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PROBE study: a sentinel surveillance system to monitor exposure of Belgian employees to hazardous chemicals: a feasibility study

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Running title: Exposure of workers to hazardous chemicals

Abstract

Objective

To test the feasibility of collecting reliable and representative data on exposure of Belgian employees to a selection of hazardous chemicals by using a sentinel surveillance method.

Method

In PROBE (Hazardous chemical **P**roducts **R**egister for **O**ccupational use in **Be**lgium), 47 occupational physicians was recruited as a sentinel network. Employees answered a web-based survey assessing their past week exposure to 22 chemicals.

Results

47% employees were exposed to at least one chemical. The most frequently reported exposures was to diesel exhaust (14%). The exposed employees were mostly older men, with most exposed during production and manufacturing, and working in smaller companies. For diesel exhaust, wood dust, and crystalline silica, 54%, 32%, and 20% of the exposed employees, did not use collective/personal protective equipment.

Conclusion

Sentinel surveillance is a feasible method for obtaining high-quality data on the exposure of Belgian employees to hazardous chemicals.

Key words: Occupational health; Hazardous chemicals, Sentinel Surveillance, Exposure, Workers

Clinical significance

Sentinel surveillance is a promising method to obtain reliable information about the exposure of employees to chemicals.

These data can have a positive impact on occupational health; they can be used for preventing work-related diseases, targeted prevention programs (e.g., the use of personal protective equipment), follow-up of exposure and trends.

Introduction

Occupational exposure of workers to chemicals is often at a considerably higher level than environmental exposure. For the prevention policy of occupational and work-related diseases such as occupational cancer, knowledge is required on several aspects of exposure (e.g., duration and intensity of exposure, number of workers affected). A previous project, the CARcinogen EXposure (CAREX) surveillance system, tried to address this knowledge gap. CAREX was an initiative of the Finnish Institute of Occupational Health in collaboration with the International Agency for Research on Cancer (IARC) and was further developed by exposure assessment experts (a team of international experts from the European Union) to estimate the burden of occupational exposure to carcinogens in Europe. EU CAREX provided estimates of carcinogen exposure for 15 countries (including Belgium) in 55 broad industry categories during 1990-1993.(1) It is clear that these data need to be updated. This could be done by expert opinion or try to obtain non-expert–generated dependable data about the occupational exposure to hazardous chemicals for developing effective prevention strategies for occupational diseases. We propose to involve occupational health specialists, active in the field, and let them report, after a training, on the current exposure and working conditions, so that an immediate response can be given to sectors about the occupational exposure to hazardous chemicals.

In a sentinel surveillance system, a group of motivated physicians from a sentinel surveillance network reports cases over a period of time.(2) Sentinel approaches are being increasingly used in occupational health and have been found a valid method to collect epidemiological health data. In the "Peilstation Intensief Melden" (PIM) study (The Netherlands), a group of motivated and trained occupational physicians (OPs) reported occupational diseases by using a sentinel surveillance system. During the study, the OPs reported a higher incidence of occupational diseases and a lower proportion of incorrect notifications. (3, 4). The use of sentinel systems to collect exposure data is limited. An exception is the French Surveillance Medicale des Risques (SUMER) study, a national cross-sectional survey of occupational risks, that collected good-quality exposure data by use of sentinel surveillance.(5) (6) In Belgium, the sentinel method has been implemented in only family medicine.

The aim of the Hazardous chemical **P**roducts **R**egister for **O**ccupational use in **Be**lgium (PROBE) study was to test the feasibility of collecting reliable and representative data on exposure of Belgian employees to a selection of hazardous chemicals by using a sentinel surveillance method.

Methods

Study population

Belgian OPs were invited to participate in the PROBE trial through Co-Prev, the umbrella association of external occupational health and safety (OHS) service providers in Belgium or VVIB-AMTI (association for in-house OPs) to test the feasibility of a sentinel surveillance system in occupational medicine. The aim of this pilot study was to recruit a representative

group of OPs (in-house/external, age, gender, etc.) to assess exposure in a group of employees representative of the Belgian workforce. The recruitment started in March 2018 and ended in August 2018.

This research project was approved in February 2018 by the Social Ethics Committee of Leuven (G-2018 02 1117).

Selection of chemicals

For the PROBE study, an expert group of policymakers, researchers, and representatives of umbrella organizations of social partners and occupational health and safety professionals (including hygienists, safety engineers, OPs) created a selection of hazardous chemicals based on 1) the outcome of a literature study (white and grey literature) analysing exposure studies in Belgian workers, 2) recent prioritization reports (7-10), and 3) the annual reports of Belgian OHS providers. The group selected 22 chemicals, belonging to 7 product categories, based on their hazardous properties (immediate or long-term, e.g., cancer), their estimated level of use in the industry, their relevance for Belgian employees, and their safety risks (Table 1).

Data collection

Recruited OPs completed an online training module that included information about the study, a short questionnaire to obtain demographic information (personal and professional), and an E-learning module about the selected chemicals.

Next, data were collected by a web-survey (LimeSurvey) available in Dutch and French. OPs were sent the link to the questionnaire about the exposure of Belgian employees to selected chemicals during the preceding working week (Supplemental Material , http://links.lww.com/JOM/A821). The survey was based on the French SUMER questionnaire and assessed the exposure of Belgian employees to selected chemicals.(6) The questionnaire consisted of two parts: 1) collecting data about the worker and his/her company and 2) collecting data about exposure to the selected chemicals. The OPs recruited employees at random (every fifth, tenth, etc. worker of the day) and were asked to complete the exposure questionnaire together with the worker during the periodic health assessment. In Belgium, all employers (small and large companies, all sectors, etc.) are obliged to provide occupational prevention care. Workers with occupational risks, which include exposure to chemical, biological, physical and psycho-social risks, routinely undergo mandatory occupational health examinations, which include a periodic medical examination. The periodicity depends on the occupational risks they are exposed to (e.g., workers exposed to carcinogens are assessed yearly). (11)

For exposure to chemicals, questions were asked about the duration of the exposure, ranging from less than 2 hr to more than 20 hr during the preceding working week. Then, the intensity of the exposure was assessed, ranging from very low to very high. For the definition of exposure levels, the limit of detection and exposure was used as a reference, with very low

being slightly higher than the general population limit or at the limit of detection; low being less than 50% of the occupational exposure limit value (OEL); high being about 50% of the OEL; and very high exceeding the OEL or equal to the exposure level of the population known to be the most exposed). Finally, the use of personal and collective protective equipment was evaluated.

OPs also were asked to indicate whether the level of exposure was estimated (based on knowledge about the workplace, company job processes or position) or measured (biomonitoring or external exposure assessment).

Results

Occupational physicians

We recruited 64 OPs from a total of 1002 Belgian OPs; 47 completed 1 or more exposure questionnaires (4.7% of the total OP population). Table 2 gives an overview of the characteristics of the participating OPs, along with the characteristics of the Belgian OP population. Of the 47 recruited OPs, 29 (62%) were female, which is a good representation of the Belgian OP population: 56% women. Other OP characteristics also agreed with the Belgian OP population; for example, 41 (87%) worked for an external OHS and 6 (13%) for an in-house OP; the mean age was 48±10 years; the mean seniority was 15±9.5 years in the field of occupational medicine; and 53% worked full time. Characteristics that were not representative of the Belgian OP population were the high number of Dutch-speaking OPs (n=37, 79%) and OPs working in the region of Flanders (n=36, 77%).

Employees

A total of 666 employees completed the exposure questionnaire, with a mean of 14 questionnaires per OP. The characteristics of the Belgian employees participating in the study are in Table 3. A total of 504 (76%) were male, which is not representative of the Belgian working population (54%). The average age was 42 ± 11 years; 602 (90%) were of Belgian nationality (other nationalities: French, Italian, Dutch, Polish, Moroccan, Spanish, Turkish, etc.). The seniority was less than 1 year for 14%, 1 to 3 years for 13%, 3 to 10 years for 23%, and more than 10 years for 50%. Overall, 84% of the employees were working full-time and the mean part-time employment rate was 65±19%. About one third of the employees worked in the construction sector (31%).

Exposure to hazardous chemicals

In total, 47% (n = 315) of the employees were reported to be exposed to one or more chemicals during the preceding working week; 26% were exposed to one chemical, 11% to two chemicals, and 6% to three or more chemicals (Figure 1).

Most exposed employees were male (88%), were older than 50 years (30%), had a main function in production and manufacturing (31%), worked in the sector manufacturing (35%), had a seniority of more than 10 years (51%), and worked in small- and medium-sized enterprises (<6, 6 – 20, and 21 – 50 employees) (Table 4). The top nine chemicals of exposure were diesel exhaust (14% of employees), welding fumes (12%), toluene (10%), wood dust (9%), benzene (7%), crystalline silica (6%), formaldehyde (4%), asbestos (4%), and lead and its compounds (3%) (Table 5). As an example, we describe for diesel exhaust — the chemical with the most exposure — the exposure parameters, the protective measures and the characteristics of the employees: the 91 employees were exposed to diesel exhaust, had an exposure duration from less than 2 hr to more than 20 hr with mostly very weak to weak exposure intensity. For preventing exposure to diesel exhaust, several types of personal and collective protective equipment were used, with 49 employees not using any type of protection. Employees exposed to diesel exhaust were mostly men (98%), were older than 50 years, and were mainly employed in installation, repair, and technical maintenance.

Discussion

Using a sentinel surveillance method, PROBE gathered occupational data for Belgian employees exposed to chemicals. These data can be used for both epidemiological studies and policymaking. Overall, 47% (n = 315) of the employees were exposed to one or more of the 22 selected chemicals during the preceding working week; 26% were exposed to one chemical, 11% to two chemicals, and 6% to three or more chemicals. In 2015, 17% of the employees in the EU reported being exposed to chemicals at work and 15% reported inhaling smoke, gas, powder or dust.(12) The SUMER 2010 study showed that more than 10% of the employees were exposed to at least one carcinogenic, mutagenic, or reprotoxic chemical.(6)

As compared with other exposure data, the proportion of exposed employees in the PROBE study is quite high (47%). SUMER assessed exposure to 89 chemicals (compared with 22 chemicals in PROBE) as well as exposure to other occupational risks such as noise, biological agents, etc. With the higher number of agents included in the SUMER study, it could present lower sensitivity. In PROBE, we focused on a carefully selected set of chemical agents. In addition, all OPs participating in PROBE received online training.

Despite the random selection of employees during the periodic health assessment to participate in the survey, we cannot rule out an overrepresentation of workers from industries with more exposure to chemicals. In Belgium, all workers with occupational risks, which include exposure to chemical, biological, physical and psycho-social risks, routinely undergo mandatory occupational health examinations.(11) Therefore, the possible source of overrepresentation of workers from the chemical industry is more likely to be a lower motivation to participate in this research of OPs not working in the chemical sector. In addition, PROBE recruited more male employees (men are generally more exposed to chemicals than women) and employees from industry (more use of chemical products) as compared with the general Belgian workforce, what may be a third explanation for the higher reporting rate of exposed employees.

The chemicals to which employees were exposed most frequently during the preceding working week were diesel exhaust (14%), welding fumes (12%), toluene (10%), wood dust (9%), benzene (7%), crystalline silica (6%), formaldehyde (4%), asbestos (4%), and lead and its compounds (3%). This frequency agreed with the 8 most frequent substance exposures in SUMER, namely, diesel exhaust, mineral oils, wood dust, crystalline silica, formaldehyde, lead and lead compounds, asbestos, and phthalates (mineral oils and phthalates were not selected in PROBE).(6)

Employees exposed frequently were male (88%), older than 50 years (30%), had a main function in production and manufacturing (31%), worked in the sector manufacturing (35%), with seniority of more than 10 years (51%), and employed in small- or medium-sized enterprises. Overall, 69 employees were recruited from companies of 21 to 50 employees and 43 of these 69 (62%) employees were exposed to one or more chemicals. In SUMER 2010, mainly men, young employees (students and interns), and employees in construction and maintenance were exposed. These sectors are typically male sectors; however, within the same sector, male employees are more exposed than are female employees.(13) Both SUMER and PROBE found that exposed employees mostly work in small companies. In general, small companies tend to have less adequate prevention policies than larger companies.(6, 14) Several contextual factors and reasons include financial constraints, lack of time and expertise, low safety awareness, and little or no knowledge of Occupational Health and Safety (OHS) legislation and associated regulations. (15-17) In addition, small- and medium-sized enterprises often have to fight for survival. The owner is mostly the employer with different responsibilities, handling many different issues at the same time. Therefore, health and safety is often not the main priority. (18)

The duration of the exposure of the employees varied from less than 2 hr to more 20 hr per week. OPs were asked to estimate or measure the intensity of exposure, and the intensity was rated very weak to weak for most employees. The actual exposure levels are difficult to determine because the results depend on the measurement method used, time of sampling, detection limit, etc. In addition, most exposure levels were estimated by the OPs based on expertise, which yielded a subjective or qualitative appreciation rather than an objective quantification.

The questionnaire also asked about the use of personal and/or collective protective measures. The answers show an insufficient level of use of protective equipment. For diesel exhaust, 54% (highest percentage) of the employees did not use any protective equipment or the equipment was not available. In most cases, the exposure intensity was rated very low to low, but 21% of the employees not using any protective equipment were exposed for more than 20 hr during the preceding working week. Slightly better results for the use of protective equipment were found in other studies such as SUMER 2003/2010: 42% and 32% of French employees, respectively, did not use any protective equipment during exposure to diesel exhaust (very low to low intensity exposure).(13, 19)

This feasibility study clearly shows the potential of the sentinel approach for obtaining reliable data on occupational exposure to hazardous chemicals. However, for more comprehensive insights, more OPs and more employees need to be investigated. Incentives to

stimulate sector participation are required. In SUMER 1994, 1200/5600 OPs were recruited (21.5% response rate, which is 5 times higher than that in the PROBE study). In SUMER 2003/2010, 1800 OPs (32% response rate) and 2400 OPs (42.9% response rate) participated. The 2400 OPs recruited 53 940 employees, which is a representative sample of the working population in France.(13, 19, 20) The high participation rate in SUMER most likely is explained by the leverage of the French labour authorities, which commissioned this survey. The lower participation rate in the PROBE study could be explained in part by fact that this was feasibility study to test the sentinel approach, lack of time of the OP (it takes 10 min, on average, to complete the exposure questionnaire, two thirds of the average time of a periodic health assessment), high work pressure, coinciding studies, etc.

To improve future study participation and data collection, we should look into ways to cut down the OP time to complete questionnaires, for example by deploying study nurses or by providing a validated version of the questionnaire so that employees can complete them independently. Alternatively, OHSs could endorse research by finding time for study participation in the agendas of their OPs. When looking at evolution in the participation rates in SUMER, we see a great potential for the recruitment process of PROBE. The Belgian OPs need to become more familiar with the use of the sentinel surveillance methodology in occupational medicine.

Conclusion

Sentinel surveillance is a promising method to obtain reliable information about the exposure of employees to chemical products. This approach will be useful in Belgian occupational medicine to collect data for epidemiological research and for policy making. This approach can have a positive impact on occupational health because the data can be used for preventing work-related diseases, targeted prevention programs (e.g., on use of personal protective equipment), follow-up of exposure and trends.

References

1. Kauppinen T, Toikkanen J, Pedersen D, Young R, Ahrens W, Boffetta P, et al. Occupational exposure to carcinogens in the European Union. Occup Environ Med. 2000;57(1):10-8.

2. Bakusic J, Lenderink A, Lambreghts C, Vandenbroeck S, Verbeek J, Curti S, et al. Methodologies to identify work-related diseases: Review of sentinel and alert approaches. European Risk Observatory Literature Review. European Agency for Safety and Health at Work (EU-OSHA); 2017.

3. van der Molen HF, Kuijer PP, Smits PB, Schop A, Moeijes F, Spreeuwers D, et al. Annual incidence of occupational diseases in economic sectors in The Netherlands. Occup Environ Med. 2012;69(7):519-21.

4. Spreeuwers D, de Boer AG, Verbeek JH, de Wilde NS, Braam I, Willemse Y, et al. Sentinel surveillance of occupational diseases: a quality improvement project. Am J Ind Med. 2008;51(11):834-42.

5. Havet N, Penot A, Morelle M, Perrier L, Charbotel B, Fervers B. Trends in occupational disparities for exposure to carcinogenic, mutagenic and reprotoxic chemicals in France 2003-10. Eur J Public Health. 2017;27(3):425-32.

6. Havet N, Penot A, Morelle M, Perrier L, Charbotel B, Fervers B. Varied exposure to carcinogenic, mutagenic, and reprotoxic (CMR) chemicals in occupational settings in France. Int Arch Occup Environ Health. 2017;90(2):227-41.

7. Palmen N, Verbist K. Prioritization of new and emerging chemical risks for workers and follow-up actions. National Institute for Public Health and the Environment; 2015.

8. Expert forecast on emerging chemical risks related to occupational safety and health. European Agency for Safety and Health at Work; 2009.

9. Service contract to create a database and create a model to estimate the occupational exposure for a list of hazardous chemicals in the Member States of the European Union and in the EFTA/EEA countries. European Commission; 2016.

10. Puts C, Ter Burg W. Identifying prevelant carcinogens at the workplace in Europe. National Institute for Public Health and the Environment; 2015.

11. Godderis L, Johannik K, Mylle G, Bulterys S, Moens G. Epidemiological and performance indicators for occupational health services: a feasibility study in Belgium. BMC Health Serv Res. 2014;14:410.

12. Gevaarlijke stoffen - Veiligheid en gezondheid op het werk – EU-OSHA. Available from: https://osha.europa.eu/nl/themes/dangerous-substances.

13. Dares. Surveillance médicale des expositions aux risques professionnels (Sumer) : édition 2010. Available from: https://dares.travail-emploi.gouv.fr/dares-etudes-et-statistiques/enquetes/article/surveillance-medicale-des-expositions-aux-risques-professionnels-sumer-edition#L-enquete-Sumer-2010.

14. Legg S, Olsen K, Laird I, Hasle P. Managing safety in small and medium enterprises. Safety Science; 2015. p. 189-96.

15. Masi D, Cagno E. Barriers to OHS interventions in Small and Medium-sized Enterprises. Safety Science2015. p. 216-41.

16. Micheli G, Cagno E. Dealing with SMEs as a whole in OHS issues: Warnings from empirical evidence. Safety Science2010. p. 729-33.

17. Seneviratne M, Phoon WO. Exposure assessment in SMES: a low-cost approach to bring OHS services to small-scale enterprises. Ind Health. 2006;44(1):27-30.

18. Hasle P, Limborg HJ. A review of the literature on preventive occupational health and safety activities in small enterprises. Ind Health. 2006;44(1):6-12.

19. Dares. Surveillance médicale des expositions aux risques professionnels (Sumer) : édition 2003. Available from: https://dares.travail-emploi.gouv.fr/dares-etudes-et-statistiques/enquetes/article/surveillance-medicale-des-expositions-aux-risques-professionnels-sumer-edition-115982.

20. Dares. Surveillance médicale des expositions aux risques professionnels (Sumer) : édition 1994. Available from: https://dares.travail-emploi.gouv.fr/dares-etudes-et-statistiques/enquetes/article/surveillance-medicale-des-expositions-aux-risques-professionnels-sumer-edition-115983.

FIGURES AND TABLES

FIGURE 1. BELGIAN EMPLOYEES (*N*=666) EXPOSED OR NOT TO CHEMICALS DURING THE PRECEDING WORKING WEEK.

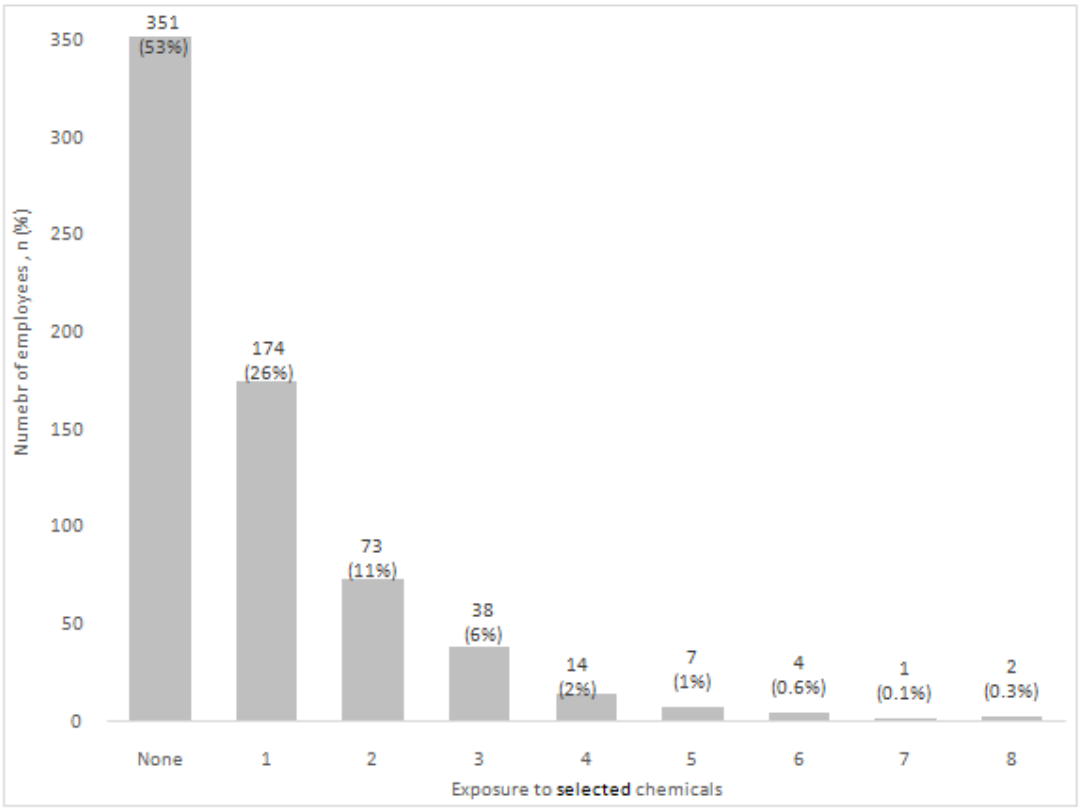

Table 1. Selection of chemical products.

Solvents	**Dust particles**	**Organic compounds**
Chlorinated hydrocarbons	Wood dust	Formaldehyde
Trichloroethylene	Crystalline silica	
Perchloroethylene	Powder coatings	**Fibres**
Methylene chloride		Asbestos
1,2-dichloroethane	**Fumes**	Refractory ceramic fibers
Chloroform	Welding fume	
	Diesel exhaust	
Aromatic hydrocarbons		
Benzene	**Isocyanates**	**Metals**
Toluene	Methylene diphenyl isocyanate (MDI)	Cadmium
	Hexamethylene diisocyanate (HDI)	Lead
Ketones	Toluene-di-isocyanate (TDI)	Beryllium
Methyl-iso-butyl ketone (MIBK)		

TABLE 2. CHARACTERISTICS OF THE PARTICIPATING OCCUPATIONAL PHYSICIANS (OPS)

Characteristics	Participating OPs (*n* = 47)	Belgian OP population (*n* = 1002)
Gender, n (%)		
Male	18 (38)	440 (44)
Female	29 (62)	562 (56)
OHS, n (%)		
Internal	6 (13)	62 (6)
External	41 (87)	940 (94)
Age, *years*		
Mean (SD)	48 (±10)	46 (±9)
Range	27–66	26–72
Seniority as OP, years		
Mean (SD)	15 (±9.5)	
Range	1–38	
Language, n (%)		
Dutch	37 (79)	573 (61)
French	10 (21)	362 (39)
Region, n (%)		
Flanders	36 (77)	
Wallonia	11 (23)	
Working time		
Full-time, n (%)	19 (53)	407 (41)
Part-time, n (%)	28 (47)	595 (59)
Part-time employment rate, %, mean (SD)	85 (±19)	79 (±23)
Range employment rate, %	40–100	10–110
Number of workers under surveillance, *n*		
Mean (SD)	2,678 (±1307)	
Range	600–6969	
Sector, *n (%)*		
Industry	38 (81)	
Services	29 (62)	
Health Care	28 (60)	
Transportation	24 (51)	
Construction	22 (47)	
Catering industry	20 (43)	
Other sectors	17 (36)	
Education	16 (34)	
Trade	14 (30)	

OHS: occupational health service

TABLE 3. CHARACTERISTICS OF BELGIAN EMPLOYEES PARTICIPATING IN THE PROBE STUDY (N=666).

Characteristics	Participating employees
Gender, n (%)	
Male	504 (76)
Female	162 (24)
Age, years	
Mean (SD)	42 (±11)
Range	17–71
Nationality, n (%)	
Belgian	602 (90)
Other	64 (10)
Seniority, years, n (%)	
< 1	97 (14)
1–3	86 (13)
3–10	152 (23)
≥ 10	331 (50)
Working time	
Full time, n (%)	561 (84)
Part time, n (%)	105 (16)
Part-time employment rate, %, mean (SD)	65 (±19)
Range part-time employment rate, %	10–95
Sector*, n (%)	
Professional, Scientific and Technical Activities	18 (3)
Public Administration and Defense; Compulsory Social Security	68 (10)
Manufacturing	206 (31)
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	66 (10)
Transportation and Storage	48 (7)
Administrative and Support Service Activities	59 (9)
Construction	59 (9)
Human Health and Social Work Activities	61 (9)
Financial and Insurance Activities	34 (5)
Education	20 (3)
Other	27 (3)

***** The Statistical Classification of Economic Activities in the European Community (NACE) was used to characterize the economic sector in which the employee was employed.

TABLE 4. CHARACTERISTICS OF EMPLOYEES (*N*=315) EXPOSED TO AT LEAST ONE HAZARDOUS CHEMICAL PRODUCT.

Characteristics	Exposed employees, n (%)
Total number	315 (47)
Gender	
Male	227 (88)
Female	38 (12)
Age category, years	
< 25	15 (5)
25–29	39 (12.5)
30–39	89 (28)
40–49	77 (24.5)
≥ 50	95 (30)
Nationality	
Belgian	280 (89)
Other	35 (11)
Main function	
Construction	40 (12)
Services	3 (1)
Handling of goods, storage, logistics	31 (10)
Trade and sales	3 (1)
Installation, repair, technical maintenance	66 (21)
Research and development	16 (5)
Production and manufacturing	98 (31)
Cleaning, surveillance, housekeeping	9 (3)
Care	15 (5)
Other	34 (11)
Sector*, n (%)	
Professional, Scientific and Technical Activities	7 (2)
Public Administration and Defense; Compulsory Social Security	31 (10)
Manufacturing	109 (35)
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	32 (10)
Transportation and Storage	21 (7)
Administrative and Support Service Activities	23 (7)
Construction	49 (16)
Human Health and Social Work Activities	18 (6)
	11 (4)

Education	14 (4)
Other	
Seniority, years	
< 1	36 (11)
1–3	37 (12)
3–10	82 (26)
≥ 10	160 (51)
	Total exposed employees/total employees, %
Company size, no. employees	
>200	40
51-200	49
21-50	62
6-20	60
<6	51

***** The Statistical Classification of Economic Activities in the European Community (NACE) was used to characterize the economic sector in which the employee was employed.

TABLE 5. OVERVIEW OF THE CHEMICALS TO WHICH THE EMPLOYEES WERE EXPOSED THE MOST.

***n* (%)**		**Diesel exhaust**	**Welding fumes**	**Toluene**	**Wood dust**	**Benzene**	**Crystalline Silica**	**Formaldehyde**	**Asbestos**	**Lead and its compounds**
	Number of employees	91 (14)	77 (12)	67 (10)	60 (9)	44 (7)	40 (6)	26 (4)	26 (4)	23 (3)
Exposure parameters	**Exposure duration**									
	< 2 h	27 (30)	32 (42)	35 (52)	24 (40)	24 (54.5)	13 (32.5)	12 (46)	23 (88)	7 (30)
	2 to 10 h	36 (40)	14 (18)	20 (30)			16 (40)	7 (27)	0 (0)	7 (30)
	10 to 20 h	10 (11)	14 (18)	5 (7.5)	10 (17)	12 (27)	4 (10)	6 (23)	0 (0)	3 (13)
	≥ 20 h	18 (39)	17 (22)	6 (9)	9 (15)	1 (2)	7 (17.5)	1 (4)	1 (4)	5 (22)
	Unknown	0 (0)	0 (0)	1 (1.5)	15 (25)	6 (13.5)	0 (0)	0 (0)	2 (8)	1 (4)
					2 (3)	1 (2)				
	Intensity of exposure									
	Very weak	27 (30)	28 (36)	28 (42)	19 (31.5)	29 (66)	12 (30)	15 (57.5)	22 (84)	14 (61)

	Weak	40 (44)	24 (31)	28 (42)	22 (36.5)	12 (27)	22 (55)	2 (7.5)	3 (12)	4 (17)
	Strong	19 (21)	22 (29)	8 (12)	12 (20)	3 (7)	6 (15)	8 (31)	0 (0)	4 (17)
	Very strong	2 (2)	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Unknown	3 (3)	3 (4)	3 (4)	6 (10)	0 (0)	0 (0)	1 (4)	1 (4)	1 (4)
	Intensity definition method	85 (86)	64 (83)	55 (82)	58 (97)	38 (86)	37 (93)	19 (73)	24 (92)	15 (65)
	Estimated…	6 (14)	13 (17)	12 (18)	2 (3)	6 (14)	3 (7)	7 (27)	2 (8)	8 (35)
	Measured…									
Protectivemeasures	**Collective protections**	53 (58)	16 (21)	24 (36)	28 (47)	17 (39)	17 (42.5)	11 (42)	17 (65)	7 (30)
	None	28 (31)	53 (69)	36 (54)	19 (32)	22 (50)	17 (42.5)	8 (31)	3 (12)	13 (57)
	Ventilation	18 (20)	33 (43)	13 (20)	12 (20)	7 (16)	8 (20)	5 (19)	1 (4)	11 (48)
	Local exhaust	1 (1)	1 (1)	3 (4.5)	0 (0)	1 (2)	1 (2.5)	3 (12)	1 (4)	0 (0)
	Laminar flow cabinet	1 (1)	2 (3)	5 (7.5)	1 (1.5)	4 (9)	2 (5)	1 (4)	1 (4)	2 (9)
	Closed system	13 (14)	10 (13)	5 (7.5)	9 (15)	5 (11)	4 (10)	1 (4)	4 (15)	3 (13)
	Other									
	Personal protections	75 (82)	26 (34)	11 (16)	31 (52)	12 (27)	17 (42.5)	6 (23)	9 (35)	9 (40)
	None	11 (12)	34 (44)	49 (73)	13 (22)	30 (68)	9 (22.5)	20 (77)	12 (46)	13 (57)
	Dermal	4 (4)	31 (40)	23 (34)	23 (38)	11 (25)	20 (50)	5 (19)	17 (65)	2 (9)
	Respiratory	9 (10)	42 (55)	26 (39)	13 (22)	22 (50)	14 (35)	6 (23)	5 (19)	4 (17)
	Ocular									
	No protections	49 (54)	6 (8)	8 (12)	19 (32)	7 (16)	8 (20)	4 (15)	5 (19)	2 (9)
Characteristics of the employees	**Gender**									
	Male	89 (98)	68 (88)	59 (88)	58 (97)	42 (95.5)	39 (98.5)	12 (46)	26 (100)	16 (60)
	Female	2 (2)	9 (12)	8 (12)	2 (3)	2 (4.5)	1 (1.5)	14 (54)	0 (0)	7 (30)
	Age category, years	9 (10)	3 (4)	4 (6)	5 (8)	4 (9)	2 (5)	2 (8)	1 (4)	1 (4)
	< 25	9 (10)	10 (13)	8 (12)	4 (7)	9 (20.5)	4 (10)	6 (23)	2 (8)	2 (9)
	25–29	22 (24)	23 (30)	21 (31.5)	19 (32)	14 (32)	7 (17.5)	4 (15.5)	7 (27)	10 (44)
	30–39	21 (23)	18 (23)	21 (31.5)	15 (25)	9	19 (47.5)	4 (15.5)	6 (23)	5 (22)
	40–49	30 (33)	23 (30)				8 (20)	10 (38)	10 (38)	5 (22)

	≥ 50			2 (19)	17 (28)	(20.5) 8 (18)			
	Main employment sector	7 (8)	5 (6)	1 (13)	15 (25)	4 (9)	12 (30)	0 (0)	9 (35)	4 (17)
	Construction	1 (1)	0 (0)	0 (0)	0 (0)	2 (4.5)	0 (0)	0 (0)	1 (4)	0 (0)
	Services	17 (19)	3 (4)	3 (4.5)			3 (7.5)	0 (0)	0 (0)	0 (0)
	Handling of goods, storage, logistics	3 (3)	0 (0)	2 (3)	10 (16.5)	3 (7) 1 (2)	0 (0)	0 (0)	0 (0)	0 (0)
	Trade and sales	29 (32)	31 (40)	21 (31)	0 (0)	15 (34.5)	7 (17.5)	2 (8)	10 (38)	6 (26)
	Installation, repair, technical maintenance	2 (2)	1 (1)	5 (7.5)	1 (2)	10 (23)	4 (10)	5 (19)	0 (0)	3 (13)
	Research and development	17 (19)	32 (42)	17 (25)	13 (21.5)	2 (4.5)	33 (32.5)	5 (19)	2 (8)	9 (39)
	Production and manufacturing	1 (1)	0 (0)	5 (7.5)	14 (23)		0 (0)	2 (8)	0 (0)	0 (0)
	Cleaning, surveillance, housekeeping	12 (13)	1 (1)	3 (4.5)		2 (4.5)	0 (0)	8 (31)	0 (0)	1 (4)
	Care		4 (5)	4 (6)			1 (2.5)	4 (15)	4 (15)	0 (0)
	Other				1 (2)	1 (2)				
					1 (2)	4 (9)				
					5 (8)					
Company	**Size of enterprise, no employees**	39 (43)	34 (44)	23 (834	20 (33)	14 (32)	2 (5)	20 (76.5)	10 (38)	14 (61)
	> 200	22 (24)	15 (20)	21 (31)			4 (10)	2 (7.5)	6 (23)	3 (13)
	51–200	14 (15)	16 (22)	10 (15)	14 (23)	14 (32)	7 (17.5)	0 (0)	2 (8)	0 (0)
	21–50	12 (13)	10 (13)	10 (15)	9 (15)	7 (16)	19 (47.5)	2 (7.5)	3 (12)	3 (13)
	6–20	4 (4)	2 (3)	3 (5)	11 (18)	8 (18)	8 (20)	2 (7.5)	4 (15)	3 (13)
	< 6				6 (10)	1 (2)				