



Chmielewski J., Kordyzon M., Dziechciaż M., Rezaei A., Wójtowicz B.,
Gworek B., Łuszczki J.J. 2022.

*Environmental and occupational exposure to chemicals
and related occupational diseases.*

J. Elem., 27(4): 897-915. DOI: 10.5601/jelem.2022.27.4.2256



RECEIVED: 19 February 2022

ACCEPTED: 16 November 2022

ORIGINAL PAPER

ENVIRONMENTAL AND OCCUPATIONAL EXPOSURE TO CHEMICALS AND RELATED OCCUPATIONAL DISEASES*

**Jarosław Chmielewski¹, Marta Kordyzon²,
Małgorzata Dziechciaż³, Azita Rezaei⁴, Bożena Wójtowicz⁵,
Barbara Gworek⁶ Jarogniew J. Łuszczki⁷**

¹ The Stanisław Sakowicz Inland Fisheries Institute
National Research Institute in Olsztyn, Poland

² Institute of Health Sciences, Collegium Medicum
The Jan Kochanowski University in Kielce, Poland

³ Health Care Institute

State School of Higher Vocational and Economic Education in Jarosław,
Poland

⁴ Institute of Medical Sciences, Collegium Medicum
The Jan Kochanowski University in Kielce, Poland

⁵ Institute of Geography, Pedagogical University of Krakow, Poland

⁶ Institute of Environmental Protection

National Research Institute in Warsaw, Poland

⁷ Institute of Rural Health in Lublin, Poland

Abstract

Exposure to chemical substances at work may result in negative health effects for workers that are classified as occupational diseases after meeting the formal requirements. Objective of the work: to analyse results of inspections by the State Sanitary Inspectorate in the Mazovia Province in years 2012-2019. Materials and methods: Data concerning occupational diseases were obtained within the scope of access to public information from the Provincial Sanitary and Epidemiological Station in Warsaw. The analysis included data on occupational diseases according to disease entities, pathogenic factor, place of work defined according to the Polish Classification of Activity, and occupational exposure to chemical substances. Results: Occupational diseases for which chemical agents constituted an identified aetiological factor during this period of the analysis of the incidence of occupational diseases resulting from occupational exposure to chemical substances among workers employed at employment establishments subject

Jarosław Chmielewski, Ph.D., The Stanisław Sakowicz Inland Fisheries Institute – National Research Institute, 10-719 Olsztyn, St. Oczapowskiego 10, e-mail: j.chmielewski@ios.gov.pl

* Source of financing: The project is financed from the Research Fund of the Jan Kochanowski University in Kielce no SUPB.RN.21.158, which is intended to support the continuity and development of the university's scientific research.

to the official control accounted for 25.9% (445) of all 1717 (100%) diagnosed occupational diseases. The incidence of occupational diseases resulting from exposure to chemical substances has shown an increasing trend since 2017. The main aetiological agent of the diagnosed occupational diseases was asbestos dust, which was responsible for 325 identified cases. Allergenic agents and irritants were the second aetiological causative factor of the diagnosed occupational diseases – 56 cases. Dust containing free crystalline silica was the third aetiological factor causing 47 cases. Conclusions: Understanding the long-term health effects of exposure to chemical substances and application of occupational health and safety regulations requires continuation of official inspections of the working conditions as well as preventive measures aimed at health education of workers, use of protective measures and examination of the work environment.

Keywords: chemical agents, occupational exposure, occupational disease

INTRODUCTION

A growing number of chemical substances entering the economy poses a threat to the health of workers. Chemical substances that may adversely affect health of the workers who are exposed to their effects are used in almost each work environment. Chemical substances in the work environment may appear in the form of gases, vapours, liquids or solids. Under the conditions of occupational exposure, absorption of the substances occurs primarily through the respiratory tract, skin and gastrointestinal tract. The risk connected with the use of chemical substances and mixtures equates with the probability of the occurrence of adverse health effects in the workers (Chmielewski et al. 2015, 2020).

The threshold limit value (TLV) and short-term exposure limit (STEL) in the work environment air constitute the criteria for occupational exposure assessment related to the presence of harmful chemicals in the work process (Regulation... 2012).

Chemical substances are hazardous chemical substances and mixtures that fulfil the hazard criteria resulting from physical and/or chemical properties specified in Parts 2 to 5 of Annex 1 (Requirements for the classification and labelling of substances and mixtures presenting a risk) of Regulation No 1272/2008 of the European Parliament and of the Council [Regulation (EC) No 1272/2008].

Identification of chemical agents occurring in the work environment takes place on the basis of the list of the chemical substances applied in the work process, then on the basis of measurements or estimation of the concentrations of these agents in the air and a comparison of the measurement results with the applicable standards (hygienic norms, limit values), and – in the English-language literature – the limit values determining the permissible concentrations of chemical substances in the air depend on the averaging period they pertain to (Chmielewski et al. 2015, 2020).

Occupational diseases correspond to the health condition of employees as well as the level of hygienic working conditions. The analysis of data on the incidence of occupational diseases provides information concerning development of health problems of the employees. It allows one to identify workplaces, employment establishments, sectors of the national economy where irregularities in the organization and supervision of the working conditions occur and, consequently, to indicate the need for prophylactic measures preventing occurrence of occupational pathologies appear (Chmielewski et al. 2015, 2017, 2020).

According to the Central Statistical Office (Polish abbreviation: GUS), in Poland in 2019 the number of people employed in the conditions of a risk to health or life was 532.3 thousand, including individuals exposed to factors related to the work environment – 316.4 thousand (59.4%), where 13,363 people (4.2%) worked in the conditions of exposure to chemical factors in the work environment. According to the terminology adopted by the Central Statistical Office, risk factors arise from the work environment, denoting the impact of harmful factors on the employee occurring in the work process whose concentration or intensity is greater than the threshold limit value (TLV) or permissible exposure limit (PEL) of the Polish standards or other sanitary standards, even if personal protective equipment was used (Central Statistical Office, Working Conditions 2019).

Pursuant to the requirements of Directive 98/24/EC (Council Directive 1998) as well as national regulations (Regulation... 2004) on occupational health and safety related to the presence of chemical agents in the workplace, each employer should determine which chemical agents posing a risk to employees are present in their work environment as well as conduct and document the assessment of the occupational risks caused by these agents (Regulation 1997). The employer is also obliged to perform the tests and periodic measurements when the workplace is endangered with chemical substances that have specified threshold limit values (TLV) in the national legislation (Regulation... 2018).

An occupational disease is identified when it has been caused by the effects of factors harmful to health occurring in the work environment or by the manner of performed work (Chmielewski et al. 2013, Boschman et al. 2017, Chmielewski et al. 2020, 2020a).

The Regulation of the Council of Ministers of 2009 (Regulation... 2009) constitutes the legal basis for adjudicating occupational diseases in Poland. According to the above regulation, occupational diseases are regarded as those that are included in the list if – as a result of assessment of the working conditions – it can be stated incontestably or with high probability that the disease has been caused by the impact of harmful factors which occur in the work environment or in connection with the manner of performing the work.

The legal and substantive requirement for recognition of the occupational

disease by the State Sanitary Inspectorate is the fulfilment of the following conditions: the disease must be included in the list of occupational diseases; this disease must be diagnosed by an authorised institution; clinical symptoms of the disease must correspond to the biological effects of the harmful agent that occurs in the work environment; in order to assess the health effects of the harmful agent it is necessary to determine the type of agent; to determine the time of contact and to establish the mechanism of action or pathway of spread of the agent, however, without the necessity of determination of the concentration of the agent; the time during which documented disease symptoms occurred after the end of exposure does not exceed the period specified in the list (Chmielewski et al. 2015, 2020a, 2021).

Despite the constant progress of medical knowledge and regular improvement of working conditions, occupational diseases still constitute a serious problem of public health. This is due to a number of reasons, including the following ones: lack of sufficient knowledge and awareness of employees about possible negative health effects of work under exposure to chemical agents; difficulties related to identification of aetiological factors, a lack of association of the working conditions with the disease, a lack of specificity of clinical symptoms, variable individual susceptibility of the exposed, inaccurate diagnosis of aetiological factors of the identified diseases, a lack of connection of the medical information between occupational medicine and family medicine as well as limited technical possibilities to provide workers with completely safe working conditions (Chmielewski et al. 2013, Cwynar et al. 2013, Chmielewski et al. 2018, Wiszniewska et al. 2018).

Numerous authors emphasize insufficient reporting of occupational diseases, including the quality of diagnosis and identification of occupational diseases in general. Therefore, knowledge of the issue and the ability to link working conditions to individual health condition is significant for population health in the broadest sense (Salski et al. 2016, Boschman et al. 2017, Feder et al. 2018, Wiszniewska et al. 2018, Carles et al. 2019, Jałowska et al. 2019, Lu et al. 2019, Alaguney et al. 2020, Bovio et al. 2020, Świątkowska 2020).

MATERIALS AND METHODS

The objective of the work is to analyse the epidemiological situation of occupational diseases where chemical substances constituted the aetiological factor, diagnosed in employees from the territory of the Mazovia Province (*województwo mazowieckie*) from 2012 to 2019. The analysis was conducted on the basis of data (as of 31 December) on identified occupational diseases included in the records of the Provincial Sanitary and Epidemiological Station in Warsaw. The analysis did not include occupational diseases for which proceedings were not completed or appeals were pending.

The basis for selection of occupational diseases analysed in this work was the information included in the records of occupational diseases in the employment establishments where exposure to chemical agents causing occupational diseases occurred. The analysis only included decisions on diagnosis of occupational diseases in employees as of 31 December. Data concerning employment relate only to workers employed on the basis of employment relationship (contract of employment, nomination, appointment). Data includes full-time employees, including seasonal and occasional workers, as well as part-time employees in the main employment establishment.

Occurrence of occupational diseases has been described using the absolute number of cases in relation to the number of the employed or working people.

The scale of exposure to chemical agents in the conditions exceeding the threshold limit value (TLV) in the work environment in employment establishments supervised by the State Sanitary Inspectorate (Polish abbreviation: PIS) has been presented according to the type of agent and the Polish Classification of Activities, as well as control activities aimed at ensuring safe and hygienic working conditions as part of the preventive inspections of the State Sanitary Inspectorate.

CONCLUSIONS

Occupational diseases where identified aetiological factors were chemical agents present in the work environment in the years from 2012 to 2019 constituted 25.9% (445) of all diagnosed 1717 (100%) occupational diseases within the territory of the Mazovia Province. The data analysis showed that within the territory of the Mazovia Province in years 2012-2016, excluding the year 2013 when a temporary increase in the incidence (54 cases) was recorded, the number of diagnosed occupational diseases caused by chemical agents remained at the same level of 42 diagnosed diseases. However, there was a marked increase in the incidence of occupational diseases in the years 2017 and 2019.

Official inspections of the conditions of the work environment and assessment of occupational exposure to chemical agents and industrial dusts are among the most important occupational health protection activities implemented by the State Sanitary Inspectorate.

Despite the applicable legal regulations specifying the issues of occupational health and safety in relation to exposure to chemical agents, there are situations in employment establishments where employees perform professional activities in violation of the following provisions, among others: on chemical substances and their mixtures (Act... 2011), i.e. provisions concerning the registration, evaluation, authorisation and restriction of the use

of chemical substances, REACH [Regulation (EC) No 1907/2006 – and classification, labelling and packaging (CLP) – Regulation (EC) No 1272/2008].

The knowledge of chemical agents occurring in the work environment as well as concentrations of the substances harmful to health present in the air and volumes of the doses absorbed by employees allows work processes managers to apply appropriate countermeasures in order to reduce the occupational risk and – as a result - limit negative health effects. Health education and prophylaxis of the employees are important for reducing the negative health effects of occupational exposure to chemical substances in the work process (Chmielewski et al. 2015, 2017, 2018, 2020, *a,b,c*).

Irregularities detected by inspections of the State Sanitary Inspectorate in terms of violations of the listed regulations have been presented in Table 1.

The official preventive inspections by the State Sanitary Inspectorate in the analysed period showed a decrease by 63.7% in the number of employment establishments with irregularities in the use of chemical substances and their mixtures from 546 (100%) in year 2012 to 198 (36.3%) employment establishments in year 2019.

Effectiveness of the exercised official preventive inspections conducted by the State Sanitary Inspectorate may be evidenced by the fact that since 2016 there has been a noticeable decrease in employment establishments faulty in all areas subject to supervision. The only exception are single years in which a temporary upward trend is visible, relating to: a lack of packaging labelling in Polish, a lack of inventory of chemical substances/their mixtures, a number of chemical substances/ mixtures for which safety data sheets were questioned, a lack of inventory of chemical substances/their mixtures, a number of chemical substances/mixtures for which labelling was questioned.

The respiratory system is the most important route of absorption of chemical substances by humans and – therefore – the most reliable method of assessment of occupational exposure to these substances is direct measurement of their concentrations in the work environment workplace (Chmielewski et al. 2013, 2017, 2020).

In order to illustrate cases of working in the conditions exceeding the threshold limit value (TLV) of chemical agents in the work environment in supervised employment establishments in the analysed period, detailed data have been presented in Table 2, showing the number of employment establishments and workers employed in these conditions.

The analysis of the exposure of workers employed in the conditions exceeding the threshold limit value (TLV) of chemical agents in the Mazovia Province shows the number of workers performing professional activities in these conditions is at the level from 0.03% (79 workers in 2014) to 0.13% (342 workers in 2018) in relation to the number of employed workers in the inspected work establishments. The above may confirm the companies taking care of employers ensuring hygienic working conditions.

Table 1

Compliance of the use of chemical substances with the Law on Chemical Substances and their Mixtures, REACH and CLP in supervised employment establishments

Specification	Year							
	2012	2013	2014	2015	2016	2017	2018	2019
Number of employment establishments with detected irregularities regarding chemical substances and mixtures (in total)*	546	469	543	485	304	221	231	198
Number of users where the following have been found								
A lack of up-to-date inventory of the applied hazardous substances, hazardous mixtures, critical substances or critical mixtures	197	198	194	208	143	92	115	80
Unlawful labelling of chemical substances and mixtures	28	32	22	19	16	9	7	7
A lack of safety data sheets	161	151	156	164	137	68	91	63
Unlawful safety data sheets	34	39	60	25	13	14	23	23
Number of chemical substances / mixtures for which safety data sheets have been questioned	62	154	79	91	55	87	92	67
Number of chemical substances / mixtures for which labelling has been questioned	52	55	33	44	66	11	117	24
Number of users where incorrectly labelled containers, tanks, unlined pipelines for hazardous substances and mixtures	7	10	11	24	3	3	3	0
Number of orders in decisions concerning the issues								
A lack of the inventory of chemical substances / mixtures	149	168	158	177	136	84	100	73
A lack of safety data sheets	130	131	144	142	122	86	84	50
Incorrect/outdated safety data sheets	15	16	17	24	11	15	22	29
A lack of / incorrect packaging labelling	7	17	17	22	5	6	1	4
A lack of packaging labelling in polish language	5	4	4	5	10	4	2	1
A lack of chemical instructions / access to safety data sheet information for workers	106	156	100	143	106	45	58	55
A lack of / incorrect labelling of containers / tanks / pipelines	6	11	12	15	3	2	3	0
A lack of labelling of storage areas for chemicals	25	19	15	28	15	7	6	8

* concerning both placing on the market and the use of chemical substances

Table 2

Exceedances of the threshold limit value (TLV) in chemical agents in the work environment in relation to the number of employment establishments and workers employed in these conditions (as of 31 December)

Specification	Year							
	2012	2013	2014	2015	2016	2017	2018	2019
Number of employment establishments in the register	15 955	16 129	16 967	17 589	17 985	18 155	18 643	18 603
Number of inspected employment establishments	5085	5178	5139	5303	5039	4666	4555	4478
Number of employment establishments where the inspections confirmed exceedances of the chemical agents	14	18	8	22	25	16	27	17
Number of workers								
Employed in the work establishments in total	602 514	600 038	618 007	639 763	681 289	688 147	716 120	687 265
Employed in the inspected work establishments In total	285 674	265 098	262 512	278 128	291 964	277 530	263 850	267 524
Employed in the conditions exceeding the maximum permissible concentration for chemical agents	89	222	79	180	250	217	342	168

In the analysed period of time, the highest number of employees working in the conditions exceeding the threshold limit value (TLV) of chemical agents in the work environment according to the Polish Classification of Activities included the manufacture of machinery and equipment, not elsewhere classified – the highest number of cases (399), followed by the health care system (323), while the manufacture of motor vehicles, trailers and semi-trailers, excluding motorbikes was in the third place (167).

As the analysis for the period covering the years 2013, 2016, 2019 shows, the largest number of workers (660 employees – 100%) in the conditions exceeding the threshold limit value (TLV) of chemical agents in the work environment by the type of agent were exposed to manganese and its inorganic compounds (calculated as Mn) – inhalable fraction – the 1st place 173 employees (26.2%), the second most numerous group of 116 employees (17.6%) were exposed to manganese and its inorganic compounds (calculated as Mn) – respirable fraction, and in the third place there were 87 workers (13.2%) exposed to formaldehyde, while 71 workers (10.8%) were exposed to nitrous oxide (4th place) and 51 workers (7.2%) were exposed to xylene – a mixture of (1,2-, 1,3-, 1,4-) isomers (5th place).

Occupational diseases caused by chemical agents by disease entities

In years 2012 to 2019, in the Mazovia Province, there were 445 cases of occupational diseases whose aetiological factor was a chemical factor. The most frequently registered ones included pneumoconiosis – 254 cases, i.e. 57.1% of all diseases. Asbestosis with 205 cases and accounting for 80.7% of the group was prevalent. Silicosis was diagnosed in 45 people (17.1% in this group).

Malignant neoplasms with 77 cases (17.3% of occupational pathologies) constituted the second group in terms of the number of the reported conditions. Lung cancer was dominant – 40 cases (57.1% in this group), while pleural or peritoneal mesothelioma represented 33 cases (42.8% in this group).

Skin diseases ranked third with 51 cases, accounting for 11.5% of all occupational diseases. Allergic contact dermatitis predominated – 40 cases (78.4% in this group) and irritant contact dermatitis was reported in 10 cases (19.6% in this group).

Pleural or pericardial diseases caused by asbestos dust – 48 (10.8% of all occupational diseases) constituted the next most numerous group. There were 42 cases of pleural or pericardial diseases caused by asbestos dust – extensive pleural thickening, accounting for 87.5% in this group.

The following single cases, such as: bronchial asthma – 4 cases; allergic rhinitis – 4 cases; chronic obstructive bronchitis – 3 cases; acute poisoning – 2 cases; extrinsic allergic alveolitis – 1 case; nasal septum perforation induced by irritant and corrosive agents – 1 case, were reported.

The list and number of diagnosed occupational diseases caused by chemical agents have been presented in Table 3.

Occupational diseases by causative agent

In years 2012 to 2019, in the Mazovia Province, the main aetiological factor of diagnosed occupational diseases was asbestos dust, which was responsible for 325 identified cases of occupational diseases. The most frequently registered disease resulting from exposure to this factor was asbestosis – 205 cases (63.1% in this group). Among diseases of pleura or pericardium induced by asbestos dust, diffuse thickening of pleura with 42 cases, representing 12.9% of this group, constituted the second most common disease in this group. Lung cancer was diagnosed in 39 cases (12% in this group). Pleural or peritoneal mesothelioma was diagnosed in 33 people (10.1% in this group).

Allergic and irritant factors were the second most aetiological causative factor of the identified occupational diseases – 56 cases. Allergic contact dermatitis predominated in this group – 40 cases (71.4% in this group). Irritant contact dermatitis was reported in 10 cases (1.8% in this group).

Dusts containing free crystalline silica ranked third with regard to aetiolo-

Table 3

Number of diagnosed occupational diseases by item in the list of occupational diseases
(as at 31 December)

Item of the list	Occupational disease	Year								
		Total	2012	2013	2014	2015	2016	2017	2018	2019
	Occupational diseases in total	1717	223	213	192	195	195	211	237	251
	Occupational diseases caused by chemical agents in total	445	42	54	42	42	42	77	70	76
1	Acute or chronic poisoning or its sequelae caused by chemical substances	2		1					1	
3	Pneumoconiosis:	254	24	27	23	21	24	49	36	50
3.1	silicosis	45	7	2	8	3	5	6	6	8
3.3	pneumoconiosis associated with tuberculosis	1			1					
3.4	welders' pneumoconiosis	1					1			
3.5	asbestosis	205	17	25	14	18	18	43	28	42
3.8	pneumoconioses due to metal dusts	2							2	
4	Diseases of pleura or pericardium induced by asbestos dust:	48	4	9	2	5	5	6	6	11
4.1	diseases of pleura or pericardium induced by asbestos dust – diffuse thickening of pleura	42	4	6	2	4	5	6	6	9
4.2	diffuse plaques of pleura or pericardium	6		3		1				2
5	Chronic obstructive bronchitis which has caused fixed impairment of pulmonary ventilation with decrease in forced expiratory volume during the first second of expiration (FEV1) < 50% of predicted value, induced by exposure to dusts and irritant gases if cases of an excess of appropriate hygienic measures at the workplace were documented within the last 10 years	3		1	1		1			

cont. Table 3

Item of the list	Occupational disease	Year								
		Total	2012	2013	2014	2015	2016	2017	2018	2019
6	Bronchial asthma	4		1		1			2	
7	Extrinsic allergic alveolitis:	1								1
7.2	chronic form	1								1
12	Allergic rhinitis	4				1			1	2
14	Nasal septum perforation induced by irritant and corrosive agents	1		1						
17	Malignant neoplasms induced by human carcinogens present in work environment:	77	5	8	11	10	9	13	15	6
17.1	lung cancer	40	2	5	5	4	7	5	7	5
17.2	pleural or peritoneal mesothelioma	33	2	2	6	5	2	7	8	1
17.3	neoplasm of haematopoietic system – multiple myeloma	1						1		
17.5	urinary bladder cancer	2		1		1				
17.7	laryngeal cancer	1	1							
18	Skin diseases:	51	6	9	5	4	3	9	9	6
18.1	allergic contact dermatitis	40	6	4	5	4	2	7	9	3
18.2	irritant contact dermatitis	10		4			1	2		3
18.5	contact urticaria	1		1						

gical factors causing occupation diseases – 47 cases. Silicosis, responsible for 45 occupational diseases, constituted the main disease in this category.

There were single cases of neoplasms, such as urinary bladder cancer, neoplasm of haematopoietic system – multiple myeloma, lung cancer; other diseases were: chronic obstructive bronchitis, bronchial asthma, allergic rhinitis, welders' pneumoconiosis, pneumoconioses due to metal dusts, acute or chronic poisoning or its sequelae caused by chemical substances, nasal septum perforation induced by irritant and corrosive agents.

Table 4 illustrates the structure of diagnosed occupational diseases according to their aetiology.

Diagnosed occupational diseases by causative agent
(as at 31 December)

Item of the list	Causative agent	Year								
		Total	2012	2013	2014	2015	2016	2017	2018	2019
	Aromatic amines	1		1						
17.5	urinary bladder cancer	1		1						
	Benzene	1						1		
17.3	neoplasm of haematopoietic system – multiple myeloma	1						1		
	Vinyl chloride	1				1				
17.5	urinary bladder cancer	1				1				
	Chromium	1		1						
17.7	laryngeal cancer	1		1						
	Allergenic agents and irritants (chromium, nickel, formaldehyde, chloramine-T, para-phenylenediamine, styrene, thiram, chloromethylisothiazolinone, methylisothiazolinone, plastic, cement, latex, epoxy resins, polyester resins, paint pigments, industrial cleaners, disinfectants, foodstuffs and others)	56	6	9	5	4	4	8	11	9
18.1	allergic contact dermatitis	40	6	4	5	4	3	6	9	3
18.2	irritant contact dermatitis	10		4			1	2		3
18.5	contact urticaria	1		1						
12	Allergic rhinitis	3							1	2
6	bronchial asthma	1							1	
7.2	extrinsic allergic alveolitis: chronic form	1								1
	Chemical agents:	3	1		1		1			
5	Chronic obstructive bronchitis which has caused fixed impairment of pulmonary ventilation with decrease in forced expiratory volume during the first second of expiration (FEV1) < 50% of predicted value, induced by exposure to dusts and irritant gases if cases of an excess of appropriate hygienic measures at the workplace were documented within the last 10 years	2			1		1			
6	bronchial asthma	1	1							
	Asbestos dust	325	25	41	27	31	32	61	49	59

DISCUSSION

Increasing frequency of use and variety of chemical substances available in the work processes creates the need for the proper supervision of occupational health and safety in contact with these agents. Chemical substances pose a potential threat to human health, causing numerous adverse health effects, including ones classified as occupational diseases. As a result, it is important for each person who handles chemicals to know and understand the health risks associated with their use. Inspections of their proper use by both the authorities appointed for this purpose as well as employers and employees constitutes an equally significant element of prophylaxis (Kurt, Basaran 2020, Hernández-Mesa et al. 2021, Steindal, Grung 2021).

Any work leads to changes in the human body and reduces strength, although it results in an occupational disease much less frequently. The effects of exposure to harmful chemicals can be topical (irritation and sensitization effects on the skin and mucous membrane) and systemic (effects on human internal organs), and their intensity can be of acute or chronic nature. Distant consequences of exposure to toxic substances (carcinogenic and mutagenic effects as well as pathological changes in offspring) are also distinguished (Chmielewski et al. 2015, 2017, 2020b).

The problem of occupational disease is primarily a medical problem. The relationship of a disease to the performed work is adjudicated by occupational medicine specialists. Occupational disease clearly confirms deterioration of the quality of life by devaluation of the health condition (Boschman et al. 2017, Benavides et al. 2019, Lu et al. 2019, Drexler 2020).

One of the measures of the effective prevention of occupational diseases, both within the scope of obligations of the employer and state authorities responsible for supervision of working conditions and, more broadly, public health, is an analysis of the data on occupational diseases (Boschman et al. 2017, Chmielewski et al. 2017).

The increase in the incidence of occupational diseases caused by chemical agents from 42 cases in the year 2015 (9.4% in this group) to 76 cases in the year 2019 (17.1%) representing almost doubling of the number of cases (94.5%) is not only a noticeable trend within the territory of the Mazovia province. A similar upward trend was observed in Korea where the number of occupational diseases occurring as a result of exposure to harmful substances almost doubled from 1959 in the year 2015 to 4035 in the year 2019. (Moon et al. 2021).

In the analysed period from 2012 to 2019, malignant tumours of occupational origin were detected in 77 cases and they accounted for 17.3% of all occupational diseases caused by chemical agents (445 cases). In comparison, cancers of occupational aetiology in the period from 2003 to 2019 represented only 1.94% of all occupational diseases in the Podkarpackie province (Rybka 2020).

In comparison, 440 cases (100%) of occupational skin diseases were reported nationwide in the period from 2012 to 2017, whereas 36 cases (8.2%) were reported in the same period in the Mazovia province (Jałowska et al. 2019).

Feder et al. confirmed occupational exposure to asbestos on the basis of the analysis of 1038 cases from the German Mesothelioma Register, and reported suspected asbestos-related disease in 767 cases in year 2015. Based on the conducted study, they confirmed that even after very long intervals of up to 40 years since the last exposure, asbestos fibres were still detectable in the examined lung tissues. The above finding is very significant for employees working in the conditions of exposure to asbestos while applying for recognition of an occupational disease (Feder et al. 2018).

In the light of the research performed, Świątkowska confirmed an increase in diagnosed asbestos-related pathologies from 8% in 2000 to 25% in 2019. In the years from 2000 and 2019, 2078 diseases caused by exposure to asbestos were diagnosed among workers reporting for medical examinations. Among these diseases, asbestosis was the predominant one with 1880 cases (90.5%), followed by lung cancer with 121 cases (5.8%) and pleural mesothelioma with 77 patients (3.7%). The above data correspond with the data on aetiological factors and diagnosed occupational diseases in the Mazovia Province (Świątkowska 2020).

As shown in the study by Jałowska et al., in 2017, skin diseases were ranked seventh among the most frequently diagnosed occupational diseases in Poland, whereas in 2003, they occupied the fifth position. A total of 1694 cases of occupational skin diseases were diagnosed from 2003 to 2017. The most frequently diagnosed occupational skin disease was allergic contact dermatitis – 1364 cases of this disease, which represents 80.5% of all reported occupational skin diseases. Chromates, chemicals used in rubber industry, formaldehyde, resins and adhesives constitute the most frequent allergenic substances causing this disease. The second most frequent occupational skin disease in the above period was irritant contact dermatitis – a total of 219 cases were registered, i.e. 12.9% of all occupational diseases in this group. Chemical substances are the most common agents causing contact dermatitis due to irritation in the workplace. Contact urticaria was diagnosed in 68 people, accounting for 4.0% of all occupational diseases. Urticaria is in the third place among the most common occupational diseases (Jałowska et al. 2019). The above data are consistent with data relating to occupational diseases in this group diagnosed among workers in the Mazovia Province.

Data pertaining to occupational cancers from the period covered by the analysis in the Mazovia Province are consistent with results of the study by Rybka covering the Podkarpackie Province in the years from 2003 to 2019. Rybka proved that occupational cancers accounted for 1.94% of all occupational diseases. Since 2006, incidence of occupational cancers has remained at a similar level. The most common sites of cancers of occupation-

al aetiology included: a lung, bronchi and the larynx. The most frequently identified and diagnosed occupational cancers among the diagnosed cancers of occupational aetiology in the Podkarpackie Province were lung cancer and bronchial cancer (item 17.1 of the list, 8 cases in total). There were 4 cases of laryngeal cancer (item 17.7 of the list) and pleural or peritoneal mesothelioma (item 17.2 of the list). There were 2 cases confirmed from item 17.3 of the list – neoplasm of haematopoietic system and item 17.4 of the list – skin cancer (Rybka 2020). The data related to the identified cancers of occupational aetiology resulting from exposure to chemical agents from the Podkarpackie Province correlates with the data from the Mazovia Province in the period covered by the analysis.

SUMMARY

For several years, health problems associated with exposure to chemical agents have constituted the subject of research of both global and national scientific institutions, including the Health and Safety Executive (HSE), the European Agency for Safety and Health at Work (EU-OSHA) and Central Institute for Labour Protection - National Research Institute in Warsaw (Polish abbreviation: CIOP-PIB) as well as the Nofer *Institute of Occupational Medicine in Łódź* (Polish abbreviation: IMP).

The continuous increase in the use of chemical agents in the work environment constitutes one of the main causes of occupational diseases in Poland. There is a need for conscious involvement of all participants in the process, from authorities and institutions responsible for supervising employment establishments through employers and employees, in order to minimise the risk of occupational diseases.

Workers are exposed to chemical agents at numerous workplaces. As confirmed by inspections of the State Sanitary Inspectorate, employers should reduce exposure of the worker to the lowest possible level by fulfilling their basic obligations (including making and documenting occupational exposure assessments, determining the values of the threshold limit values for chemical substances regularly, keeping the relevant records and implementation of the proper preventive measures).

Promotion of pro-health attitudes among employees and employers by the authorities of the State Sanitary Inspectorate and the National Labour Inspectorate should constitute an important element of both prophylaxis and prevention of occupational diseases.

It is reasonable and fully justified to build awareness of employees about health risks related to work with the use of chemical agents, including the threats after completion of work under exposure to these agents due to the long latency period of particular disease entities.

Conflict of interest

The authors declare no potential conflict of interest concerning the authorship and/or publication of this article.

REFERENCES

- Act of 25 February 2011 *on chemical substances and their mixtures*. (in Polish) <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20110630322/U/D20110322Lj.pdf>
- Boschman J.S., Brand T., Frings-Dresen M.H.W., van der Molen H.F. 2017. *Improving the assessment of occupational diseases by occupational physicians*. *Occup. Med-c.*, 67(1): 13-19. DOI: 10.1093/occmed/kqw149
- Bovio N., Richardson D.B., Guseva Canu I. 2020. *Sex-specific risks and trends in lung cancer mortality across occupations and economic activities in Switzerland (1990-2014)*. *Occup. Environ. Med.*, (8):540-548. DOI: 10.1136/oemed-2019-106356
- Carles C., Verdun-Esquer C., Leclerc I., Baldi I. 2019. *Occupational cancers: Risks and prevention*. *Bull Cancer.*, 106(7-8):665-677. (in French) DOI : 10.1016/j.bulcan.2018.10.010
- Council Directive 98/24/EC of 7 April 1998 *on the protection of the health and safety of workers from the risks related to chemical agents at work* (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31998L0024>
- Chmielewski J., Nagas T., Trzepla E., Orłak K. 2013. *A prick and a cut as factors increasing the hazard/risk/danger of occupational disease among veterinary surgeons and technicians*. *Życie Wet.*, 88(8): 647-650. (in Polish) <https://vetpol.org.pl/dmdocuments/ZW-2013-08-07.pdf>
- Chmielewski J., Jackowska N., Nagas T., Wojciechowska M., Anusz K., Szpringer M., Jagusztyn I., Trela M., Zagórski J. 2015. *Occupational exposure to chemicals in veterinary practice*. *Życie Wet.*, 90(11): 711-714. (in Polish) <https://vetpol.org.pl/dmdocuments/ZW-11-2015-01.pdf>
- Chmielewski J., Dziechciaż M., Czarny-Działak M., Uściński P., Rutkowski, Florek-Łuszczki M., Żeber-Dzikowska I. 2017. *Environmental health threats in the work process*. *Med Środowiskowa – Environmental Medicine*, 20(2): 52-61. (in Polish) DOI: 10.19243/2017207
- Chmielewski J., Czarny-Działak M., Laurman-Jarząbek E., Ślusarczyk J., Żeber-Dzikowska I., Wójtowicz B., Gworek B., Dziechciaż M. 2018. *Anesthetic gases: application, environmental exposure and ways of risk reduction*. *Przem. Chem.*, 97(10): 1760-1763. (in Polish) DOI: 10.15199/62.2018.10.25
- Chmielewski J., Starz-Nowak G., Gworek B., Król H., Szpringer M., Wójcik T., Dziewisz E., Kowalska A., Czarny-Działak M. 2020. *Chemical substances occurring in the work environment as an etiological factor of occupational diseases*. *Przem. Chem.*, 99(5): 718-726. (in Polish) DOI: 10.15199/62.2020.5.9
- Chmielewski J., Żeber-Dzikowska I., Kosecka J., Wójtowicz B., Działak M., Osuch M., Gworek B., Chmielowiec B., Czarny-Działak M. 2020a. *Exposure to chemicals as an etiological agent of occupational skin diseases and related health education*. *Przem. Chem.*, 99(8): 1254-1260. (in Polish) DOI: 10.15199/62.2020.8.28
- Chmielewski J., Szpringer M., Łuszczki J.J., Czarny-Działak M., Dutkiewicz E., Zięba E., Gworek B., Dziechciaż M., Nowak-Starz G. 2020b. *Occupational and environmental exposure to substances and chemical mixtures that are toxic to human reproduction*. *Przem. Chem.*, 99(6): 865-874. (in Polish) DOI: 10.15199/62.2020.6.7
- Chmielewski J., Wójtowicz B., Żeber-Dzikowska I., Dziechciaż M., Sierpiński R., Cedro A., Markowski K., Gworek B., Szpringer M. 2020c. *Occupational exposure of electroplating workers to chemical substances and related health effects in the context of health education and prevention*. *Przem. Chem.*, 99(8): 1196-1201. (in Polish) DOI: 10.15199/62.2020.8.16
- Chmielewski J., Raczek M., Puścion M., Chmielowiec B., Pawlas N., Łuszczki J. J. 2021.

- COVID-19 caused by the SARS-CoV-2 virus as an occupational disease of medical professionals.* Med Ogólna Nauki Zdr, 27(3): 235-243. (in Polish) DOI: 10.26444/monz/139319
- Cwynar E., Kosińska M., Tomczyk-Socha M. 2013. *Analysis of notifications of suspicions of diseases caused by the way the job is performed in the context of pathologies regarded as occupational diseases.* Med. Pr., 64(3): 387-396. (in Polish) DOI: 10.13075/mp.5893.2013.0033.
- Drexler H. 2020. *Rare occupational diseases.* Internist (Berl), 61(6): 626-633. (in German) DOI: 10.1007/s00108-020-00788-y
- Feder I.S., Theile A., Tannapfel A. 2018. *Histological findings and lung dust analysis as the basis for occupational disease compensation in asbestos-related lung cancer in Germany.* Int. J. Occup. Med. Env., 31(3): 293-305. DOI: 10.13075/ijomeh.1896.01148
- GUS. 2020. *Working conditions in 2019.* (in Polish) <https://stat.gov.pl/obszary-tematyczne/rynek-pracy/warunki-pracy-wypadki-przy-pracy/warunki-pracy-w-2019-roku,1,14.html>
- GUS. 2014. *Accidents at work and work-related health problems* (in Polish) <https://stat.gov.pl/obszary-tematyczne/rynek-pracy/warunki-pracy-wypadki-przy-pracy/wypadki-przy-pracy-i-problemy-zdrowotne-zwiazane-z-praca,2,2.html>
- Hernández-Mesa M., Le Bizec B., Dervilly G. 2021. *Metabolomics in chemical risk analysis – A review.* Anal. Chim. Acta., 1154: 338298. DOI: 10.1016/j.aca.2021.338298
- Jałowska M., Szymoniak-Lipska M., Żaba R., Adamski Z. 2019. *Epidemiology of occupational skin diseases in Poland in the period 2003-2017.* Dermatol Rev, 106(4): 384-395. DOI: 10.5114/dr.2019.88255
- Kurt O.K., Basaran N. 2020. *Occupational exposure to metals and solvents: allergy and airway diseases.* Curr. Allergy Asthma Rep., 20(8):38. DOI: 10.1007/s11882-020-00931-7
- Lu Y., Yan H., Zhang L., Liu J. 2019. *A comparative study on the prediction of occupational diseases in China with hybrid algorithm combining models.* Comput. Math. Method. M., 8159506. DOI: 10.1155/2019/8159506
- Moon H.I., Han S.W., Shin S., Byeon S.H. 2021. *Comparison of the qualitative and the quantitative risk assessment of hazardous substances requiring management under the occupational safety and health act in South Korea.* Int. J. Env. Res. Pub. He., 18(3): 1354. DOI: 10.3390/ijerph18031354
- Salski W., Wiszniewska M., Salska A., Tymoszek D., Walusiak-Skorupa J. 2016. *Work-related rhinitis – Is it always an occupational disease?* Med. Pr., 67(6), 801-815. (in Polish) DOI: 10.13075/mp.5893.00423
- Steindal E.H., Grung M. 2021. *Management of PFAS with the aid of chemical product registries – an indispensable tool for future control of hazardous substances.* Integr. Environ. Asses., 17(4):835-851. DOI: 10.1002/ieam.4380
- Świątkowska B. 2020. *The Amiantus Program in Poland – 20 years of implementation.* Med. Pr., 71(5), 595-601. (in Polish) DOI: 10.13075/mp.5893.00997
- Regulation of the Minister of Labour and Social Policy dated 26 September 1997 *on general regulations of labour safety and hygiene.* (in Polish) <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU19971290844/O/D19970844.pdf>
- Regulation of the Minister of Health of 30 December 2004 *on health and safety at work related to the presence of chemical agents in the workplace.* (in Polish) <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20050110086/O/D20050086.pdf>
- Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 *concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC* <https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32006R1907>

-
- Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 *on classification, labelling and packaging of substances and mixtures*, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (Text with EEA relevance) <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32008R1272>
- Regulation of the Council of Ministers of 30 June 2009 *on occupational diseases*. (in Polish) <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20091050869>
- Regulation of the Minister of Health of 24 July 2012 *on chemical substances, mixtures, agents or technological processes having carcinogenic or mutagenic effects in the workplace*. (in Polish) <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20120000890>
- Regulation of the Minister of Family, Labour and Social Policy of 12 June 2018 *on the maximum permissible concentrations and intensities of factors harmful to health in the working environment*. (in Polish) <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001286/O/D20181286.pdf>
- Rybka A. 2020. *Neoplastic diseases (cancer) of occupational origin between 2003-2019 in Podkarpackie voivodeship*. *Przegl. Epidemiol.*, 74(3): 483-491. DOI: 10.32394/pe.74.42
- Wiszniewska M., Lipińska-Ojrzanowska A., Witkowska A., Tymoszek D., Kleniewska A., Kluszczyński D., Walusiak-Skorupa J. 2018. *Occupational cancers – epidemiology and certification*. *Med. Pr.*, 69(1): 93-108. (in Polish) DOI: 10.13075/mp.5893.00620