

Cohort Profile: The European Occupational Exposome Mega Cohort Consortium (OMega-X)

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Key Features

- The European Occupational Exposome Mega Cohort Consortium (OMega-X) was established as a long-term resource to support large-scale coordinated cohort analysis to advance knowledge regarding the health impacts of complex working-life exposures.
- Twenty-four cohorts based in eight European countries, as well as multi-country studies, containing >20 million participants, currently form the Consortium.
- Industrial/occupational and population-based cohorts range in size from a few hundred to thousands of workers; large-scale register-based general-population cohorts comprise millions of workers. Most cohorts were established and followed participants since the year 2000; some follow workers from the 1950s to the 1990s. Job-history data primarily capture the working lifetime or follow-up period.
- The Consortium is supported by online inventories and tools. The European job-exposure matrix (EuroJEM) provides harmonized exposure assessment information by job code for airborne infectious agents, chemical and particle exposures, heat stress, noise, physical workload, precarious employment, psychosocial exposures, and solar ultraviolet radiation.
- Analyses have to date examined a broad range of occupational exposures in relation to cancer; cardiometabolic, musculoskeletal, neurodegenerative, and respiratory diseases; mental disorders; and work-participation outcomes.
- Application procedures for researchers to propose a new analysis or for new cohorts to join the Consortium are available.

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Why was the cohort set up?

Europe has a long tradition of occupational health research and currently has a range of industry-, occupation-, and population-based cohorts that have collected a wealth of data on occupational exposures and health outcomes [1, 2]. We sought to create a cohort consortium to facilitate large-scale coordinated analysis across multiple European studies to advance knowledge regarding complex working-life exposures and health.

The overall aim of the European Occupational Exposome Mega Cohort Consortium (OMega-X) is to evaluate occupational risk factors and the occurrence of major noncommunicable diseases (NCDs) based in an exposome perspective [3]. It also seeks to create a long-term resource to study occupations, work-related exposures, and health during and after the working life [4].

The Consortium was formed as part of the EU Exposome Project for Health and Occupational Research (EPHOR) project (<https://www.ephor-project.eu/>) (2020–5) [3], which builds upon a previous network that sought to coordinate European occupational cohorts (OMEGA-NET) (<https://omeganetcohorts.eu/>) (2017–22) [2]. EPHOR sought to better characterize the working-life exposome including through forming the cohort consortium, a European job-exposure matrix (EuroJEM), and the use of exposome-based analytics. Large-scale cohort data are needed to support agnostic exploration and studies of rare exposures or outcomes, and to identify vulnerable life stages or population subgroups. The recent EU INTERCAMBIO project (<https://intercambio-project.eu/>) (2024–8) further extends the work of the Consortium with a focus on the mental and physical health impacts of occupational climate exposures [5].

The Consortium is a key resource for research on: (i) the most important working-life risk factors for the development of NCDs (including cancer, cardiometabolic, musculoskeletal, neurodegenerative, and respiratory diseases, and mental disorders), (ii) the way in which occupational factors and NCDs influence work participation and working-life expectancy, (iii) whether previously unknown working-life risk factors can be identified, (iv) whether working-life and non-working-life exposures interact, (v) whether those with relevant morbidities are particularly vulnerable, (vi) whether critical exposure time windows can be identified, including preconception and prenatal periods, and (vii) whether transgenerational effects of working-life exposures can be observed.

Who is in the cohort?

Cohorts were eligible if they were active with accessible data; had at least one follow-up that had already been performed or was planned; contained information on occupation, industry, or at least one occupational exposure; and were registered in an online inventory of occupational cohorts (<https://occupationalcohorts.net>) [1]. Cohorts with an interest in NCDs as well as in work participation and working-life expectancy as outcomes [6] were invited to participate. Overall, a total of 24 cohorts based in eight European countries (Belgium, Denmark, Finland, France, Norway, Spain, Sweden, the Netherlands), as well as multi-country studies, containing data on >20 million participants, formed the Consortium (Fig. 1).

Included cohorts range from smaller studies including hundreds to thousands of workers with detailed occupational exposure and/or outcome characterization, to large-scale register-based general-population cohorts including millions of participants representing entire working populations of some countries (Table 1 and Supplementary Table S1). The diversity of included cohorts was intended to enable the Consortium to be adaptable to address a range of research questions and to serve as a flexible resource for epidemiological research over time.

Cohorts were established for a variety of reasons, including to serve as large nationwide databases, as general-purpose cohorts with an interest in occupational risk factors, or as cohorts that were focused on certain occupations (e.g. utility-company workers) or exposures (e.g. night-shift work). Other cohorts focused on particular outcomes (e.g. respiratory disease and allergy). Cohorts typically recruited participants based on national sampling frames, though some were based in specific geographic subregions (e.g. GCAT in Catalonia, Lifelines in Northern Netherlands).

Cohorts were largely established and followed participants after the year 2000. Some, however, followed workers from the 1950s (SLFF), 1960s (Danish Styrene cohort, Nor-Work), 1970s (DOC*X, SNOW, SWIP), 1980s (HUNT), or 1990s (ECRHS, GAZEL, PRECUBE, RHINE, the SUS Study) for decades. All cohorts included both male and female workers, except for SwedSweeps and WeldCancer, which focused on males. Cohorts generally captured the full age range of the working population, though some focused more on younger (e.g. the SUS Study) or older (e.g. STREAM) workers. Although birth or child cohorts were not a primary focus [7], in a small number of studies, information was captured on adolescent workers (e.g. HUNT, Lifelines) or the offspring of adult workers (e.g. DOC*X, RHINESSA).

Participation rates at enrollment in general-population-based cohorts ranged from 8% in CONSTANCES to 78% in ECRHS or 89% in HUNT1 and can vary according to personal or demographic characteristics such as sex, age, or educational attainment [8–10]. In the Work Environment and Health in Denmark (WEHD) cohort, there were differences in participation by job type, which were only partially explained by other sociodemographic factors [10]. In RHINESSA, there were similar parental characteristics among participating and nonparticipating offspring [11]. Among industry- or occupation-based studies, participation rates ranged from 44% (GAZEL) to 100% (ATOHS, Danish Styrene cohort) and, in register-based cohorts, they were also nearly 100%. Enrollment has been completed for most cohorts, though some cohorts remain open with enrollment ongoing.

How often have they been followed up?

Cohorts used a variety of methods to follow up participants, including active contact, either alone or in combination with clinical/functional evaluation or biomarkers. Other cohorts primarily used passive methods such as death certificates, electronic medical records, or other registry-based approaches. In some studies, a mix of both active and passive follow-up is performed at differing time intervals. In CONSTANCES and GAZEL, yearly follow-up combines active contact (questionnaires) with linkage

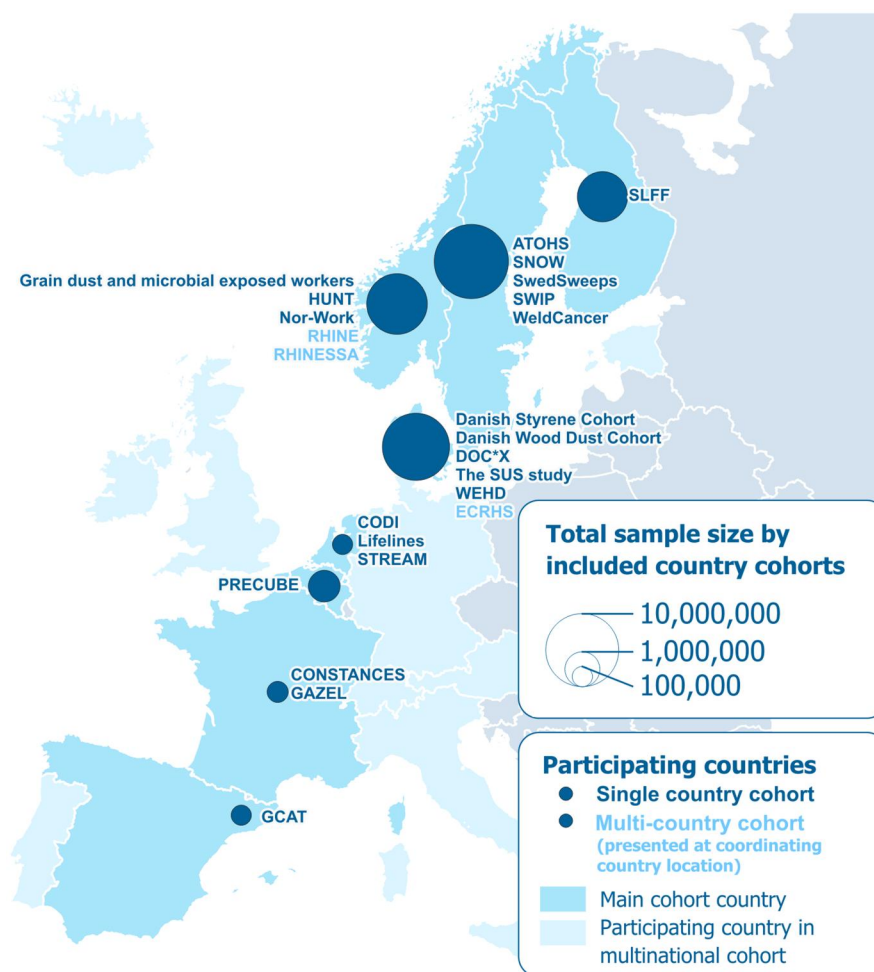


Figure 1 Cohorts forming OMEGA-X.

to national health and administrative registers. In GCAT, annual follow-up through electronic health records is performed, whereas active contact (questionnaires) occurs periodically. The total number of follow-ups performed ranges from one through to essentially continuous follow-up (in registry-based designs). Most cohorts have follow-ups planned. Although participation rates over follow-up were relatively high in most cohorts, in some that typically relied on active follow-up methods, they were sometimes <50% of enrolled participants ([Supplementary Table S2](#)). In HUNT, attrition was greater among older participants and those with poorer health [12]. In Lifelines, participants who withdrew differed by education and employment status [13].

What has been measured?

Cohorts captured a wide range of demographic, occupational, biological, and health-outcome data. All cohorts contain basic demographic data. For occupational history, information typically covers the working lifetime or follow-up period ([Table 1](#)). In some registry-based cohorts, however, there are data gaps of ≥ 10 years in the early years of follow-up due to use of census-based occupational data. This required imputation for missing

years based on cohort-specific assumptions. In more recent years, occupational information is captured annually based upon job-employment records or administrative data. In other cohorts, occupational-history information is captured directly from participants. In a small number of cohorts, occupational information was available for only a specific time period, at enrollment, or for the longest-held job.

Cohorts have used multiple occupational-exposure assessment methods, including questionnaires, expert assessment, job-exposure matrices (JEMs), environmental or personal sampling, breath or exposure biomonitoring, or combinations thereof ([Supplementary Table S3](#)). Occupational exposures of interest among the cohorts were commonly psychosocial domains, ergonomics and physical workload, dusts and fibers, and the organization of work and working time. Some cohorts compiled detailed data on specific topics. Working Hours and Health in Healthcare in Sweden (ATOHS) holds detailed registry-based data on working hours, day by day for the follow-up period. In the Danish styrene cohort, modeled occupational styrene exposure was estimated based on personal airborne measurements [14].

Cohorts used a variety of systems to code job-title data that have been harmonized to the International Standard Classification of Occupations (ISCO)-88(COM) to apply EuroJEM (below). In some instances, coding system crosswalks were used

Table 1 Overview of cohorts in Omega-X.

Cohort, country	Source population	Follow-up			Enrollment				Occupational information				Outcome data						
		Men (n)	Women (n)	Children/ adoles- cents (n)	Participation rate (%)	Age range (minimum– maximum, mean years) ^a	Status	Time period	Data source	Job coding	Data type	Cancer	Cardio- meta- bolic	Mental dis- orders	Musculo- skeletal	Neurode- genera- tive	Respi- Work ratory partici- pation		
ATOHS, Sweden CODI, the Netherlands	Industry/occupa- tion-based	2008–2023	15 000	45 000	Not available	100	17–75, 40	Ongoing	Follow-up period	Job-employment records; registry-based	Yes	Registry-based	X	X	X	X	X		
	General popula- tion: national	2017–2025	9775	8236	389	53	15–83, 41	Ongoing	Follow-up period	Questionnaire, per- sonal (self-reporting or interview)	No	Questionnaire, individ- ual (self-recording or interview); regis- try-based	X	X	X	X	X		
CONSTANCES, France	General popula- tion: national	2013–2024	102 000	117 000	Not applicable	8	18–69, 46	Completed	Lifetime	Questionnaire, per- sonal (self-reporting or interview); job-employ- ment records; job calendar	Yes	Biomarker; death certificates; medical records; registry-based	X	X	X	X	X		
Danish Styrene Cohort, Denmark	Industry/occupa- tion-based	1968–2012	60 478	11 774	Not available	100	16–80+, 34	Completed	Follow-up period	Questionnaire, per- sonal (occupational/ industry modules); in- dustry-based question- naire; job-employment records; registry-based; environmental samples	Yes	Death certificates; medical records; registry-based	X	X	X	X	X		
Danish Wood Dust Cohort, Denmark	Industry/occupa- tion-based	2003–2004	1665	368	Not available	88	16–67, 36	Completed	Lifetime	Questionnaire, per- sonal (occupational/ industry modules); industry-based questionnaire; environmental samples	Yes	Biomarker; clinical/ functional evaluation					X		
DOC* ^x , Denmark	General popula- tion: national; mother–child cohort; generation (parents–child- dren) study	1976–2022	3.0 million	2.4 million	2.5 million	95	16–105, 35	Ongoing	Follow-up period	Job-employ- ment records	Yes	Death certificates; medical records; regis- try-based	X	X	X	X	X		
ECRHS, multi-country	General popula- tion: international	1999–2003	5000	5000	Not applicable	78	20–44, 33	Ongoing	Lifetime	Questionnaire, per- sonal (self-reporting or interview; occupa- tional/industry modules); environmental samples	Yes	Biomarker; clinical/ functional evaluation; questionnaire, individ- ual (self-recording or interview)	X			X	X		
GAZEL, France	Industry/occupa- tion-based	1990–2025	15 011	5614	Not applicable	44	35–50, 44	Completed	Lifetime	Questionnaire, per- sonal (self-reporting or interview); job-employ- ment records	Yes	Death certificates; medical records; ques- tionnaire, individual (self-recording or interview)	X	X	X	X	X		
GCAT, Spain	General popula- tion: regional	2017–2023	7852	11 373	Not applicable	Not available	40–65, 51	Completed	Lifetime	Questionnaire, per- sonal (self-reporting or interview)	Yes	Death certificates; medical records; ques- tionnaire, individual (self-recording or interview)	X	X	X	X	X		

(continued)

Table 1 (continued)

Cohort, country	Source population	Follow-up			Enrollment			Occupational information				Outcome data						
		Men (n)	Women (n)	Children/adolescents (n)	Participation rate (%)	Age range (minimum–maximum, mean years) ^a	Status	Time period	Data source	Job coding	Data type	Cancer	Cardio-metabolic	Mental disorders	Musculo-skeletal	Neurodegenerative	Respi-ratory	Work participation
Grain dust and microbial exposed workers, Norway	Industry/occupation-based	2008–2009	94	10	2	80	16–61, 41 exposed; 21–60, 46 unexposed	Completed	Current, at enrollment/measurement	Questionnaire, personal (self-reporting or interview); environmental samples; other (personal exposure samples)	No	Biomarker; clinical/functional evaluation; questionnaire, individual (self-recording or interview)	X					X
HUNT, Norway	General population: regional	1984–2019	66 000	56 000	8000	89 ^b	13–101, 51	Ongoing	Follow-up period (lifetime when linked to national registers)	Questionnaire, personal (self-reporting or interview); occupational/industry modules; breath samples	Yes	Biomarker; questionnaire, individual (self-recording or interview); registry-based	X	X	X	X	X	X
Lifelines, the Netherlands	General population: regional	2006–2025	70 674	97 055	14 801	34	0–93, 42	Ongoing	Follow-up period	Questionnaire, personal (self-reporting or interview); job calendar	Yes	Biomarker; clinical/functional evaluation; questionnaire, individual (self-recording or interview)	X	X	X	X	X	X
Nor-Work, Norway	General population: national	1960–2022	3.3 million	2.5 million	Not available	100	17–80, 43	Ongoing	Lifetime	Job-employment records; registry-based	Yes	Death certificates; medical records; registry-based	X	X	X	X	X	X
PRECUBE, Belgium	General population: national and regional	1993–2025	370 000	330 000	3000	100	15–80, 41	Ongoing	Follow-up period	Questionnaire, personal (self-reporting or interview); occupational/industry modules; job-employment records; job calendar; environmental samples	Yes	Questionnaire, individual (self-recording or interview)	X	X	X	X	X	X
RHINE, multi-country	General population: international	1999–2022	10 071	11 588	Not applicable	86	20–44, 31	Ongoing	Lifetime	Questionnaire, personal (self-reporting or interview)	Yes	Questionnaire, individual (self-recording or interview)	X				X	X
RHINESSA, multi-country	General population: international; general population: regional; general population (parents–children) study	2012–2025	3720	5094	1139	35	4–72, 28	Ongoing	Lifetime	Questionnaire, personal (self-reporting or interview); occupational/industry modules; job-employment records; job calendar	Yes	Biomarker; clinical/functional evaluation; questionnaire, individual (self-recording or interview)	X			X	X	X
SLIFF, Finland	General population: national	1952–2023	1.8 million	1.8 million	Not applicable	100	18–68, 43	Ongoing	Lifetime	Job-employment records; registry-based	Yes	Death certificates; registry-based	X	X	X	X	X	X
SNOW, Sweden	General population: national	1970–2020	2.5 million	2.5 million	Not available	100	15–75, 43	Ongoing	Lifetime	Job-employment records; registry-based	Yes	Biomarker; clinical/functional evaluation; death certificates; medical records; registry-based	X	X	X	X	X	
STREAM, the Netherlands	General population: national	2010–2024	8112	7006	Not applicable	71	45–64, 54	Completed	Current, at enrollment	Questionnaire, personal (self-reporting or interview)	No	Questionnaire, individual (self-recording or interview); registry-based	X	X	X	X	X	X

(continued)

Table 1 (continued)

Cohort, country	Source population	Follow-up			Enrollment			Occupational information					Outcome data					
		Men (n)	Women (n)	Children/ adoles- cents (n)	Participation rate (%)	Age range (minimum– maximum, mean years) ^a	Status	Time period	Data source	Job coding	Data type	Cancer	Cardio- meta- bolic	Mental dis- orders	Musculo- skeletal	Neurode- genera- tive	Respi- ratory	Work partici- pation
SwedSweeps, Sweden	Industry/occupa- tion-based	2010–2026	300	Not applicable	Not applicable	87 ^c	19–66, 43	Completed	Longest	Questionnaire, per- sonal (self-reporting or interview); biomonitor- ing samples	No	Biomarker; clinical/ functional evaluation; questionnaire, individ- ual (self-recording or interview); regis- try-based	X	X			X	
SWIP, Sweden	General popula- tion: national	1973–2016	2.7 million	2.7 million	Not available	100	16–64, 40	Completed	Lifetime	Job-employment records; registry-based	Yes	Death certificates; medical records; regis- try-based	X	X	X			X
The SUS Study, Denmark	Industry/occupa- tion-based	1995–2008	1734	232	Not available	79	17–49, 19	Completed	Lifetime	Questionnaire, per- sonal (occupational/ industry modules); in- dustry-based question- naire; job-employment records; environmen- tal samples	Yes	Biomarker					X	
WEHD, Denmark	General popula- tion: national; in- dustry/occupa- tion-based	2012–2024	11 861	14 217	Not applicable	51	18–64, 45	Completed	Lifetime	Questionnaire, per- sonal (self-reporting or interview; occupa- tional/industry mod- ules); job-employment records; registry-based	Yes	Death certificates; medical records; ques- tionnaire, individual (self-recording or inter- view); registry-based	X	X	X	X	X	X
WeldCancer, Sweden	Industry/occupa- tion-based	2010–2026	228	Not applicable	Not applicable	Not available	18–65, 44	Completed	Follow-up period	Questionnaire, per- sonal (self-reporting or interview; occupa- tional/industry mod- ules); environmen- tal samples	No	Biomarker; clinical/ functional evaluation; questionnaire, individ- ual (self-recording or interview); registry- based	X	X			X	

^a For registry-based studies, provided based upon a reference year.^b HUNT 1.^c Company response rate, chimney sweeps.

ATOHS, Working Hours and Health in Healthcare in Sweden; CODI, Cohort Study on Sustainable Employability; DOC^aX, Danish Occupational Cohort with exposure data; ECRHS, European Community Respiratory Health Survey; GCAT, Genomes for Life, A Prospective Study of the Genomes of Catalonia; HUNT, The Trøndelag Health Study; Nor-Work, Norwegian Working Age Cohort; RHINE, Respiratory Health in Northern Europe; RHINESSA, The Multi-Generation Respiratory Health in Northern Europe, Spain and Australia Cohort; SLFF, State of the Labour Force in Finland; SNOW, Swedish National Cohort on Work and Health; STREAM, Study on Transitions in Employment, Ability and Motivation; SWIP, Swedish Work, Illness, and Labour-Market Participation Cohort; WEHD, Work Environment and Health in Denmark.

[15]. EuroJEM was developed to provide harmonized exposure assessment data based on job title for agents of priority interest [3, 16]. Other relevant JEMs with additional exposures have also been applied.

Other available cohort data include factors such as alcohol consumption, smoking, physical activity, diet, and medical history (Supplementary Table S4). In some registry-based cohorts, personal lifestyle data are available for a subset of participants. Residential-history information was also captured in several cohorts, in some cases with environmental exposures assigned to participant residence. Outcome information includes disease incidence, disability, and mortality, collected by questionnaires, registers, or medical records. In several cohorts, blood, urine, or other biological samples were captured, in some cases with extensive outcome biomarker or multiomics data available (e.g. ECRHS, GCAT, WeldCancer). Information on sickness absence was captured in several studies.

EuroJEM

EuroJEM includes eight individual JEMs covering 18 exposures [16]. JEMs were formed based upon the harmonization of existing national JEMs to a common exposure assignment and coding system [ISCO-88(COM)] or were newly developed here (Table 2). Harmonized JEMs were created for chemical and particle exposures, noise, physical workload [17], and psychosocial exposures [18]. Newly developed JEMs were created for airborne infectious-agent transmission [19], heat stress [20], precarious employment, and solar ultraviolet (UV) radiation [21]. The individual JEMs that comprise EuroJEM are registered in an online inventory of occupational-exposure assessment tools (<https://occupationalexposuretools.net>) [22].

Ongoing work includes evaluation of the performance of the JEMs. For the physical-workload JEM, developed through the harmonization of existing JEMs from Finland, France, Norway, and Sweden, there was satisfactory predictive validity of musculoskeletal pain [17]. The psychosocial JEM, developed through the harmonization of JEMs from Finland, Norway, and Sweden, demonstrated good predictive validity of diagnosed depression in relation to decision authority (Table 3) [18]. Analysis using the solar UV radiation JEM recently reported exposure-response relations with both melanoma [23] (Fig. 2) and non-melanoma (Fig. 3) skin cancer incidence—particularly basal cell carcinoma [24]. JEMs developed for occupational heat stress and solar UV radiation are currently being further extended and a new JEM for cold stress is being created [5].

What has it found?

Analysis has largely focused on the application of EuroJEM (supplemented by other JEMs). Studies have examined single and multiple occupational exposures by using standard and exposome-based approaches [25–28]. Analysis protocols were harmonized between cohorts to the greatest extent possible. Research questions of primary interest to date are shown in Supplementary Table S5 [29].

Associations of cumulative occupational exposure to heavy lifting and working with hands above shoulder level and diagnosed

shoulder disease were examined by using four large-scale register-based cohorts, with positive exposure-response relationships observed [30]. For respiratory disease, temporal trends in the incidence of interstitial lung disease (ILD) subtypes were examined in three large-scale cohorts [31]. The incidence rates differed for some ILD subtypes by cohort, country, and time period, which may reflect changes in diagnostic criteria or occupational exposures over time. Lifetime cumulative occupational exposure profiles for 49 agents were also examined in relation to ILD incidence, with respirable crystalline silica (RCS) emerging as a common risk factor [28]. Exposome patterns for pulmonary sarcoidosis overlapped with those for hypersensitivity pneumonitis and that of idiopathic interstitial pneumonia with those for silicosis and asbestosis. Associations of the occupational exposome with the incidence of chronic obstructive pulmonary disease revealed mineral dust and RCS as main risk factors [25, 27]. Other ongoing work includes the analysis of multiple occupational exposures in relation to ischemic heart disease and stroke [26], among other topics. Findings to date have supported existing evidence on known/suspected occupational risk factors and also identified previously unrecognized associations.

What are the main strengths and weaknesses?

We have demonstrated the feasibility and added value of large-scale collaboration and the application of an exposome approach in occupational cohort research. The Consortium is a flexible resource that includes a diverse set of major European studies that can be customized to the research questions at hand. The large population with long follow-up time enables the study of rare outcomes (e.g. some ILD subtypes), long latency periods, as well as vulnerable subgroups. Other features include a governance framework, harmonized occupational exposure assessment, data preparation, and analysis methods, and established outcome working groups. The associated research infrastructure includes inventories of occupational cohorts and exposure assessment tools, automated job coding, EuroJEM, and tutorials on multiple-exposure-response, exposure-time-response, and hierarchical regression analysis methods (https://www.we-expose.eu/tools-for-health-scientists#occupational_cohorts).

Each cohort is associated with its own strengths and limitations. Some cohorts have examined the impacts of potential selection bias and selective attrition. In CONSTANCES, a random cohort of nonparticipants is being followed by using national databases and prevalence estimates are being adjusted for selection effects by using sampling weights and reweighting [9]. In ECRHS and RHINE, the main exposure-outcome associations were generally found to be unchanged by participant loss over the follow-up time [32]. The diversity across the cohort designs here can also be exploited to provide information on the impacts of particular biases in individual studies [33].

There are also challenges in preparing lifelong annual job-history information due to missing job-history data, changes in coding systems over time, and translation from national systems, which required tailored approaches. To account for missing lifestyle data in registry-based studies, a JEM can be used, e.g. for predicted smoking probability; however, the potential

Table 2 Overview of EuroJEM.

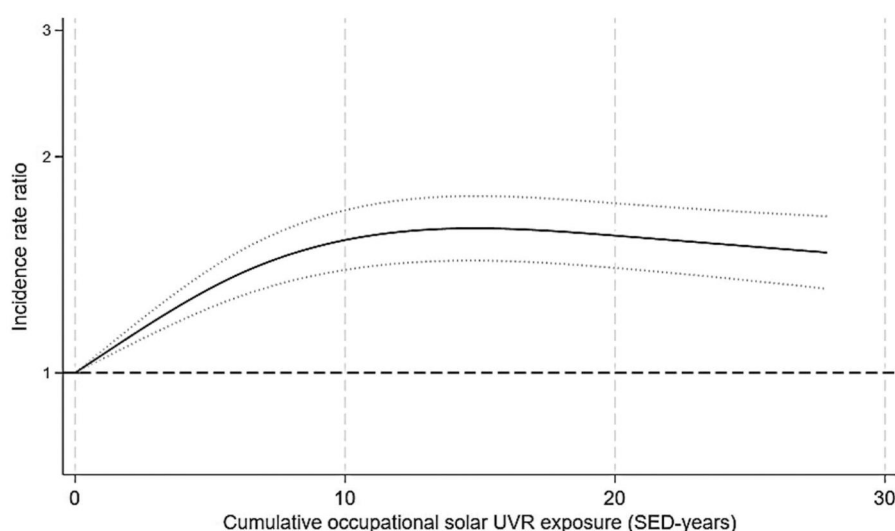
Agent(s)	Specific agents	Input data/input JEMs	Exposure metric(s)	Time period	Axes
Harmonized JEMs					
Chemicals and particles	Diesel engine exhaust, nickel, respirable crystalline silica, wood dust	DEEJEM, DOM-JEM, FINJEM, MatEmEsp, MATGENE, Swedish diesel JEM, SWEJEM, SYN-JEM	Exposure prevalence percentage (<5, 5 to <25, 25 to <75, 75–100), average exposure level among exposed (continuous)	1970–2020 (10-year intervals)	Geographical region, year interval
Noise	Noise exposure	Danish noise JEM, SWEJEM	8-h Laeq level on a continuous scale of 1–5 dB	1970–2020 (5-year intervals)	Year interval
Physical workload	Faster breathing due to heavy physical workload, heavy lifting, working in a forward bent posture, working in kneeling or squatting positions, working with hands above shoulder level	Finnish JEM for physical risk factors, JEM CONSTANCES, Norwegian mechanical JEM, SWEJEM	Exposure prevalence percentage (0–5, 6–24, 25–49, 50–74, 75–100)	1997–2019 (overall)	None
Psychosocial exposures	Decision authority, job demands	Psychosocial JEMs from Sweden, Finland, and Norway	Exposure prevalence percentage (0–24, 25–49, 50–74, 75–100)	1990–2015 (overall)	None
Newly developed JEMs					
Airborne infectious agents	Infectious-agent infection through airborne or droplet transmission	COVID-19 JEM, expert assessment, solar UV radiation JEM (hours per day working inside), national data on hours per week on-site	Risk score from 1 (low risk) to 3 (high risk)	Not specified	Hours spent per week on-site, hours working inside, number of contacts, type of contacts, in close physical contact with others
Heat stress	Annual heat-stress hours	Historic environmental climate, solar UV radiation JEM (hours per day working outside), clothing, local heat and cooling sources, physical-workload JEM	Annual hours of wet bulb globe temperature reference value exceedance	1970–2024	Geographical region, year
Precarious employment	Employment insecurity, income inadequacy, lack of rights and social protection	National statistics	Index of five items corresponding to the three dimensions, ranging between –10 and +2 (cutoff for low employment quality of less than –3)	2008–2013	Sex and age groups
Solar ultraviolet (UV) radiation	Solar UV radiation	Expert ratings of duration of outdoor work, summary estimates of personal workday solar UV radiation exposure	Arithmetic mean workday standard erythral dose	Not specified	Latitude, season

Table 3 Associations between EuroJEM psychosocial exposures (% likelihood) and diagnosed depression—meta-analysis of findings among national cohorts in Finland, Norway, and Sweden by sex.^a

	Men HR (95% CI)	<i>I</i> ² %	Women HR (95% CI)	<i>I</i> ² %
High job demands (%)				
Low (0–24)	1.00		1.00	
Medium (25–49)	1.11 (1.03–1.20)	81.3	1.17 (1.05–1.30)	92.5
Medium–high (50–100)	0.89 (0.79–1.00)	91.5	1.08 (0.92–1.26)	96.2
Low decision authority (%)				
Low (0–24)	1.00		1.00	
Medium (25–49)	1.23 (1.09–1.38)	93.5	1.21 (1.17–1.25)	45.7
Medium–high (50–100)	1.50 (1.33–1.68)	93.3	1.28 (1.22–1.35)	79.3

Age- and education-adjusted hazard ratio (HRs) and 95% confidence intervals (CIs) (adapted from Salonen *et al.* [18]) (license: CC BY 4.0).

^a The total across the three national cohorts included 2 771 268 men and 2 877 906 women.

**Figure 2** Incidence-rate ratio of cutaneous melanoma associated with cumulative occupational solar UV exposure [restricted cubic spline standardized erythema dose (SED)-years], DOC*X cohort [17] (licenses: CC BY 4.0).

for inadequate adjustment remains [34, 35]. Efforts to date have also not yet exploited available data on personal or environmental measurements, biological or multiomics data, or on intra-generational participants in some studies. Future work may build upon these resources [19].

EuroJEM offers harmonized exposure assessment for a range of exposures, taking into account temporal variation for some of them, e.g. chemicals and particles, and heat stress. Although EuroJEM contains data on 18 agents, analyses to date have also relied on supplementary JEMs to capture a broader range of exposures. For large population-based cohorts, JEMs are the only feasible method for exposure assessment; however, it is important to acknowledge limitations when they are used [36]. The input JEMs included in the harmonization were also primarily based in Northern and Western Europe. Efforts to combine JEMs with other underlying input data may support future efforts in their calibration and validation or in hybrid exposure modeling efforts.

Unlike other consortia that have coordinated central databases or implemented decentralized data pooling methods such

as using DataSHIELD [37–39], this was not feasible here given the national ethical and legal constraints impacting several major studies. Thus, work to date has relied on coordinated analysis between cohorts, including meta-analysis where warranted.

Can I get hold of the data? Where can I find out more?

The Consortium invites collaboration from researchers, including external researchers, who wish to conduct analysis or from cohorts that wish to join the Consortium. Procedures to propose a new analysis or to join the Consortium are available on the website of the occupational cohort inventory (<https://occupationalcohorts.net>). The website also provides an up-to-date listing of ongoing analyses and detailed meta-data for participating cohorts. EuroJEM is available through a dedicated website (<http://ki.se/en/imm/eurojem>). To propose a new data analysis, researchers may complete a standard analysis proposal form, which is discussed with the Consortium Steering Committee for

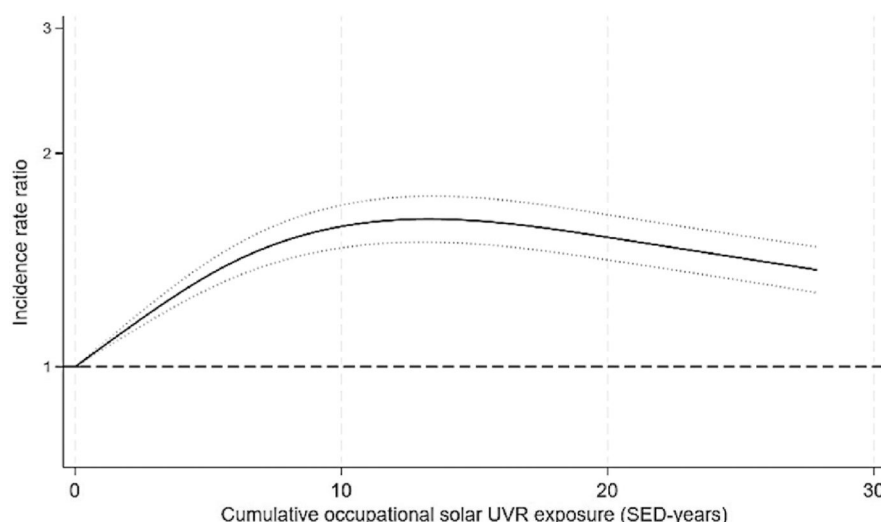


Figure 3 Incidence-rate ratio of basal cell carcinoma associated with cumulative occupational solar UV exposure [restricted cubic spline standardized erythema dose (SED)-years], DOC*X cohort [18] (licenses: CC BY 4.0).

approval. Analysis proposals related to the main objectives of the Consortium are prioritized. Individual cohorts opt in to the analysis proposed. Data from each participating cohort are managed separately by each institution, which supports the preparation of cohort results with researchers and ensures that associated ethical requirements are met. Researchers involved in ongoing analyses participate in regular meetings with the associated outcome working group. Enquiries can also be submitted to Michelle Turner, ISGlobal (michelle.turner@isglobal.org) and Ingrid Sivesind Mehlum, STAMI (ingrid.s.mehlum@stami.no). The Consortium provides a unique opportunity to support advances in occupational cohort and exposome research in Europe [40].

Ethics approval

Each of the included cohorts is performed according to the principles of the Declaration of Helsinki and has been reviewed and approved by their respective local institutional review boards or regulated by national legislation, including with respect to their participation in the EPHOR cohort consortia. Written informed consent has been obtained for participants or, in the case of registry-based cohorts, data were anonymized or pseudonymized and handled according to existing data-protection regulations in place. ATOHS: the study was approved by the Regional Ethics Committee in Stockholm (2016/2490–31; 2017/1157–32); CODI: TNO ethical review board 2025–808; the CONSTANCES and GAZEL cohorts received approval from the Institutional Review Board of the French National Institute of Health and Medical Research (Inserm IRB00003888, authorization nos 01–011, 21–842, and 01–017, respectively) and from the national data-protection authority, Commission Nationale Informatique et Liberté, CNIL (authorization nos 910486 and 105728, respectively); Danish Styrene Cohort: registry-based cohort with supplementary questionnaire data and required according to Danish law; Danish Wood Dust: the Scientific Committee for Viborg and Northern Jutland (2–16–4–0001–04); DOC*X: the

study was registered at the repository of the Central Denmark Region (j.no.: 1–16–02–196–17); ECRHS: separate ethics application approvals per study center are listed at www.ecrhs.org and available by request to the coordinator Vivi Schlünssen (vs@ph.au.dk); GAZEL: received the approval of France's national ethics committee (CNIL no. 2025–049); GCAT: CEIC (approval no. PI-13–020); Grain Dust and Microbial Exposed Workers: the Regional Ethical Committee of South-East Norway; HUNT: approved by national regulation (FOR-2018–04–27–645); Lifelines: approved by the Medical Ethical Committee of the University Medical Center Groningen, the Netherlands (2007/152); Nor-Work: Regional Ethics Committee South-East (reference number 17344); PRECUBE: general approval granted by the Commission for Medical Ethics of IDEWE (OG 117). This approval authorizes the secondary use and post hoc analysis of fully anonymized data originally collected in the context of legally mandated occupational health surveillance, in compliance with applicable Belgian legislation and relevant international ethical and data-protection frameworks, including the General Data Protection Regulation (EU) 2016/679. Data processing is limited to purposes compatible with the original collection and is conducted in accordance with the principles of lawfulness, fairness, transparency, purpose limitation, data minimization, and confidentiality. No directly or indirectly identifiable personal data are processed. Notwithstanding this general approval, each research project using the PRECUBE dataset is subject to a prior assessment of its scientific objectives, methodological scope, and data determinants. Where the nature of the research question, data linkage, or analytical approach falls outside the scope of the existing approval, additional project-specific review and approval by a competent ethics committee will be sought prior to commencement of the study; RHINE: main approval from the Regional Committee for Medical and Health Research Ethics REC West (approval number 236168); RHINESSA: main approval from the Regional Committee for Medical and Health Research Ethics REC West (approval number 2012/1077). Separate ethics application approvals per study center are listed at <https://www.helse-bergen.no/499702/siteassets/seksjon/rhinessa/documents/>

[overview-of-ethics-committees-and-approval-numbers-of-rhine-ssa-centers.pdf](#); SLFF: in Finland, research using pseudonymized register data does not need to undergo review by an ethics committee; SNOW: Regional Ethics Committee, Stockholm, Sweden (ref. no. 2018/1298–31/2); STREAM: the Medical Ethical Committee of the VU University Medical Center Amsterdam declared that the Medical Research Involving Human Subjects Act does not apply to STREAM (ID: 2012–080); SwedSweeps: approved by the Regional Ethics Committee Lund University, Sweden (2013/414); SWIP: ethical approval was obtained from the Stockholm ethics review board (reference nos 2017/1224–31 and 2018/1675–32); the SUS Study: the Scientific Committee for Region Midt (M-20070074); Work Environment and Health in Denmark (WEHD): registered and approved by the Danish Data Protection Agency (Datatilsynet, journal no. 2015–57–0074); WeldCancer: approved by the Regional Ethics Committee Lund University, Sweden (2010/132).

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Author contributions

Conceptualization: M.C.T., A.P., I.S.M. Methodology: M.C.T., A.P., I.S.M. Software: M.C.T., A.P., V.S., J.S., M.A., I.S.M. Formal analysis: M.C.T., A.P., K.O.H., V.S., J.S., R.L.H., S.S. Investigation: M.C.T., A.P., K.O.H., V.S., J.S., R.L.H., S.S. Resources (cohort): H.B., K.B., U.B., R.D.C., D.F., A.H.G., L.G., P.G., A.J., H.K., S.K., T.L., K.C.N., K.O.H., V.S., J.S., T.S., A.S., C.S. Data curation: M.C.T., A.P., V.S., J.S., M.A., I.S.M. Writing—original draft: M.C.T. Writing—review and editing: M.C.T., A.P., H.B., K.B., U.B., R.D.C., D.F., A.H.G., L.G., P.G., A.J., H.K., S.K., T.L., K.C.N., K.O.H., V.S., J.S., T.S., A.S., C.S., R.L.H., S.S., M.A., J.K., I.S.M. Funding acquisition: M.C.T., A.P., K.B., L.G., V.S., J.S., S.S., M.A., I.S.M.

Supplementary material

[Supplementary material](#) is available at *IJE* online.

Conflicts of interest

None declared.

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Data availability

Please see “Can I get hold of the data?” above as well as “Supplementary data” for further information.

Use of artificial intelligence (AI) tools

None used.

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Cohort Profile