing cohorts only if the required information is available and the task of recoding the data is undertaken. For future studies the resulting classifications can serve as a guide for the collection of the required job history data.

4.3 The methodological working steps

To evaluate the usefulness of the ESCO and of its new more detailed ISCO-08+ coding system on improving coding systems for exposure assessment of epidemiological studies we have undertaken a pilot exercise based on the following two exposure factors: a) welding fumes and b) diesel exhaust. These substances are selected since both are important exposure agents and are both relatively easily to assess in terms of exposure within workplaces. Previously it was highlighted that the number of people with the job title "welder" is much smaller (11 million workers globally) than the number of people who routinely or intermittently weld during (~ 110 million workers globally) – an argument that generally supports the use of the welding activity instead of the corresponding job title in identifying exposed workers (11). In addition, diesel exhaust is represented in the EUROJEM (the exposure tool that is being compiled within EPHOR) with a previously elaborated JEM that combined expert opinion with literature assessments (12). The availability of this earlier JEM provides us with a unique opportunity to try to benchmark a JEM developed based on the skills/tasks and competences and the linked ISCO-08+ classification used within ESCO against a JEM that has been developed based on the more “traditional” method of using a version of the ISCO coding system.

The specific working steps followed to achieve the underlying objectives are summarised in Figure 2 and described in more detail below.

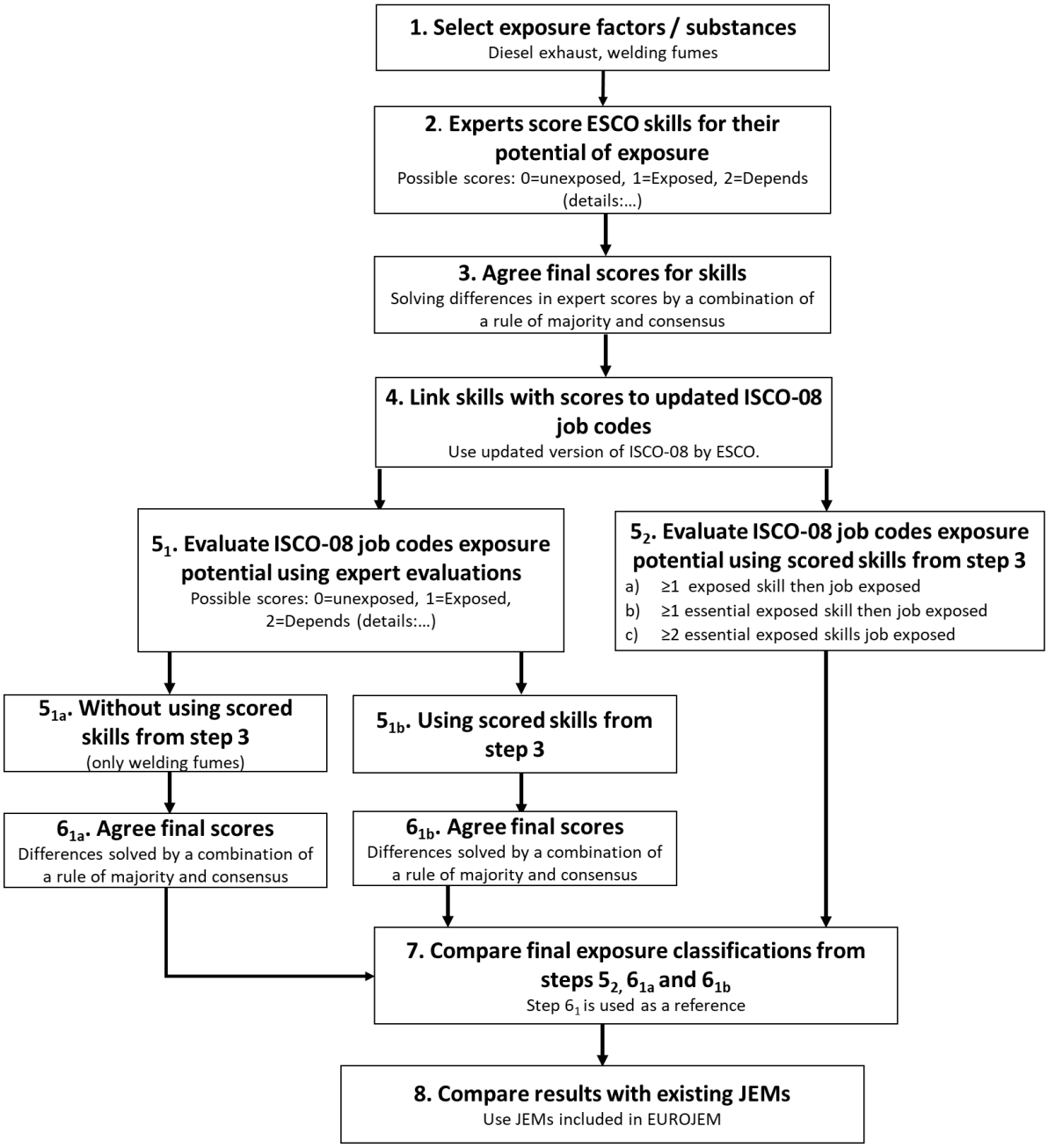

Figure 2. Flow chart describing the process for evaluating the potential for improving for improving coding systems for Job exposure matrices.

The first step in the process (i.e. **Step 1**) focuses on selecting the substance/s to be used in the exercise. As noted earlier in our case these substances comprise of welding fumes and diesel. Following substance selection, the actual evaluation process commences starting with the earlier described bottom-up approach (**Step 2**). In this approach the list of skills/activities/competences in ESCO associated to the exposure/s of interest are scrutinised. The aim is to assess the likelihood of exposure during a specific skill/activity or competence by assigning a score to each activity according to the following:

Score	Label	Definition
0	Unexposed	Skill/activity is unexposed under any condition (i.e. industry)
1	Exposed	Skill/activity is exposed under any context/condition
2	Depends	Exposure during skill/activity depends on the context/conditions present

For a score of 2 to be assigned the conditions/context needed to be important and be made clear. For example, when considering exposure to wood dust an unlikely exposed skill/activity under any conditions will represent office work (score=0). Logging will represent on the contrary a likely exposed skill/activity in all conditions (score=1) whereas sweeping will be a relevant skill/activity for wood dust exposure only when the worker involved is employed in a wood processing industry, furniture manufacturing, and construction (score=2). In the latter case, the condition that exposure may depend on the industry involved needs be noted alongside the assigned score of 2. Other important context/conditions that could be considered may reflect to the environment performed and/or the material involved. Three experts were involved in independently scoring/rating the included skills/activities according to the above criteria.

Definitions

Welding refers to a process that melts the base materials during the process of joining them. This is distinctly different from brazing and soldering which work in lower temperatures and fill the gap by melting another substance. Thereby, and considering that the IARC evaluations do not cover other hot processes we assessed the likelihood of exposure to welding fumes only when welding was performed and not during brazing and soldering. Brazing and soldering skills and activities were considered as non-exposed.

For diesel we assess the likelihood of exposure during an activity or skill with a reference for the evaluations on the period between the late 2000 and early 2010s (i.e. 2005-2010). This is because of the introduction of new diesel engines in 2007 which resulted in reductions in emission levels. These reductions were evident though mostly in later years given the time required for the existing fleet of vehicles to be replaces whereas assessment of historical exposures is also relevant for JEMs including for any comparisons we need make with existing JEMs (see **step 8** below). Average background levels of Elemental carbon (EC), the most representative marker for diesel exhaust exposure, in this and the preceding period are reported to typically be in the range of 1-5 μg EC/m^3. Skills and activities that require prolonged exposure to outdoor environmental exposures (e.g. traffic control) are typically considered as exposed. The same applies also for activities like selling hot-dogs on the side of the road or cycling as part of work (e.g. for distributing leaflets, or food delivery). On the contrary activities like roofing which could be performed in near proximity to a busy road but most commonly are not we consider them as unexposed. The same applies for activities that involve desk evaluations, office work etc. For the shipping industry, work onboard ships is considered as unexposed to diesel considering that most ships are using marine grade diesel fuel which is typically different that diesel used in cars and smaller engines. On the contrary exposed in the docs can be likely depending of course on the involved tasks. Work in Power stations also considered non -exposed since power stations typically use heavy oils for fuel.

Once skills have been scored according to the above criteria by all experts then any disagreements between the assigned scores by the experts are removed (**step 3**). For this, and to relax the burden of work, final scores were decided by a combination of a majority rule and a consensus agreement. In this process the exposure ratings of "depends" were used as identifiers of cases for further evaluation in the consensus process. In this process, a final classification of two possible scores was applied: exposed (score=1) or unexposed (score=0). The process for reaching the final scores is described below.

First a comparison of the scores of the three experts was performed and a preliminary final score was assigned as follows:

- When the same exposed (score=1) or unexposed (score=0) score has been assigned by all 3 expert raters then this was the score assigned to the skill in question.
- If one of the experts rated the skill as unexposed and the other two agreed that it is exposed (score=1) then the majority score was applied.
- If one of the experts rated the skill as unexposed and the other two agreed that it depends (score=2) then a discussion to reach consensus for final score was held.

- If two of the experts rated the exposure for the skill as "depends" (score=2) and one rated the skill as exposed (score=1) then then a discussion to reach consensus for final score was held.
- If two of the experts rated the skill as exposed (score=1) and one rated it as "depends" (score=2) then a discussion to reach consensus for final score was held.
- If two of the experts rate the skill as non-exposed (score=0) and one rated as "exposed" (score=1) or "depends" (score=2) then a discussion to reach consensus was held.
- In all other cases of disagreement (including e.g. when one says unexposed, one exposed and the other depends), a discussion to reach consensus was held.
- All consensus decisions favoured specificity over sensitivity – i.e. an unexposed score was assigned when skills were unclear, referred to generic knowledge etc.

We subsequently linked the list of skills associated to the exposure of interest with the ISCO-08+ coding system developed by ESCO (**Step 4**). The combined list was then used to identify 5-8 digit ISCO-08 that were exposed to the agent of interest based on whether or not workers in the specific occupation performed an activity where exposure was likely. Essentially this exercise resulted in the development of a number of new JEMs comprising of two axes: a) a job axis based on ISCO-08+ and b) a binary exposure axis (yes/no) for the exposure factor of interest.

We used two separate approaches to develop these JEMs:

a) one that involved expert evaluations at the job code level (**Step 5_1**) and
b) one that did not involve expert evaluations at the job code level (**Step 5_2**)

Under the first sub-step approach (**Step 5_1**) experts are evaluating whether a job code is exposed according to the following criteria:

Table 3. Criteria for evaluation exposure status of the individual ISCO-08 job codes.

Criterion	Defintion
1	The exposure to the factor of interest occurs and is not coincidental (i.e. infrequent – less than 1-2 a week for a short time).
2	At least half of the workers belonging to the job code are non-coincidental exposed to the factor of interest.
3	The exposure to the factor of interest, when it occurs, is above background. For diesel we define background levels of Elemental carbon (EC), the most representative marker for diesel exhaust exposure, as in the range of 1-5 µg EC/m3 based on results in the period of late 200 and early 2010.

On the above "coincidental expose" is defined as any exposure that is infrequent (i.e. less than 1-2 a week for a short time), not resulting from performing the exposed activity in person or by working very closely to a person that does so. For example when assigning exposure according to this criteria a foreman in the wood industry will be exposed to wood dust since he will be working closely to sanders and process operators whereas on the contrary a clerk will not be expose to wood dust even though he may enter the workplace as this will take place only

coincidentally. A CEO in the same wood factory would also be considered as unexposed according to these criteria despite that they may seldom walk the floor of the factory and thereby be exposed to wood dust. Similarly, a farmer may perform welding as part of his working activities. Although that this is an activity that can lead to direct exposure to welding fumes, it is highly unlikely that it will be performed by the farmers frequently enough to be considered as resulting in meaningful long term exposure estimates (i.e. at least 1-2 times a week as discussed above). Thereby, farmers according to the above should also be considered as unexposed to welding fumes.

For diesel jobs for which exposure may be above background levels but is of limited time and infrequent was considered as non-exposed. For example a hot dog stand seller will be considered as exposed as these usually put their canteen or stand near road with heavy traffic (e.g. highways) or in places where event are taking place where in general diesel exposures will be present. The same applies for a delivery or distribution workers using bicycles. On the contrary a roofer although that they may work near a busy road this may not take place frequently whereas they tend to always work in elevated highs. As a consequence and lower likelihood of exposure a roofer will be considered as non-exposed according to this criteria.

Nevertheless, for the above we first commence with the top-to-bottom approach (**step 5$_{1a}$**) and assign an exposure status for the exposure factor of interest blind to the evaluation performed for the individual skills (**step 3**) to all the occupations included in ISCO-08+. This step is essential to allow, among others, the sensitivity of assigning exposure status based on whether or not a job code is linked to an exposed skill or activity to be evaluated. Considering the size of the evaluation involved however we restricted this step only on the factor of welding fumes and performed separately for the 1-4 (original) and 5-8 (ISCO-08+) digit codes of the ISCO-08 classification.

Exposure assignment is independently performed by three experts using the following exposure scores, i.e.:

Score	Label	Definition
0	Unexposed	Job code is unexposed under any condition (i.e. industry)
1	Exposed	Job code is exposed under any context/condition
2	Depends/uncertain	Exposure depends on condition or status is unclear

Any disagreement between experts, similarly to the assessment for skills/activities were addressed through a combination of a majority rule and a consensus agreement (**step 6$_{1a}$**). Specifically:

- When the same exposed (score=1) or unexposed (score=0) score has been assigned by all 3 expert raters then this was the final score assigned to the job code.
- If one of the experts rated the job code as unexposed and the other two agreed that it is exposed (score=1) then the majority score was applied.
- If two of the experts rate the skill as non-exposed (score=0) and one rated as “exposed” (score=1) then a discussion to reach consensus was held.

- All other cases of disagreement (including when uncertainty was noted) were solved through a discussion to reach consensus.
- All consensus decisions favoured specificity over sensitivity – i.e. an unexposed score was assigned.

Following this assessment, the experts were asked to repeat their evaluations for the ISCO-08 but this time after looking on the skill/activities underlying the specific jobs (**step 5_{1b}).** This step was performed only on the 5-8 digit occupational codes of the ISCO-08 classification (i.e. ISCO-08+) since ESCO does not link the skills classification to the original 1-4 digit occupational codes. All job codes with at least an exposed skill/activity were reviewed according to the criteria described in Table 3. If one or more of those criteria were not fulfilled then the exposure score for the job code was overwritten with zero and the job code was considered as unexposed. Any disagreements between the experts are addressed through a combination of a majority rule and a consensus agreement (**step 6_{1b}**) on the same manner as in **step 6_{1a}**.

In the second approach (**step 5_2**) the exposure status of job codes was assessed solely based on the results of the assessments at the skill/activity classification level (**step 3)** and without any further quality control. This approach does not involve any expert assessments at the job code level for quality control or adequacy. The intent is to use these assessments to evaluate whether assigning exposure to jobs using only the results of the assessments for skills/activities leads to meaningful exposure assignments. Three different methods to assign exposure scores to the job titles are applied based on the number of exposed skills/activities and their importance (i.e. whether they are essential or optional) for the job title. Specifically:

Method 1: To be considered as exposed a job code need to be linked to at least one exposed skill/activity. The importance of the skill/activity (i.e. whether is essential or optional) to the job is irrelevant. We call this method "ESCOJEM-1".

Method 2: To be considered as exposed a job code needs to be linked to at least one exposed skill/activity that is essential for it. We call this method "ESCOJEM-2".

Method 3: To be considered as exposed a job code needs to be linked to at least two exposed skills/activities that are essential for it. We call this method "ESCOJEM-3".

Following this, the final exposure assignments that have been developed across the different methods are compared between them (**step 7**). This is performed using standard statistical approaches for agreement analyses (see section 4.4 below). In these comparisons the assignments established under the sub-**step 5_1** – i.e. those including a re-evaluation by an expert are used as the reference to allow for the assessment of the meaningfulness of assigning exposure solely based on the skills/activities involved and without any quality control (i.e. evaluations derived from **step 5_2**). In a final exercise (**step 8**) the delivered evaluation for diesel, essentially a new JEM, under step **6_{1b}** is compared to the existing diesel exhaust JEM included in EUROJEM. Since the two JEMs have been developed using different versions of the ISCO classification system these comparisons are completely theoretical and focus on evaluating the benefits and limitations of using the ESCO classification system when assessing exposure. The results are also to be used to assess whether the existing JEM needs to be updated and to develop a relevant "lessons learned" material.

4.4 Completed and summarised work

Within the allowed working timeline steps 1-4 of Figure 2 have been completed in full for both selected exposures, i.e. diesel exhaust and welding fumes. However, given the large number of expert evaluations and consensus meetings involved, the research team was unable to complete steps 5-7 for diesel exhaust within the same working period. The present deliverable thereby summarises all required analyses results for welding fumes only. For diesel exhaust, a description and a complete evaluation of step 4 is presented and summarised instead.

4.5 Statistical analysis

Simple descriptive statistics are used to describe the scores assigned to the individual job and skill/activity codes included in the ESCO classification system. To evaluate the reliability and agreement between experts across the different steps we use three indicators:

a) an overall agreement score raging in values from 0 (0%) to 1 (100%) with the latter suggesting total agreement.
b) a weighted kappa coefficient with results classified as poor (<0.20), fair (0.21–0.40), moderate (0.41–0.60), good (0.61–0.80) and excellent (0.81–1) agreement.

Weighted kappa coefficients and proportions of overall agreement were also calculated as a the measures of inter-method agreement when comparing the different exposure assignments resulting from steps 5_1 and 5_2.

The ESCO and ISCO-08+ usefulness on developing more meaningful job codes for exposure assessment was explored by its ability to identify fifth to eight digit sub-categories of occupations that are exposed to diesel and welding fumes and for which the original fourth digit code of the ISCO-08 system was unexposed.

Analysis was performed with SAS (Statistical Analysis System) software v 9.4.

5. Results

As noted above thus far we have completed all required work for the welding fumes up to step 7 whereas for diesel exhaust we are currently processing step 5_{1b}. In the following sections we present the results starting from the agreement analysis of the exposure assignment process that uses the newly developed skills/activities classification (steps 2 and 3). Then the results of the assignment process using expert evaluation for welding fumes is presented (steps 5_1 to 6_1) followed by a summary of the assignments based solely on the assessment of skills (step 5_2). A comparison of the welding fumes assignments that involved expert evaluations follows (step 6_{1a} and step 6_{1b}). The sections closes with a summary of the comparisons of the assignment for welding fumes developed solely based on exposed skills/activities against the assignment developed based on the approach combining skills/activities with an expert evaluation (step 6_{1b}).

5.1 Evaluating the likelihood of exposure of skills/activities included in ESCO

5.1.1 The individual assessments (Figure 2, step 2)

Table 4 describes the distribution of scores assigned by the three experts across the 13,962 skills/activities codes included in the ESCO classification system for both welding fumes and diesel exposures. As it can be seen from Table 4, the three experts scored approximately 0.3-0.5% of all skills as exposed or potentially exposed (i.e. depends) for welding fumes. For diesel exhaust however the distribution of scores was somewhat different between experts with expert 2 scoring less skills/activities as exposed or potentially exposed compared with the other two experts involved in the process (1.1 vs 2.6 and 3.5 for experts 2, 1 and 3, respectively). It worths being noted that expert 3 very seldom used the coding "depends".

Table 4. Distribution of assigned exposure scores for welding fumes and diesel exhaust by the three experts across skills/activities included in the ESCO classification system.

Assigned exposure score	**n (%)**		
	Expert 1	**Expert 2**	**Expert 3**
Welding fumes			
0 = Non-exposed	13,850 (99.2)	13,904 (99.6)	13,892 (99.5)
1 = Exposed	22 (0.2)	35 (0.3)	70 (0.5)
2 = Depends	11 (0.1)	23 (0.2)	0 (0.0)
Total	13,962 (100)	13,962 (100)	13,962 (100)
Diesel exhaust			
0 = Non-exposed	13,589 (97.3)	13,805 (98.9)	13,463 (96.4)
1 = Exposed	174 (1.2)	27 (0.2)	493 (3.5)
2 = Depends	199 (1.4)	130 (0.9)	6 (0.0)
Total	13,962 (100)	13,962 (100)	13,962 (100)

Table 5 summarises the agreement analysis results overall and among the different pairs of experts. Overall, no pair of experts showed considerably different Kappa compared with remaining expert pairs. According to the estimated Kappa coefficients there was moderate overall agreement for welding fumes and fair overall agreement for diesel exhaust. According to estimated Kappas agreement between individual pairs of experts was moderate only for expert 1 and 2 for welding fumes. The rest of the comparison showed fair to low agreement based on the estimated Kappas. However, when looking at the estimated absolute agreement scores these were consistently values above 0.95 suggesting that experts agreed in the vast majority of the job codes being assessed.

When performing sensitivity analysis by dichotomising the assigned scores to unexposed (score=0) and potentially exposed (score 1 or 2) then the estimated overall kappa coefficients (95% CI) for diesel exhaust somewhat increased to 0.283 (0.255-0.310) whereas for welding fumes they remained similar with a value of 0.414 (0.312-0.516) suggesting that the small prevalence of exposed codes could potentially impact on the estimated kappa coefficients results (13, 14).

Table 5. Agreement scores and kappa coefficients overall and per pair of experts. Assessment involve 13,962 skill/activity codes included in the ESCO classification system.

Exposure parameter	Aggreement		Kappa	
	Value	95% CI	value	95% CI
Welding fumes				
Expert 1 vs Expert 2	0.997	0.967-0.969	0.431	0.307-0.554
Expert 1 vs Expert 3	0.995	0.956-0.958	0.349	0.239-0.459
Expert 2 vs Expert 3	0.994	0.959-0.962	0.302	0.207-0.397
Overall	0.995	0.961-0.963	0.377	0.279-0.474
Diesel exhaust				
Expert 1 vs Expert 2	0.968	0.965-0.971	0.151	0.109-0.193
Expert 1 vs Expert 3	0.957	0.954-0.960	0.313	0.279-0.348
Expert 2 vs Expert 3	0.961	0.957-0.964	0.193	0.158-0.228
Overall	0.962	0.959-0.965	0.209	0.186-0.232

CI=confidence interval

5.1.1 The consensus results (Figure 2, step 3)

Table 6 describes the distribution of exposed and unexposed skills/activities following the consensus agreements between experts. Overall, only sixty-four (0.4%) of the 13,942 skill/activity codes included in ESCO were evaluated as exposed to welding fumes by the experts whereas the corresponding number for diesel was 508 (3.6%).

Table 6. Distribution of exposed and non exposed skill/activity codes following the consensus agreement between the involved experts.

Assigned exposure score	Welding fumes		Diesel	
	n	%	n	%
Non-exposed	13,898	99.6	13,455	96.4
Exposed	64	0.4	508	3.6
Total	13,962	100	13,962	100

A description of all 64 skills/activities evaluated as exposed to welding fumes by the experts following the consensus meeting is shown in table 7 below. The original scores assigned to the skills/activities by the experts are also shown. Amid the size of the skills/activities involved the corresponding list of exposed skills/activities for diesel exhaust are not shown in the present.

Table 7. Description and original exposure scores assigned by the expert for the 64 ESCO (European Skills, Competences, Qualifications and Occupations) skills/activities identified as exposed to welding fumes following the consensus meeting.

Skill group	Main label preferred for skill	Skill description	Assigned score		
			Expert 1	Expert 2	Expert 3
mechanics and metal trades	non-ferrous metal processing	Various processing methods on non-ferrous metals and alloys such as copper, zinc and aluminium.	0	0	1
mechanics and metal trades	manufacturing of metal structures	The production of metal structures for construction.	0	0	1
electricity and energy	transmission towers	Types of tall structures which are used in the transmission and distribution of electrical energy, and which support overhead power lines, such as high voltage AC and high voltage DC transmission towers. The different types of tower designs and materials used for its construction, and the types of currents.	0	0	1
shaping materials to create products	apply smithing techniques	Apply techniques and use technologies in relation to the various smithing processes, including sculpting, forging, upsetting, heat treating, and finishing.	0	0	1
repairing and installing mechanical equipment	carry out repair of vehicles	Provide repair for vehicles and routine level checks, such as engine tune-ups, oil changes, tire rotation and changes, wheel balancing, replacing filters, repair engine failures; repair mechanical and electrical systems malfunctions; replace parts and components; repair body damage.	0	0	1
mechanics and metal trades	metalworking	The process of working with metals to create individual parts, assemblies, or large-scale structures.	0	0	1
building and repairing structures	maintain construction structures	Repair and maintain existing construction structures in order to keep these structures in a safe and sanitary condition, and compliant to safety standards and regulations.	0	0	1
mechanics and metal trades	manufacturing of metal containers	The manufacture of reservoirs, tanks and similar containers of metal, of types normally installed as fixtures for storage or manufacturing use. The manufacture of metal containers for compressed or liquefied gas.	0	0	1
installing wooden and metal components	maintain mechanical equipment	Observe and listen to machinery operation to detect malfunction. Service, repair, adjust, and test machines, parts, and equipment that operate primarily on the basis of mechanical principles. Maintain and repair vehicles meant for cargo, passengers, farming and landscaping.	0	0	1

mechanics and metal trades	manufacturing of steel drums and similar containers	The manufacture of pails, cans, drums, buckets, boxes, through metalworking processes.	0	0	1
mechanics and metal trades	forging processes	The various processes in the metalforming practices of forging, such as swaging, open-die forging, automatic hot forging, cogging, impression-die forging, roll forging, upsetting, press forging, and others.	0	0	1
electricity and energy	manufacturing of heating equipment	The manufacture of electrical ovens and water heaters by metalworking processes.	0	0	1
mechanics and metal trades	types of metal manufacturing processes	Metal processes linked to the different types of metal, such as casting processes, heat treatment processes, repair processes and other metal manufacturing processes.	0	0	1
joining parts using soldering, welding or brazing techniques	weld underwater	Use underwater arc welding equipment to make welds beneath the water surface. Protect yourself from electric shocks by shielding the weld from the water.	0	0	1
installing wooden and metal components	assemble truss constructions	Use trusses, metal structures that derive strength from their construction involving triangular shapes, to construct stages for performances.	0	0	1
motor vehicles, ships and aircraft	vehicle manufacturing process	Series of steps taken in order to produce a car or any other motor vehicle such as the design, the chassis and body assembly, the painting process, the interior assembly and the quality control.	0	0	1
mechanics and metal trades	electron beam welding machine parts	The various parts of a metalworking machine designed to join metal pieces together using electron beams, such as the vacuum chamber, primary anode, cathode or electron gun, focusing coil, deflection coil, prism, telescope, and others.	1	0	0
shaping materials to create products	operate forging tongs	Operate the appropriate forging tools and equipment safely, including forging tongs for handling and moving hot metal workpieces during forging processes.	1	0	0
fabricating medical and prosthetic devices	manufacture medical devices	Put together medical devices according to company specifications and national and international regulations. Use specialised materials, tools, and machinery to assemble the medical devices. Apply molding, welding, or bonding techniques according to the type of medical device. Retain a high level of cleanliness throughout the manufacturing process.	0	1	0

monitoring safety or security	maintain rail infrastructure	Inspect rails for cracks and damage, replace worn rails, tighten up loose screws, perform welding work if necessary. Maintain railway embankment, side walkways and drainage installations.	0	1	0
fabricating precision instruments or jewellery	assemble jewellery parts	Assemble and thread different jewellery parts together such as pearls, locks, wire, and chains by soldering, clamping, welding or lacing the materials.	0	1	0
operating metal, plastic or rubber forming equipment	build rebar cages	Insert the metal rods and operate the machine which builds the circular frames of concrete pipes. For larger diameters, use welding equipment to manually form the frame.	0	1	0
installing and repairing electrical, electronic and precision equipment	repair battery components	Repair battery components through replacing cells, repairing wiring, or spot-welding cells.	0	1	0
operating metal, plastic or rubber forming equipment	use shaping machinery	Use various types of welding and cutting tools to shape and customize surfaces and materials.	0	1	0
chemical engineering and processes	laser types	The various types of lasers, their specific qualities and their applications, such as for cutting, engraving, welding, and others.	0	1	0
mechanics and metal trades	mechanical engineering applicable to edible oil seed	Applying mechanical engineering principles to edible oil seed such as the installation of machinery, repair, and welding practices, steam equipment installation and the applications of this equipment in the processing of oil seeds and the production of the oil.	0	1	0
assembling electrical and electronic products	assemble mechatronic units	Assemble mechatronic units using mechanical, pneumatic, hydraulic, electrical, electronic, and information technology systems and components. Manipulate and attach metals through using welding and soldering techniques, glue, screws, and rivets. Install wiring. Install drive systems, sensors, actuators, and transducers. Mount switches, control devices, coverings, and protection.	0	1	0
mechanics and metal trades	metalworking tools	The equipment and tools used in metalworking processes, such as welding or soldering torches, saws, deburring files, and metal drills.	0	1	0
installing and repairing electrical, electronic	repair electronic components	Repair, replace or adjust damaged electronics components or circuitry. Use hand tools and soldering and welding equipment.	0	1	0

and precision equipment					
installing and assembling building fixtures	assemble windows	Assemble the profiles to build window or glass door frames using cutting, trimming, sealing and welding equipment,fix the metal fittings with power tools, and insert the glass pane.	0	1	0
repairing and installing mechanical equipment	repair coquille defects	Repair coquille malfunctions and damage, such as cracks or broken edges using hand tools and welding machines.	0	1	1
installing heating, ventilation and air conditioning equipment	repair heating equipment	Repair, by use of welding techniques applied to cut and formed metal sheets, boilers, heat exchangers, fired heaters, tanks, reactors and other pressure vessels, and others.	0	1	1
assembling and fabricating products	install containers	Prepare transportable components and assemble the container body, piping, fittings and control systems on site using technical documentation and various specific tools such as welding equipment.	0	1	1
operating metal, plastic or rubber forming equipment	tend electron beam welding machine	Tend a metalworking machine designed to join metal pieces by use of an electron beam exuding a concentrated heat source, monitor and operate it according to regulations.	1	1	0
mechanics and metal trades	electron beam welding processes	The various processes of welding using electron beams, such as electron beam focusing, beam defelection, penetration, and others.	1	1	0
assembling and fabricating products	assemble toys	Fit body parts and accessories together using different tools and techniques depending on the toy materials such as gluing, welding, screwing or nailing.	1	1	0
operating metal, plastic or rubber forming equipment	tend laser beam welding machine	Tend a metalworking machine designed to join metal pieces by use of a laser beam exuding a concentrated heat source, monitor and operate it according to regulations.	1	1	0
mechanics and metal trades	metal joining technologies	The various technologies used for the joining and assembling of fabricated metal workpieces.	2	0	1
installing wooden and metal components	perform metal work	Work with metal and iron materials in order to assemble individual pieces or structures.	2	0	1
smoothing surfaces of objects or equipment	ensure coquille uniformity	Oversee uniformity of coquilles; use casting equipment and tools such as welding machines.	1	1	1

joining parts using soldering, welding or brazing techniques	weld in hyperbaric conditions	Use arc welding techniques to make welds in conditions of very high pressure, usually in an underwater dry chamber such as a diving bell. Compensate for the negative consequences of high pressure on a weld, such as the shorter and less steady welding arc.	1	1	1
joining parts using soldering, welding or brazing techniques	perform metal active gas welding	Weld metal, mostly steel, workpieces together using active gas mixtures such as concotions of argon, carbon dioxide and oxygen.	1	1	1
joining parts using soldering, welding or brazing techniques	weld mining machinery	Cut and weld pieces of metal in order to repair broken metal parts, or to assemble new parts.	1	1	1
joining parts using soldering, welding or brazing techniques	perform metal inert gas welding	Weld metal workpieces together using inert gasses or gas mixtures such as argon and helium. This technique is usually used for welding aluminium and other non-ferrous metals.	1	1	1
joining parts using soldering, welding or brazing techniques	operate oxy-fuel welding torch	Operate a cutting torch fueled by oxyacetylene gas safely to perform welding processes on a workpiece.	1	1	1
joining parts using soldering, welding or brazing techniques	apply arc welding techniques	Apply and work with a variety of techniques in the process of arc welding, such as shielded metal arc welding, gas metal arc welding, submerged arc welding, flux-cored arc welding, and others.	1	1	1
joining parts using soldering, welding or brazing techniques	join metals	Join together pieces of metal using soldering and welding materials.	1	1	1
joining parts using soldering, welding or brazing techniques	use welding equipment	Operate welding equipment in a safe manner; use welding techniques such as shielded metal arc welding or flux-cored arc welding.	1	1	1
joining parts using soldering, welding or brazing techniques	operate welding equipment	Use welding equipment to melt and join together pieces of metal or steel, wearing protective eyewear during the working process.	1	1	1
joining parts using soldering, welding or brazing techniques	apply spot welding techniques	Apply and work with a variety of techniques in the process of welding metal workpieces under pressure exercised by electrodes, such as projection welding, radius style electrodes spot welding, eecentric electrodes spot welding, and others.	1	1	1

joining parts using soldering, welding or brazing techniques	apply thermite welding techniques	Weld using equipment that operates based on an exothermic reaction fuelled by thermite.	1	1	1
mechanics and metal trades	welding techniques	The different methods of welding together pieces of metal using various equipment, such as oxygen-acetylene welding, gas metal arc welding and tungsten inert gas welding.	1	1	1
joining parts using soldering, welding or brazing techniques	perform tungsten inert gas welding	Weld metal workpieces together by tungsten intert gas (TIG) welding. This arc welding process welds metal workpieces using the heat generated between an arc of electricity struck between a non-consumable tungsten metal electrode. Use an argon or helium inert gas to shield the weld from athmospheric contamination.	1	1	1
assembling furniture	build bodies for vehicles	Manufacture bodies for passenger-carrying vehicles, such as car, bus, horse-drawn carriage or railroad passenger car. Use wood, metal, fibreglass and other materials.	0	2	1
operating precision industrial equipment	apply precision metalworking techniques	Comply with precision standards specific to an organisation or product in metalworking, involved in processes such as engraving, precise cutting, welding.	2	1	1
mechanics and metal trades	spot welding machine parts	Parts of a machine designed to perform spot welding practices on metal workpieces, such as the air or hydraulic cylinder, welding head, spot welding electrodes, upper platen, lower platen, flexible bands, knee, and others.	1	2	1
developing operational policies and procedures	develop new welding techniques	Design and optimise new techniques for welding together metal pieces; devise a solution to a welding problem after having performed research into the matter. Take into account the properties of the welding materials and the equipment.	1	2	1
joining parts using soldering, welding or brazing techniques	maintain coquille parts	Carry out minor repair tasks and maintenance of coquilles and coquille parts.	2	2	1
building and repairing structures	construct canal locks	Install lock systems in sections of canals for the raising and lowering of vessels from one level to another. These are used for their passage over canals as well as for the control of the water level.	0	0	1
repairing and installing mechanical equipment	repair power tools	Provide repair and routine level checks for power tools, such as engine tune-ups, oil changes, repair engine failures, repair mechanical and	0	0	1

		electrical systems malfunctions or body damage and replace parts and components.			
installing wooden and metal components	perform maintenance work on rail tracks	Perform maintenance operations on rail tracks, such as removal of old or damaged ties, maintenance of track spanner machinery, and tightening or loosening of bolts at joints.	0	0	1
building and civil engineering	manufacturing of steam generators	The manufacture of steam or other vapour generators, the manufacture of auxiliary plant for use with steam generators: condensers, economisers, superheaters, steam collectors and accumulators. The manufacture of nuclear reactors, parts for marine or power boilers. Also the production of pipe system construction comprising further processing of tubes generally to make pressure pipes or pipe systems together with the associated design and construction work.	0	2	1
repairing and installing mechanical equipment	carry out chassis modifications	Perform chassis conversions and fitments on elements of stocks of chassis by modifying its length and weight distribution. Meet specific requirements and quality standards by consulting and communicating with engineers and technical personnel.	0	0	1
repairing and installing mechanical equipment	carry out repairs and maintenance of vehicle bodies	Execute repair and maintenance tasks to damaged vehicle bodies; follow customers' individual requests and instructions.	0	0	1

5.1 Assigning exposure to ISCO-08+ using expert evaluations (Figure 2, step 5_1)

As described earlier in step 5_1 the involved experts were asked to score the 619 and 3,007 job codes included in the ISCO-08 and ISCO-08+ classifications, respectively, for their likelihood of involving exposure to welding fumes for the workers belonging to each job code. Exposure scoring was initially performed blind to the skills/activities included in ESCO (step 5_{1b} and step 6_{1a}). The results of this exercise are summarised in the paragraphs 5.1.1 and 5.1.1.1 that follow. Following this, experts were provided with the same list of 3,007 job codes included in ISCO-08+ but this time linked to the skills/activities identified as exposed in step 3. The experts were asked to evaluate whether it was appropriate for a job with an exposed skill to be considered as exposed or not (step 5_{1b} and step 6_{1b}). Thus far, and as described in section 4.4, only the work for welding fumes has been completed until now with the related work for diesel exhaust being currently underway.

5.1.1 Without using skills to define exposure status (Figure 2, step 5_{1a})

Table 8 summarises the distribution of scores assigned by the three experts that were involved in the process for both ISCO 1-4- and 5-8-digit codes. As it can be seen the experts identified a maximum of 11 job codes as exposed to welding fumes in the 1–4-digit level. For the updated 5–8-digit codes the expert identified between 21 and 28 jobs each as being exposed to welding fumes corresponding to a maximum of 0.9% of all job included in the ISCO-08+ classification system. The prevalence of "depends" was very low with only two and three codes scored as such by experts 1 and 2, respectively.

Table 8. Distribution of assigned exposure scores for welding fumes by the three experts across job codes included in the original ISCO-08 and the ISCO-08+ classification systems.

Assigned exposure score	**1-4 digit codes *(ISCO-08)*, n (%)**			**5-8 digit codes *(ISCO-08+)*, n (%)**		
	Expert 1	**Expert 2**	**Expert 3**	**Expert 1**	**Expert 2**	**Expert 3**
0 = Non-exposed	608 (98.2)	610 (98.5)	610 (98.5)	2,986 (99.3)	2,979 (99.1)	2,986 (99.3)
1 = Exposed	11 (1.8)	9 (1.5)	9 (1.5)	19 (0.6)	25 (0.8)	21 (0.7)
2 = Depends	0 (0)	0 (0)	0 (0)	2 (0.1)	3 (0.1)	0 (0.0)
Total	619 (100)	619 (100)	619 (100)	3,007 (100)	3,007 (100)	3,007 (100)

The agreement analyses results overall and between the different pairs of experts across both the 1-4 and 5-8 digit ISCO codes are summarised in Table 9, below. In general, the agreement between the experts was good with kappa values below 0.61 only between the pair of expert 1 vs expert 2 for the 5-8 digit codes. The agreement between experts was generally better for the 1-4 digit job codes (overall k =0.79) when compared with the more detailed 5-8 digit job codes (overall k = 0.61). Similarly, the estimated proportions of agreement exceeded 99.2 % of the ISCO codes evaluated in all comparisons involved.

Table 9. Agreement scores and kappa coefficients overall and per pair of experts. Assessment involves 619 1–4-digit occupational codes included in the original ISCO-08 classification and 3,007 job codes at the 5-8 digit included in ISCO-08+.

Exposure parameter	Aggrement		Kappa	
	Value	95% CI	value	95% CI
1-4 digit codes (ISCO-08)				
Expert 1 vs Expert 2	0.997	0.992-1.000	0.695	0.453-0.927
Expert 1 vs Expert 3	0.990	0.983-0.998	0775	0.560-0.989
Expert 2 vs Expert 3	0.994	0.987-1.000	0.898	0.759-1.000
Overall	0.994	0.988-0.999	0.790	0.623-0.956
5-8 digit codes (ISCO-08+)				
Expert 1 vs Expert 2	0.992	0.989-0.995	0.478	0.304-0.652
Expert 1 vs Expert 3	0.995	0.993-0.997	0.634	0.458-0.810
Expert 2 vs Expert 3	0.994	0.992-0.997	0.613	0.446-0.779
Overall	0.994	0.992-0.996	0.612	0.474-0.749

CI=confidence interval

5.1.1.1 The consensus agreement (Figure 2, step 6_{1a})

In the consensus meeting the three involved experts agreed on 11 job codes at the 1-4 digit level (ISCO-08) and 28 jobs codes at the 5-8 job codes level (ISCO-08+) as being exposed to welding fumes. This corresponds roughly to 1.8% and 0.9% of the 619 and 3,007 jobs included in the ISCO-08 and ISCO-08+ coding systems, respectively (Table 10).

Table 10. Distribution of ISCO-08 job codes assigned an exposed or non-exposed status to welding fumes following the consensus agreement meeting between the involved experts.

Assigned exposure score	Welding fumes	
	n	%
1-4 digit codes (ISCO-08)		
Non-exposed	608	98.2
Exposed	11	1.8
Total	619	100
5-8 digit codes (ISCO-08+)		
Non-exposed	2,979	99.1
Exposed	28	0.9
Total	3,007	100

A complete list of all 28 job codes of ISCO-08+ (5-8 digit level of the classification) identified as exposed to welding fumes and their descriptions is provided in Table 11 that follows. A similar list including all 11 job codes at the 1-4 digit level (original ISCO-08) and their descriptions is provided in Table A1 of the Annex.

Table 11. List of the 28 job codes of ISCO-08+ identified as exposed in step 6_{1a}.

ISCO code	Preferred label for occupation	Description
2144.1.10	marine engineer	Marine engineers design, build, maintain and repair the hull, mechanical, electronic equipment and auxiliary systems such as engines, pumps, heating, ventilation, generator sets. They work on all types of boats from pleasure crafts to naval vessels, including submarines.
2144.1.23	welding engineer	Welding engineers research and develop optimal effective welding techniques and design the corresponding, equally efficient equipment to aid in the welding process. They also conduct quality control and evaluate inspection procedures for welding activities. Welding engineers have advanced knowledge and critical understanding of welding technology application. They are able to manage high complex technical and professional activities or projects related to welding applications, while also taking responsibility for the decision making process.
3112.1.10	rail maintenance technician	Rail maintenance technicians execute routine inspections of railway tracks, powerlines, signage stations, switches, and other railway infrastructure. They are also sent out to repair defects quickly, safely, and at any time of the day or night.
3115.1.24	welding inspector	Welding inspectors examine the connections and bonds between metals. They utilise visual tools and electrical instruments to inspect and ensure the quality and safety of connections. Welding inspectors ensure that all related welding activities, plans and materials follow the appropriate guidelines, in accordance with safety regulations. In addition to working in the field completing their examinations of welding projects, inspectors spend time in an office setting compiling their reports.
7126	Plumbers and pipe fitters	Plumbers and pipe fitters assemble, install, repair and maintain pipe systems, drains, gutters, ducts and related fittings and fixtures for water, gas, drainage, sewerage, heating, cooling and ventilation systems, and for hydraulic and pneumatic equipment. Tasks include - (a) examining blueprints, drawings and specifications to determine the layout of plumbing and ventilation systems and materials required; (b) measuring, cutting, threading, bending, jointing, assembling, installing, maintaining and repairing pipes, fittings and fixtures of drainage, heating, ventilation, water supply and sewerage systems; (c) installing gas appliances, dishwashers and water heaters, sinks and toilets using hand and power tools; (d) laying clay, concrete or cast-iron pipes in ditches to form sewers, drains or water mains, or for other purposes; (e) inspecting, examining and testing installed systems and pipes, using pressure gauge, hydrostatic testing, observation or other methods. Examples of the occupations classified here: - Drain technician - Gas fitter - Pipe fitter - Pipe layer - Plumber - Ventilation pipe fitter

7126.7	pipeline maintenance worker	Pipeline maintenance workers operate different equipment to keep the suitability of the pipelines. They perform checks for deviations and administer chemicals according to the needs and cleaning aim (e.g. corrosion shunning)
7126.8	Plumber	Plumbers maintain and install water, gas and sewage systems. They inspect pipes and fixtures on a regular basis or make repairs as needed. They bend, cut, and install pipes. They test systems and make adjustments safely and following regulations. They place sanitary equipment.
7212.2	Solderer	Solderers, operate various equipment and machinery such as gas torches, soldering irons, welding machines, or electric-ultrasonic equipment in order to solder together two or more items (usually metals), by melting and forming a metal filler in between the joints, the filler metal has a lower melting point than the adjoining metal.
7213.3	Coppersmith	Coppersmiths craft and repair items made of non-ferrous metals such as copper, brass and similar materials. They shape and form the raw materials into objects of practical or artistic purpose using smithing tools. Professional coppersmiths create detailed and highly technical devices using appropriate smithing techniques.
7214.3	structural ironworker	Structural ironworker in construction install iron elements into structures. They erect steel frameworks for buildings, bridges and other construction projects. They set metal rods, or rebar, to form reinforced concrete.
7223.7	fitter and turner	Fitters and turners use machine tools to create and modify metal parts according to set specifications in order to fit components for machinery. They ensure the finished components are ready for assembly.
7231.2	Coachbuilder	Coachbuilders execute work on vehicle bodies and coaches. They have skills to form body parts from panels, manufacture and assemble the frames and parts for vehicles.
7233.11	mining equipment mechanic	Mining equipment mechanics install, remove, maintain and repair mining equipment.
7233.7	industrial machinery mechanic	Industrial machinery mechanics work on new machinery and equipment in operation. They set up for the specific application and build accessories if necessary, perform maintenance and repair, and run diagnostics to find faults in systems or parts that need replacing.
7233.8.1	agricultural machinery technician	Agricultural machinery technicians repair, overhaul and maintain agricultural equipment including tractors, tillage equipment, seeding equipment and harvesting equipment. They perform evaluations of the equipment, perform preventive maintenance activities and repair faults.
7212.1	Brazier	Braziers operate various equipment and machinery such as torches, soldering irons, fluxes and welding machines in order to join two metal pieces together, by heating, melting and forming a metal filler between them, often brass or copper. Brazing can join metals such as aluminium, silver, copper, gold, and nickel. Brazing is a similar process to soldering but requires higher temperatures.
7212.3	Welder	Welders operate welding equipment in order to join metal workpieces together. They can use fusion welding processes

		based on different techniques and materials. They also perform simple visual inspection of welds.
7212.4	welding coordinator	Welding coordinators supervise the workflow of welding applications. They monitor welding processes performed by other welders, supervise the staff, being sometimes responsible for vocational training. They also weld particularly demanding parts. Welding coordinators ensure that the necessary welding equipment is ready for usage. They mostly coordinate welding applications and related professional activities.
7213.1	Boilermaker	Boilermakers operate a variety of equipment and machinery to create, re-pipe and retube hot water and steam boilers, producing them in all steps of the production process. They cut, gouge and shape the metal sheets and tubes for the boilers to size, using oxy-acetylene gas torches, assemble them by shielded metal arc welding, gas metal arc welding or gas tungsten arc welding, and finish them by the appropriate machine tools, power tools and coating.
7213.4	sheet metal worker	Sheet metal workers in construction use sheet metal to construct roofs, ducts for heating, ventilation and air-conditioning, gutters and other metal structures. They read plans and determine the type and amount of materials to be used, then measure, bend, cut, shape, and attach pieces of sheet metal to create the required structure.
7214.2	Shipwright	Shipwrights build and repair small type of water vessels from pleasure craft to naval vessels. They prepare preliminary sketches and create templates. They use hand and power tools to construct smaller boat themselves or supervise a team of shipbuilders. They also construct cradles and slipways for the ship's construction, transportation, launching and slipping. Depending on the vessels, they might work with different materials such as metal, wood, fibreglass, aluminium etc.
7221.1	Blacksmith	Blacksmiths heat metal, usually steel, in a forge and shape it with a hammer, chisel, and an anvil. Contemporarily, they predominantly create artisanal metal products, including ornamental work, as well as horse shoes, one of the sole metal fabricating processes that has not been industrialised.
7223.14	ornamental metal worker	Ornamental metal workers use finishing equipment and machinery to shape and finish fabricated ornamental metal workpieces, often used for the installation process in construction, such as railings, staircases, open steel flooring, fences and gates, and others.
7212.3.1	electron beam welder	Electron beam welders set up and tend machines designed to join separate metal workpieces together through the use of a high-velocity electron beam. They monitor the machining processes providing an alteration in the kinetic energy of the electrons that allows for them to transform into heat for the metal to melt and join together in a process of precise welding.
7212.3.2	laser beam welder	Laser beam welders set up and tend laser beam welding machines designed to join separate metal workpieces together through the use of a laser beam radiating a concentrated heat source that allows for precise welding.
7212.3.3	pipe welder	Pipe welders assemble and install parts and components of pipelines for the transport of goods such as water, steam and

		chemicals through them. They interpret specs such as pneumatics, hydraulics, for installation on site according to the safety and production requirements.
7212.3.4	spot welder	Spot welders set up and tend spot welding machines designed to press and join metal workpieces together. The metal resistance to the passage of electrical current and the subsequent heat created in the process allows for the local melting and joining of the parts.
8212.3.1	battery assembler	Battery assemblers are welding and assembling the battery components such as electronics parts, wiring, and casing around the cells.
8219.7	metal furniture machine operator	Metal furniture machine operators use machines and power tools to cut, shape and join metal pieces in order to produce metal furniture ranging from office furnishings to outdoors fittings. They use different types of metal such as aluminium, iron and stainless steel, and different types of processes such as metal forming and casting. They polish, apply protective layers and, in some cases, decorative finishes to the metal pieces. They assemble and join the elements to obtain the final product.

5.1.2 Using skills to define exposure status (Figure 2, step 5_{1b})

In step 5_{1b} the experts were asked to re-evaluate ISCO-08+ in terms of the likelihood of exposure to welding fumes and diesel but this time after looking on the skill/activities underlying the specific jobs. All job codes with at least one exposed skill/activity (n=289) were reviewed according to the criteria described in Table 3. If one or more of those criteria were not fulfilled, then the exposure score for the job code was overwritten with zero and the job code was considered as unexposed.

The distribution of the assigned scores across the 3,007 job codes included in ISCO-08+ assigned by the three experts is shown in Table 12. The prevalence of exposed jobs after re-viewing by the experts was increased to between 1 and 2.5% (from 0.9%), which is lower than the 9% of the total number of job codes that had at least one exposed skill/activity linked into them. Taking into account skills in the assessment, expert 3 assigned the highest number of job codes as exposed, and expert 2 the lowest.

Table 12. Distribution of assigned exposure scores for welding fumes by the three experts across the job codes included in the ISCO-08+ classification system. Only job codes at the 5-8 digit level of the classification are used.

Assigned exposure score	**n (%)**		
	Expert 1	**Expert 2**	**Expert 3**
0 = Non-exposed	2965 (98.6)	2976 (99.0)	2986 (97.5)
1 = Exposed	42 (1.4)	31 (1.0)	76 (2.5)
Total	3,007 (100)	3,007 (100)	3,007 (100)

Table 13 shows the overall and per pair agreement between the three experts when scoring of jobs was additionally informed by whether or not a job had one or more exposed skills/activities

linked into it. As it can be seen percent agreement was consistently above 98% between the three experts. Estimated weighted Kappa coefficients ranges between 0.44 and 0.60 between the different pairs of experts whereas the overall Kappa had a value (95% CI) of 0.51 (0.41-0.61) indicating the presence of moderate agreement between experts. Also here, no statistically significant difference in Kappas for the different expert pairs was detected.

Table 13. Agreement scores and kappa coefficients overall and per pair of experts. Assessment involve 3,007 job codes included in the ISCO-08+ classification system.

Exposure parameter	Aggrement		Kappa	
	Value	95% CI	value	95% CI
Expert 1 vs Expert 2	0.990	0.987-0.994	0.598	0.464-0.732
Expert 1 vs Expert 3	0.981	0.977-0.986	0.517	0.406-0.627
Expert 2 vs Expert 3	0.980	0.975-0.985	0.440	0.323-0.558
Overall	0.984	0.980-0.988	0.510	0.409-0.609

CI=confidence interval

5.1.2.1 The consensus agreement (Figure 2, step 6_{1b})

Following the consensus meeting between experts there were 51 job codes that were assigned an exposed status. This corresponds to 17.6% of all 289 job codes that had at least one exposed skill/activity linked to them, and 1.7% of all job codes (Table 14) which suggests that an exposed activity does not necessary imply assigning an exposed to that particular code.

Table 14. Distribution of ISCO-08+ job codes assigned an exposed or non-exposed status to welding fumes following the consensus agreement meeting between the involved experts.

Assigned exposure score	Welding fumes	
	n	%
Non-exposed	2,956	98.3
Exposed	51	1.7
Total	3,007	100

5.2 Assigning exposures to ISCO-08+ without using expert evaluations (Figure 2, step 5_2)

In **step 5_2**, as described earlier, we developed three different exposure assignment methods based on the results of the assessments at the skill/activity classification level (step 3) and without any further expert involvement. The three methods were based on the number of exposed skills/activities and their importance (i.e. whether they are essential or optional) for each of the job titles. The methods essentially were assigning exposure based on these information in a staged approach with criteria becoming stricter after every stage. Specifically, at first stage any job code with a linked exposed skill/activity was considered as exposed – there were 289 job codes that fulfilled this criterion (Table 15). When restricting the criteria to only those job titles linked to skills/activities that were exposed and essential for the specific jobs lead to a reduction in the number of exposed jobs of more than 50% (n=127). A further restriction to the criteria by requiring exposed jobs to have at least 2 or more exposed essential

skills/activities reduced the number of exposed jobs further and in similar levels to the resulting assignment using expert evaluations (i.e. 1.2% of all job codes included in ISCO-08+).

Table 15. Distribution of exposure scores for welding fumes across the job codes included in ISCO-08+ when using ESCO exposed skills/activities to define exposure.

Exposure score	n (%)		
	ESCOJEM-1	ESCOJEM-2	ESCOJEM-3
0 = Non-exposed	2718 (90.4)	2880 (95.8)	2970 (98.8)
1 = Exposed	289 (9.6)	127 (4.2)	37 (1.2)
Total	3,007 (100)	3,007 (100)	3,007 (100)

ESCOJEM-1: exposure is defined as linked to at least one exposed ESCO skill/activity.
ESCOJEM-2: exposure is defined as linked to at least one exposed ESCO skill/activity that is "essential" for the job.
ESCOJEM-3: exposure is defined as linked to at least two exposed ESCO skill/activity that are essential to the job.

5.3 Comparing the different approaches (Figure 2, step 7)

In the following paragraphs a comparison between the different assignments resulting from steps 5 and 6 is provided. First the two approaches involving expert evaluations at the job level are compared between them (section 5.3) followed by a comparison of the approach combining skills and expert evaluations against those that did not involve experts at the job level (section 5.4).

5.3 Comparing the assignments involving expert evaluations (Figure 2, step 6_{1a} and step 6_{1b})

The agreement score between the two assignments with experts involvement was 0.99 (0.987-0.994) with a kappa coefficient of ~0.6 indicating moderate to good agreement (Table 16).

Table 16. Agreement scores and kappa coefficients between the assessment involving experts with (Method 2) and without (Method 1) considering the underlying skills/activities to the jobs involve 3,007 job codes included in the ISCO-08+ classification system.

Exposure assignment method comparison	Aggrement		Kappa	
	Value	95% CI	value	95% CI
Method 1 vs Method 2	0.990	0.987-0.994	0.598	0.464-0.732

CI=confidence interval

A closer look at the agreement between the two approaches showed that the approach that involved using the list of exposed ESCO skills/activities from step 3 included 27 additional unique exposed job codes compared to the approach that involved expert evaluations solely at the job level - i.e. not considering skills (Table 17). In addition, four of the jobs considered as exposed in the latter were not included in the JEM based on the exposed skills/activities. These job codes included the following rail maintenance worker, plumber, electron beam welder and fitter and turner. A complete description of those ISCO-08+ codes is provided in Table 18.

Table 17. Cross tabulation of the exposure scores of the exposure assignments involving expert evaluations with and without linkage to exposed skills/activities.

Exposure assignments without linkage to exposed skill/tasks	Exposure assignments with linkage to exposed skill/tasks		
Score	**0 = Non-exposed**	**1 = Exposed**	**Total**
0 = Non-exposed	2,952 (99.9)	27 (52.9)	2,979 (99.1)
1 = Exposed	4 (0.1)	24 (47.1)	28 (0.9)
Total	2,956 (100)	51 (100)	3,007 (100)

Rail maintenance technician, plumber, and fitter and turner were not included in the final exposed jobs in the evaluations that involved the ESCO skill list. This is because these occupations were not linked to any exposed skill/activity, although that our experts evaluated them as exposed on the blind to the skills approach. On the contrary electron beam welder was included as a job with linked exposed ESCO skills/activities. Interestingly on the evaluations that did not use skills, two of the experts (expert 2 and 3) rated this job code as exposed and thereby the code was considered as exposed by a majority rule. In the second evaluation, involving skills, only one expert (expert 3) scored which job code as exposed and thereby a consensus discussion was held. In this it was decided to overwrite this job as unexposed since involved temperatures are much lower that classical welding whereas electron beam welding is small scale and performed in completely enclosed conditions.

Table 18. Description of the four ISCO-08+ job codes that were not included in the final expert assignments at job level based on the ESCO skills/activities (Figure 2, step 6_{1b}) but which were included in the final assignments that did not involve ESCO skills/activities (Figure 2, step 6_{1a}).

ISCO code	Preferred label for occupation	Description
3112.1.10	rail maintenance technician	Rail maintenance technicians execute routine inspections of railway tracks, powerlines, signage stations, switches, and other railway infrastructure. They are also sent out to repair defects quickly, safely, and at any time of the day or night.
7126.8	plumber	Plumbers maintain and install water, gas and sewage systems. They inspect pipes and fixtures on a regular basis or make repairs as needed. They bend, cut, and install pipes. They test systems and make adjustments safely and following regulations. They place sanitary equipment.
7212.3.1	electron beam welder	Electron beam welders set up and tend machines designed to join separate metal workpieces together through the use of a high-velocity electron beam. They monitor the machining processes providing an alteration in the kinetic energy of the electrons that allows for them to transform into heat for the metal to melt and join together in a process of precise welding.
7223.7	fitter and turner	Fitters and turners use machine tools to create and modify metal parts according to set specifications in order to fit components for machinery. They ensure the finished components are ready for assembly.

A list of the 27 additional job titles included in the final list of assignments based on the exposed ESCO skills/activities and their descriptions is provided in Table 19.

Table 19. List of the 27 job codes identified as exposed in Figure 2, step 6_{1b} (expert evaluations at the job level using ESCO skills/activities) but not in Figure 2, step 6_{1a} (expert evaluations at the job level not using ESCO skills/activities).

ISCO code	Preferred label for occupation	Description
1321.2.1.8	metal production manager	Metal production managers organise and manage the day-to-day and long-term project work in a metal fabrication factory, to process basic metals into fabricated metals. They create and schedule production plans, recruit new staff, enforce safety and company policies, and strive for customer satisfaction through guaranteeing the product's quality.
2141.8	maintenance and repair engineer	Maintenance and repair engineers focus on the optimization of equipment, procedures, machineries and infrastructure. They ensure their maximum availability at minimum costs.
2144.1.14	naval architect	Naval architects design, build, maintain and repair all types of boats from pleasure crafts to naval vessels, including submarines. They analyse floating structures and take various features into account for their designs such as the form, structure, stability, resistance, access and propulsion of hulls.
3113.2	hydropower technician	Hydropower technicians install and maintain systems in hydropower plants. They perform inspections, analyse problems and carry out repairs. They ensure the turbines operate in compliance with regulations, and assist the hydropower engineers in the construction of turbines.
3115.1.21	rolling stock inspector	Rolling stock inspectors inspect wagons and carriages to assess their technical condition while grouped together and before they are used forÂ transportation activities. They check technical devices, ensure complete and correct operation of the rolling stock, and prepare required technical documents and/or checklists. Depending on work organisation they are also responsible for limited ad-hoc maintenance or exchange work and the performance of brake tests.
3122.3.2	container equipment assembly supervisor	Container equipment assembly supervisors monitor the assembly process of containers such as boilers or pressure vessels. They train and coach the workers involved in the assembly to achieve production goals.
3122.4.10	metal production supervisor	Metal production supervisors oversee the day-to-day working process and activities of the labourers in a metal fabrication factory. They supervise staff, create work schedules, maintain a safe work environment and serve as the first, most accessible management representative for the workers to contact when there is need.
3123.1.19	rail construction supervisor	Rail construction supervisors monitor the construction and maintenance of railway infrastructure. They assign tasks, either on the ground or from a control room, and make quick decisions to resolve problems.
3123.1.23	structural ironwork supervisor	Structural ironwork supervisors monitor ironworking activities. They assign tasks and take quick decisions to resolve problems.
7126.3	gas service technician	Gas service technicians install and maintain gas service appliances and systems in facilities or buildings. They install the equipment in accordance with regulations, repair faults, and investigate leaks and other problems. They test the equipment and advise on the use and care of appliances and systems which use gas energy.

7127.1	heating and ventilation service engineer	Heating and ventilation service engineers install and maintain industrial heating and refrigeration systems. They set up furnaces, thermostats, ducts, vents, and other equipment needed to ensure the controlled passage and treatment of air. They also carry out repairs.
7213.2	container equipment assembler	Container equipment assemblers manufacture containers such as boilers or pressure vessels. They read blueprints and technical drawings to assemble parts and to build piping and fittings.
7222.5	tool and die maker	Tool and die makers operate a variety of equipment and machinery designed to create metal tools and dies, which are both needed in several areas of manufacturing, and produce these tools in all steps of the production process. They design the tools and dies, then cut and shape them to size and finish them by manually operated machine tools, power tools, hand tools, or programming and tending CNC tool and die making machines.
7231.5	restoration technician	Restoration technicians overhaul old and classic cars.
7233.1*	construction equipment technician	Construction equipment technicians inspect, maintain and repair heavy-duty vehicles used in construction, forestry and earthworks such as bulldozers, excavators and harvesters. They perform evaluations of the equipment, and ensure the safety and optimal efficiency of the machinery.
7233.1_1*	marine mechanic	Marine mechanics are in charge of the engines and mechanical parts of the vessel and replace defective equipment and parts. They communicate with other crew members on the operational level. Marine mechanics maintain and repair the engines and other machinery of vessels such as boilers, generators and electrical equipment.
7233.12	moulding machine technician	Moulding machine technicians service machinery used in the casting and moulding of plastics and other materials. They calibrate the equipment, perform maintenance activities, examine finished products and repair faults.
7233.13	pneumatic systems technician	Pneumatic systems technicians use blueprints and technical documentation to assemble and install equipment operated by gas or air under pressure. They set up the systems according to engineering specifications and test them to ensure good functioning order. They may also perform maintenance and repair work on installed pneumatic equipment.
7233.14	rotating equipment mechanic	Rotating equipment mechanics are responsible for preventive and corrective maintenance activities for rotating equipment such as turbines, compressors, engines, and pumps. They ensure the availability and integrity of the installed systems and equipment in terms of safety and reliability.
7233.15	textile machinery technician	Textile machinery technicians set up, maintain, inspect and repair mechanical and computer-controlled machinery used in textile manufacturing such as weaving, dyeing and finishing machines. Â
7233.4	fluid power technician	Fluid power technicians install and assemble equipment that uses liquid or gas pressure to transmit or regulate power. They also perform tests on and maintain this equipment.
7233.5	forge equipment technician	Forge equipment technicians maintain and repair forge machinery such as presses and material handling equipment. They perform evaluations of the equipment, perform preventative maintenance activities, and repair faults. They also assist in the installation of the equipment and ensure proper functionality.

7233.8.2	forestry machinery technician	Forestry machinery technicians maintain and transport forestry machinery. As part of the maintenance of forestry machinery, they make use of specialised software and data recording systems and instruments.
7233.9	marine fitter	Marine fitters work primarily in fabrication, subassembly, assembly and final assembly of all structural components on commercial and naval vessels, to include but not limited to hulls, superstructures, masts, pilot house, and engine rooms.
7411.1.4	solar energy technician	Solar energy technicians install and maintain systems that collect solar energy. They prepare the necessary fixtures, often on roofs, install solar panels, and plug them into an electronic system including an inverter to connect the solar energy systems to the electricity lines.
8219.8	metal products assembler	Metal products assemblers fit and fasten metal materials according to strictly laid down procedures in order to produce various parts or final products using power tools, hand tools, and other machinery.
9312.1.2	rail layer	Rail layers construct railway tracks on prepared sites. They monitor equipment that sets railroad sleepers or ties, usually on a layer of crushed stone or ballast. Rail layers then lay the rail tracks on top of the sleepers and attach them to make sure the rails have a constant gauge, or distance to each other. These operations are usually done with a single moving machine, but may be performed manually.

*Refer to alternative versions of the same sub-code 7233.1

5.4 Comparing the skill-based assignments for jobs with (Figure 2, step 62_b) and without expert evaluations (Figure 2, step 5_2)

Table 21 provides an overview of the agreement analysis comparing the assignments based on skills with and without expert input at the ISCO-08 level. Clearly, kappa coefficients and absolute agreement values increase as the restriction of the criteria for using skills in defining exposed jobs increase. Overall, the agreement reaches a maximum moderate level between the expert-based assignments (Expert-ISCO) and the assignments using the most restricted exposure definition based on at least two essential exposed skills (ESCOJEM-3).

Table 21. Agreement scores and kappa coefficients between the assignments for exposure to welding fumes for jobs using skills with (step 62_b) and without (step 5_2) expert input at the job level. Assessments involve 3,007 job codes included in the ISCO-08+ classification system.

Exposure assignment method comparison	Aggrement		Kappa	
	Value	95% CI	value	95% CI
Expert-ISCO vs ESCOJEM-1	0.921	0.911-0.931	0.280	0.218-0.340
Expert-ISCO vs ESCOJEM-2	0.966	0.960-0.973	0.413	0.321-0.504
Expert-ISCO vs ESCOJEM-3	0.983	0.977-0.988	0.424	0.293-0.554

CI=confidence interval; ISCOJEM-2= Expert based assignments for job using exposed ESCO skills; ESCOJEM-1 = Exposed are job codes are those with at least one exposed skill/activity; ESCOJEM-2 = Exposed are job codes are those with at least one essential exposed skill/activity; ESCOJEM-2 = Exposed are job codes are those with at least two essential exposed skills/activities;

When looking on the cross tabulation between the exposed and non-exposed jobs across the different assignment methods it is evident that the distribution and composition of exposed jobs is very different depending on the method implemented (Table 22). For example, the expert assignments based on ESCO skills (Expert-ISCO) results in 14 more exposed job categories when compared with the assignments where exposed are those job with at least two essential ESCO skills/activities linked to them (ISCOJEM-2). Another 18 jobs are completely different between the two assignment methods.

Table 22. Cross tabulation of the distribution of exposed and unexposed job codes between the skill-based assignments with expert input at the job level and those without expert input at the job code level.

Exposure assignment method comparison	ESCOJEM-x, n (%)		
	ESCOJEM-1	ESCOJEM-2	ESCOJEM-3
Exposed only in Expert-ISCO	0 (0)	13 (0.4)	32 (1.1)
Exposed only in ESCOJEM-x	238 (7.9)	89 (3.0)	18 (0.6)
Exposed in both methods	51 (1.7)	38 (1.3)	19 (0.6)
Unexposed in both methods	2718 (90.4)	2867 (95.3)	2,938 (97.7)

Expert-ISCO= Expert based assignments for Jobs using exposed ESCO skills; ESCOJEM-1 = Exposed are job codes are those with at least one exposed skill/activity; ESCOJEM-2 = Exposed are job codes are those with at least one essential exposed skill/activity; ESCOJEM-3 Exposed are job codes are those with at least two essential exposed skills/activities.

6. Discussion

In the present working task we examined whether two newly developed coding systems relevant for the EU labour market, the ESCO and the interlinked and updated 8-digit ISCO-08+ classification, can be useful in developing more meaningful exposure assignments when performing exposure assessment for general population studies.

6.1 Using the ESCO classification to identify exposed skills/activities

As described earlier the ESCO classification is a systematic categorisation of the skills, competencies and knowledge that are relevant for the EU labour market that has recently been made available. Such personal qualities refer to the ability of a worker to effectively perform their activities during their work. The activities performed are well-documented and strong predictors of a worker's exposures and thereby, we envisaged that by linking the required skills/competencies to a specific exposure factor we may more effectively identify the jobs and/or the individual workers that may be exposed. Use of activities for determining whether an individual worker is exposed or not to a specific exposure factor requires direct information on whether the worker perform or not the specific activities during their work. Such information are seldomly available within epidemiological studies of the general population where group-based exposure assessment methods such as JEMs are being used instead. These methods assign an exposure status to an individual based on the occupation/job title that they held. Consequently, in the present we have focused our evaluation of the ESCO classification on whether and the included skills/competency categories can be useful in identifying those jobs that are exposure to a) welding fumes and b) diesel exhaust particulates.

Although that our evaluations have in relation to the latter exposure factor (i.e. diesel exhaust) have not been finalised, certain insights and conclusions can be drawn from our work. When it comes to ESCO, this is a comprehensive classification that potentially serves its purpose well. However, it is evident that the classification is not quite fit-for-purpose for assessing exposures in epidemiological studies. In particular, the classification has been developed to be rather unspecific, listing all potential skills/activities, competencies and knowledge items that are relevant to an occupation without documenting whereas the activity is performed or not as required when performing exposure assessment and assignment. Similarly, the descriptions attached to each skill tend to also be broad and frequently referring to the possession of the generic knowledge of how a process or an activity is performed including the tools, methods or steps that are involved. Some examples of such generic descriptions are shown in Table A2 of the Annex. These generic definitions complicate the exposure assignment process as it is unclear whether or not exposure can be relevant for those.

When assessing exposures in group-based level it is common to favour specificity over sensitivity. This is intended to avoid misclassification of the exposure when the prevalence among workers comprising groups is small. Occupational exposures are generally considered relatively rare in the general population (15, 16). In our exposure assignments we have developed clear definitions and criteria which allowed us to identify those items for which the exposure status seemed uncertain due to e.g. lack of experience by the involved experts, unclear definitions, or conditional exposure presence (i.e. exposure status depends on where or who applies the skill/activity). Despite this the evaluations by the three individual experts turned out to be rather different irrespective of the substance involved (Table 4 and Table 5). The

estimated weighted kappa coefficients between experts ranged from 0.30 to 0.43 for welding fumes and between 0.15 to 0.28 for diesel with overall values of 0.38 and 0.21 respectively (Table 5). Although not surprising this finding suggest differences in experience and knowledge between experts. It further highlights it is important of including more than one expert when assigning exposure to the skill/activities including in the ESCO coding system.

One of the involved experts seldomly used the criterion "depends" when assigning exposure scores. Although that this has affected the estimated level of agreement between experts it is unlikely to have impacted on the ability to identify exposed skills/activities and overall conclusions drawn by the work. This is because exposure ratings of "depends" were used as to identify the skills/activities that needed to have their exposure likelihood further evaluated in the consensus discussions. A final score of exposed/'unexposed was assigned to all skills/activities included in ESCO.

Through the consensus exercise a total of 63 and 508 ESCO items were identified as exposed to welding fumes and diesel exhaust, respectively. This large difference of exposed skills/activities and competencies between the two substances can be attributed to the fact that diesel engines, the source of diesel exhaust exposure are commonly used both within workplaces for various processes as well as outside causing both direct and indirect (environmental) exposures. In contrast, welding fumes are the by-product of a very specific process (welding) to which most workers will be directly exposed. Environmental exposure to welding fumes is possible but not as common.

6.2 Using ISCO-08+ to identify exposed jobs

The ISCO-08+ classification system includes 3,007 different job descriptions, all comprising sub-groups (i.e. divisions) of the 436 unit groups (4-digit codes) included in the original version of the ISCO-08 classification. It is important to note that the included skills/activities are linked only to those 3,007 sub-groups and not the original 619 1–4-digit codes.

Due to the higher offered resolution the updated ISCO classification offers us a unique opportunity to explore whether these sub-groups can be used to create more meaningful job categories for the development of job exposure matrices. To do this we have undertaken a series of evaluation steps completed at this stage though only for welding fumes.

In the first step we had our three experts evaluating the exposure likelihood for each of the 3,007 and 619 job codes included in the updated and original version of the classification (Table 8 and Table 9) blind to the ESCO skills evaluation. These evaluations resulted in good agreement between both pairs of experts and overall. Following consensus discussions between the experts, 11 jobs were identified as exposed at the 1-4 ISCO digit level. The included occupations are comparable to those in earlier job exposure matrices like FINJEM and the ISCO-68 coded INTEROCC (17). INTEROCC contains 177 exposed to welding fumes ISCO-68 job codes of which only 30 have a prevalence of exposure above 50%; all belonging to unit groups of 3 job codes at the minor group level 3-digit (ISCO-68 job code): plumbers and pipe fitters (8-71), welders and flame cutters (8-43), and sheet metal workers (8-73). In the same JEM. An additional 42 job codes from the minor job groups of machinery fitters and

assemblers (8-41), motor vehicles mechanics (8-43), aircraft mechanics (8-44) and machine fitters, assemblers and mechanics not elsewhere classified (8-49) are estimated as having an exposure prevalence of 40%. In general, these occupations are well represented within the exposed job codes of our evaluations at the 1-4 digit of the ISCO-08 classification.

An additional 28 job codes were identified as exposed following the consensus on the 5–8-digit job codes (Table 10). Of those 28 job codes, 8 were sub-groups of unit groups (1–4-digit codes) not considered as exposed in the previous evaluation. This number of sub-groups to the unit groups codes that would otherwise be considered as unexposed increased to 18 when evaluations at the 5-8 digit code were performed accounting for the skill/activities underlying the jobs titles and their exposure status. The higher number of resulting exposed jobs when information on skills/activities was available can likely be explained by an increased awareness and insight on job responsibilities by the experts. Previously, it has been suggested that increased information may be related to increased disagreement in expert evaluations (18), which to an extend seems to also be the case in our analysis (overall kappa in evaluation without considering skills was 0.61 vs 0.51 when considering skills). However, such information bias, although plausible at an individual assessment level, is unlikely to be present on the resulting final exposure assignments following the consensus agreements.

When developing a JEM for general population studies it is typical that generic job titles are considered as exposed to reduce misclassification and increase specificity. Seldomly sub-groups of a generic job title at the 4 digits of the ISCO code may be considered at an ad-hoc basis. For example, in a previous quantitative JEM for the general population that assessed exposure to respirable crystalline silica, generic job codes such as material handlers or labourers were divided into two sub-codes comprising of those working in industries with likely exposure to silica (e.g. construction, stone quarrying, manufacturing of pottery, clay products, cement, lime or plaster) and those without. - the first were considered as sub-codes exposed to silica and the latter as not (19). Similar to this approach, the 5–8-digit job codes available by ESCO (ISCO-08+) can be used to identify the subgroups of the job codes in the original ISCO classification (4^{th} digit codes) that could potentially be considered as exposed. Our analysis for welding fumes summarised earlier has identified those even suggesting that the number of such job titles is rather considerable (18 when considering the approach where you use skills/activities).

However, for the separation of a job code to several sub-codes to be meaningful when assessing exposure and developing a JEM a meaningful prevalence of the workers performing these jobs is also needed. This in itself requires knowledge of the distribution of workers across different job titles so that job codes with small sizes of workforce can be aggregated further either in larger exposed groups, or, when this is not meaningful have their exposure status overwritten as unexposed. Unfortunately, such information, to the best of our knowledge, although commonly available for the 4^{th} digit ISCO codes though Eurostat and other national statistics, are not currently available for the 5–8-digit ISCO codes. As a result, any further work to aggregate those job codes will likely also need to be based in the evaluations by experts.

6.3 Using ESCO to identify exposed jobs

In a concurrent effort we tried to evaluate whether assigning exposure to jobs on the basis of only the exposure status of the ESCO skills/activities and without any input/ quality control by

experts can lead to meaningful exposure assignments. This, if possible, will result in a reduced effort when assigning exposure based on skills/activities.

We implemented three different methods to assign exposure scores to the job codes of ISCO-08+ based on the number of exposed skills/activities linked to them and their importance (i.e. whether are essential or optional). We then compared the agreement between the resulting evaluations with those delivered for the ISCO classification using experts with and without accounting for the exposed skills.

It needs to be made clear that there is no golden standard in these comparisons which all involve expert evaluations in at least one stage. Experts are generally considered as a credible method for assessing occupational exposures in general population studies (ref- peters et al) and an additional evaluation at the job level should be re-assuring towards a reduced misclassification potential particularly in terms of the presence of increased specificity in the final evaluations. Overall, the results from the comparisons of the different exposure assignment methods suggest the presence of moderate agreement between the exposure assignment using skills with and without expert input at the job level. However, clearly the distribution of exposed jobs differed between methods which suggest that the resulting list of exposed occupations may be subject to the method used. It is important to note that welding fumes is a substance with relative small exposure prevalence among workers of the general population. In contrast, diesel exhaust is much more prevalent exposure and thereby it may not be surprising if such findings are not observed if the same analysis is repeated for this exposure. In addition, any further aggregation of the exposed codes based on the distribution of workers across the different jobs, which, as note earlier, is desirable and needs to take place, may also affect these findings.

6.4 Future research

As discussed in section 4.4 within the given timelines we have been able to complete all working steps for welding fumes, but the work evaluating the ISCO-08 + system for diesel exhaust was not completed. It will be very useful if in the future the evaluations for the ISCO-08+ classification are also finalised for diesel exhaust. A comparison between the results of this analysis with those obtained for the welding fumes will provide insights on the potential implications of the differences between exposures when assigning exposures using these two newly developed classification systems – the ESCO and the ISCO-08+.

Clearly, some further work on 4–8-digit code level of the ISCO system is needed particularly towards aggregating the smallest exposed groups. Ideally, this should be performed based on the underlying distribution of workers that comprise these categories. Unfortunately, we have been unable to identify relevant population data and thereby experts may need to be called to assign a prevalence or assess the size importance of the involved subcodes. This means the inclusion of an additional step on the evaluation process described in Figure 2, taking place likely between steps 6 and 7 of the process.

Amid the novelty of the undertaken approach and the potential strong interest of the epidemiological and exposure assessment research community on the usefulness of the newly developed ESCO and ISCO-08+ classification systems we intend to publish the results of the undertaken evaluations in at least one scientific paper. These will, among others, also describe all lessons learned from the present work and guidance on how to most optimally use these

newly developed classifications to establish more meaningful job categories for the development of JEMs.

7. Closing remarks

The present deliverable describes the methodology and initial results of research undertaken to evaluate the usefulness of a newly developed classification system that systematically categorize the skills/activities and competencies required for performing a particular job (ESCO classification) and an interlinked and updated job classification system that groups existing occupations in greater detail than the previously available 1–4-digit ISCO-08 coding system.

The complete analysis results were obtained for one of the two substances selected and used in the process. Despite this, the results suggest a potential for the two classifications to assist in the development of more meaningful exposure categories for JEMs and some important lessons on their use have already become apparent:

- ESCO is very generic classification and a large proportion of the include entries refer to generic knowledge and are thereby highly unspecific and irrelevant in an exposure assessment context. If the intend of the evaluation is to use skills/activities to identify the jobs that are exposed to a specific substance/exposure then it is recommended that these generic knowledge/highly unspecific items are a-priory considered as unexposed.
- The size of the ESCO classification is challenging and results in a considerable effort when assigning exposure using the system. Skills within this classification are grouped in broader categories like transport services, assembling furniture, accounting and taxation, consulting. These categories can potentially be useful to identify and assign a non-exposed status to skills/activities that are not relevant to the exposure of interest.
- Using the updated ISCO-08 5–8-digit classification (i.e. ISCO-08+) is also challenging in terms of the effort required given that the included occupations are highly specific. Although that the diesel evaluations are not yet completed it seems likely that some additional work to remove small sized occupational groups from the included codes is required. Unfortunately, thus far the research team has been unable to identify relevant data that can be used to inform this process.
- ESCO skills/activities are linked only to the 5–8-digit ISCO job codes and thereby the included skills/activities cannot be used to directly identify exposed jobs at the 1-4-digit code level which is used by the original ISCO classification and commonly also by epidemiological studies.
- Despite the lack of linkage between skills and the 1–4-digit ISCO-codes, ESCO seems to be useful in identifying exposed sub-categories of occupations at this level which otherwise were to be considered unexposed.
- For exposed job-codes at the 5–8-digit code level an additional evaluation on the importance of those categories in terms of size and/or differences from the original 1-4-digit occupational group is needed. For this the needed population distribution data seem to not be available at present.
- Based on the results of our evaluations for welding fumes, using skills/activities to identify exposed jobs without any quality control by experts seems inappropriate as results are between the approaches are very different. Welding fumes is an exposure

with a low prevalence in the general population and whether the above apply also to substances with higher prevalence remains a topic for future research.

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Annex

Table A1. List of the 11 job codes at the 1-4 digit level of the ISCO-08 classification identified as exposed in step 6_{1a}.

ISCO code	Preferred label for occupation	Description
7126	Plumbers and pipe fitters	Plumbers and pipe fitters assemble, install, repair and maintain pipe systems, drains, gutters, ducts and related fittings and fixtures for water, gas, drainage, sewerage, heating, cooling and ventilation systems, and for hydraulic and pneumatic equipment. Tasks include - (a) examining blueprints, drawings and specifications to determine the layout of plumbing and ventilation systems and materials required; (b) measuring, cutting, threading, bending, jointing, assembling, installing, maintaining and repairing pipes, fittings and fixtures of drainage, heating, ventilation, water supply and sewerage systems; (c) installing gas appliances, dishwashers and water heaters, sinks and toilets using hand and power tools; (d) laying clay, concrete or cast-iron pipes in ditches to form sewers, drains or water mains, or for other purposes; (e) inspecting, examining and testing installed systems and pipes, using pressure gauge, hydrostatic testing, observation or other methods. Examples of the occupations classified here: - Drain technician - Gas fitter - Pipe fitter - Pipe layer - Plumber - Ventilation pipe fitter
7127	Air conditioning and refrigeration mechanics	Air conditioning and refrigeration mechanics assemble, install, maintain and repair air conditioning and refrigeration systems and equipment. Tasks include - (a) interpreting blueprints, drawings and other specifications; (b) assembling, installing and repairing components such as compressors, motors, condensers, evaporators, switches and gauges for air conditioning and refrigeration systems; (c) connecting piping and equipment by bolting, riveting, welding or brazing; (d) testing systems, diagnosing faults and performing routine maintenance or servicing.

		Examples of the occupations classified here: - Air conditioning equipment mechanic - Refrigeration mechanic
721	Sheet and structural metal workers, moulders and welders, and related workers	Sheet and structural metal workers, moulders and welders, and related workers, make moulds and cores for casting metal, weld and cut metal parts, make and repair articles of sheet metal, and install, erect, maintain and repair heavy metal structures, tackle, cable cars and related equipment. Tasks performed usually include: making moulds and cores for casting metal; casting, welding and shaping metal parts; making and repairing articles of sheet metal such as sheet steel, copper, tin or brass; installing, erecting, maintaining and repairing heavy metal structures as well as tackle, cable cars and related equipment. Occupations in this minor group are classified into the following unit groups: 7211 Metal Moulders and Coremakers 7212 Welders and Flame Cutters 7213 Sheet Metal Workers 7214 Structural Metal Preparers and Erectors 7215 Riggers and Cable Splicers
7212	Welders and flamecutters	Welders and flame cutters weld and cut metal parts using gas flame, electric arc and other sources of heat to melt and cut, or to melt and fuse metal. Tasks include - (a) welding metal parts using gas flame, or an electric arc, thermite compound or other methods; (b) operating resistance-welding machines; (c) using blowtorches to make and repair lead linings, pipes, floors and other lead fixtures; (d) brazing metal parts together; (e) cutting metal pieces using gas flame or an electric arc; (f) joining metal parts by hand soldering; (g) monitoring the fitting, burning and welding processes to avoid overheating of parts or warping, shrinking, distortion or expansion of material; (h) examining work pieces for defects and measuring work pieces with straight edges or templates to ensure conformity with specifications. Examples of the occupations classified here: - Brazier

		- Flame cutter - Welder
7213	Sheet-metal workers	Sheet metal workers make, install and repair articles and parts of articles made out of sheet metal such as sheet steel, copper, tin, brass, aluminium, zinc or galvanized iron. Tasks include - (a) marking sheet metal for cutting and shaping; (b) making and repairing household utensils and other articles in tin, copper and light alloys, or ornamental articles and fittings; (c) making and repairing boilers, tanks, vats and similar containers; (d) installing and repairing sheet metal parts of vehicles and aircraft; (e) converting blueprints into shop drawings to be followed in the construction and assembly of sheet metal products; (f) determining project requirements, including scope, assembly sequences and required methods and materials, according to blueprints, drawings and written or verbal instructions; (g) inspecting product quality and installation to ensure conformity with specifications. Examples of the occupations classified here: - Boilersmith - Coppersmith - Panel beater - Tinsmith
7214	Structural-metal preparers and erectors	Structural metal preparers and erectors assemble, erect and dismantle structural metal frames of buildings and other structures. Tasks include - (a) marking metal framework as a guide when drilling cutting, and shaping metal stock for use in buildings, ships and other structures; (b) drilling, cutting and shaping structural steel in a workshop; (c) erecting steel framework for buildings, bridges and other constructions; (d) assembling and erecting the framework and other metal parts of shipsâ€™ structures; (e) shaping and fitting structural steel plates of ships under construction or repair; (f) riveting structural metal members by hand, machine or pneumatic riveter. Examples of the occupations classified here:

		- Erector, structural metal - Preparer, structural metal - Riveter
722	Blacksmiths, toolmakers and related trades workers	Blacksmiths, toolmakers and related trades workers hammer and forge bars, rods or ingots of iron, steel and other metals to make and repair various kinds of tools, equipment and other articles; set machine tools for operators, or set and operate various machine tools; and polish and sharpen surfaces. Tasks performed usually include: hammering and forging iron, steel and other metals to make and repair various kinds of tools, equipment and other articles; setting machine tools for operators, or setting and operating various machine tools working to fine tolerances; polishing and sharpening metal surfaces and tools. Occupations in this minor group are classified into the following unit groups: 7221 Blacksmiths, Hammersmiths and Forging Press Workers 7222 Toolmakers and Related Workers 7223 Metal Working Machine Tool Setters and Operators 7224 Metal Polishers, Wheel Grinders and Tool Sharpeners
7221	Blacksmiths, hammersmiths and forging press workers	Blacksmiths, hammersmiths and forging press workers hammer and forge bars, rods, ingots and plates of iron, steel or other metals, and draw wire to make and repair various kinds of tools, metal articles, pieces of equipment, and agricultural and related implements. Tasks include - (a) heating metal in forge furnaces and manufacturing and repairing articles by drawing, bending, cutting, hammering metal on an anvil, punching, shearing, joining and hardening or tempering; (b) shaping heated metal into forgings on power hammers equipped with open dies; (c) operating closed-die drop hammers to forge metal articles; (d) operating a power-press machine equipped with closed dies to forge metal articles; (e) drawing wire; (f) reading work orders or blueprints to determine specified tolerances and sequences of operations for machine setup; (g) measuring and inspecting machine parts to ensure conformity with product specifications. Examples of the occupations classified here: - Blacksmith - Drop hammer worker

		- Forging press worker - Hammersmith
7222	Toolmakers and related workers	Toolmakers and related workers make and repair custom-made and specialized tools, sports guns, locks, dies, patterns, machinery components and other metal articles using hand and machine tools to work metal to fine tolerances. Tasks include - (a) reading and interpreting engineering drawings and specifications of tools, dies, prototypes or models; (b) preparing templates and sketches, and determining work processes; (c) visualizing and computing dimensions, sizes, shapes and tolerances of assemblies, based on specifications; (d) positioning, securing and measuring metal stock or castings to lay out for machining; (e) setting up, operating and maintaining conventional and computer numerically controlled machine tools to cut, turn, mill, plane, drill, bore, grind or otherwise shape work pieces to prescribed dimensions and finish; (f) fitting and assembling parts to make and repair jigs, fixtures and gauges; (g) repairing and modifying sports guns and other small arms; (h) making, fitting, assembling, repairing and installing lock parts and locks; (i) making and repairing metal patterns for preparation of foundry moulds; (j) laying out lines and reference points on metal stock to guide other workers who cut, turn, mill, grind or otherwise shape metal; (k) verifying dimensions, alignments and clearances of finished parts for conformity with specifications, using precision measuring instruments and testing completed items for proper operation. Examples of the occupations classified here: - Die maker - Gunsmith - Jig maker - Locksmith - Patternmaker - Toolmaker

7231	Motor vehicle mechanics and repairers	Motor vehicle mechanics and repairers fit, install, maintain, service and repair engines and the mechanical and related equipment of passenger cars, delivery trucks, motorcycles and other motor vehicles. Tasks include - (a) detecting and diagnosing faults in engines and parts; (b) fitting, examining, testing and servicing motor vehicle and motorcycle engines; (c) replacing engine components or complete engines; (d) fitting, examining, adjusting, dismantling, rebuilding and replacing defective parts of motor vehicles; (e) installing or adjusting motors and brakes, and adjusting steering or other parts of motor vehicles; (f) installing, adjusting, servicing and replacing mechatronics components of motor vehicles; (g) performing scheduled maintenance services, such as oil changes, lubrications and engine tune-ups, to achieve smoother running of vehicles and ensure compliance with pollution regulations; (h) reassembling engines and parts after being repaired. Examples of the occupations classified here: - Automotive brakes systems service technician - Diesel fitter (road transport) - Engine fitter (motor vehicle) - Garage mechanic - Moped repairer - Motorcycle mechanic - Motorized rickshaw mechanic - Motor vehicle engine and fuel systems service technician - Motor vehicle mechanic - Motor vehicle mechatronics service technician - Motor vehicle repairer - Motor vehicle service technician - Small engine mechanic
7233	Agricultural and industrial machinery mechanics and repairers	Agricultural and industrial machinery mechanics and repairers fit, install, examine, service and repair engines, agricultural and industrial machinery and mechanical equipment, except motor vehicle, aircraft and electric motors. Tasks include - (a) fitting, installing, examining, servicing and repairing engines, machinery and mechanical equipment;

		(b) oiling and greasing stationary engines and machinery; (c) inspecting and testing new machinery and mechanical equipment for conformity with standards and specifications; (d) disassembling machinery and equipment to remove parts and make repairs; (e) examining parts for defects such as breakage and excessive wear; (f) operating newly repaired machinery and equipment to verify the adequacy of repairs; (g) recording repairs and maintenance performed. Examples of the occupations classified here: - Construction machinery mechanic - Construction machinery repairer - Farm machinery repairer - Mining machinery fitter - Mining machinery repairer - Stationary engine fitter - Stationary engine repairer - Train engine fitter - Train engine repairer

Table A2. Examples of generic ESCO skills and relevant descriptions

Skill group	Main label preferred for skill	Alternative labels	Description
operating watercraft	understand different types of locks and their operation	understand the operation of various types of locks, perform water lock operations, understand the operation of locks and bridges, understand the operation of bridges and water locks, understand the operation of different types of locks, understand different water locks and their operation, comprehend and perform lock operations, comprehend lock traversal operations, perform lock traversal operations, comprehend and apply principles of lock operations	Master various engineering constructions and functions of bridges and locks in the field of navigation. Conduct locking and entering procedures.
building and civil engineering	traffic engineering	traffic engineering, traffic engineering fieldwork, traffic engineering studies, engineering for traffic traffic engineering analyses, traffic engineering applications, traffic engineering analysis, traffic engineering work, traffic engineering research	The subdiscipline of civil engineering that applies engineering methods to create safe and efficient traffic flows of people and goods on roadways, including sidewalks, traffic lights, and cycle facilities.
installing wooden and metal components	apply restoration techniques	apply restoration methods apply restoration techniques implement restoration methods	Select and apply appropriate restoration techniques in order to achieve the required restoration goals. This encompasses preventive measures, remedial measures, restoration processes and management processes.
teaching safety procedures	train staff in safety procedures	train staff in safety measures, deliver safety training to staff, provide training to staff on safety procedures, educate staff in safety, procedures, implement staff safety procedures training, implement safety procedures training for staff, provide staff training on safety procedures, train staff in safety procedures	Educate and train team members in the safety procedures relevant to the mission of the team.
accepting feedback	execute working instructions	perform working instructions, execute work orders execute work instructions, execute working instructions, execute job instructions apply working instructions	Understand, interpret and properly apply work instructions regarding different tasks in the workplace.