ASBESTOS DANGER IN CENTRAL EUROPE IS NOT YET OVER – THE SITUATION IN THE CZECH REPUBLIC

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SUMMARY

Objectives: In the Czech Republic, asbestos has been classified as a known human carcinogen since 1984. The use of asbestos-containing products was limited to scenarios where the use of other materials was not possible. Since 1997, the manufacture of asbestos materials has been forbidden, and in 1999, the import, manufacture and distribution of all types of asbestos fibres was legally banned by Act No. 157/1998 Coll. Although the use of asbestos is forbidden, the risk of exposure still exists given the ongoing demolition and reconstruction of buildings in which asbestos has been used. In addition, a novel risk has arisen through the quarrying of asbestos-containing aggregates and their subsequent use. The aim of this paper was to describe and evaluate asbestos in terms of history, legislation, current risk of occupational exposure and its health consequences in the Czech Republic over the last three decades.

Methods: This retrospective descriptive study used the collected data on occupational exposure and occupational diseases. The counts of workers occupationally exposed to asbestos were obtained from the Registry of Work Categorization; the numbers and structure of occupational diseases caused by asbestos were taken from the Czech National Registry of Occupational Diseases. Data on the total number of mesothelioma cases recorded in the Czech National Cancer Registry was provided by the Institute of Health Information and Statistics of the Czech Republic.

Results: A total of 13,112 subjects were registered as occupationally exposed to asbestos during the period 2001–2020. A total of 687 cases of asbestos-related occupational diseases were reported in the period 1991–2020 in the Czech Republic, comprising 178 cases of asbestosis, 250 cases of pleural hyalinosis, 168 cases of pleural or peritoneal mesothelioma, 90 cases of lung cancer, and one case of laryngeal cancer. The data from the Czech National Cancer Registry, available for a shorter period (1991–2018), reveal 1,389 cases of mesothelioma, of which only ~11% were recognised as occupational, despite the fact that the occupational causality of mesotheliomas is estimated to be up to 90% of mesotheliomas. Moreover, the latency of mesotheliomas since the last occupational exposure reached up to 50 years and this trend is still slightly increasing, unlike asbestosis, where a high cumulative dose of inhaled asbestos is needed. The real proportion of occupational lung cancers may obviously be even higher, especially in smokers, where occupational causes including asbestos are not suspected by most physicians.

Conclusion: Czech data on asbestos-related occupational diseases, especially cancers, are grossly underestimated, which is most apparent through the low proportion of mesotheliomas diagnosed as occupational. Asbestos materials in older buildings remained in situ and may represent a danger during reconstruction works. The current source of exposure appears to be quarrying of asbestos-containing aggregate and its subsequent use. Awareness of the professional community is therefore crucial, not only for the possibility of compensating those affected, but also for the early detection of the diseases through the dispensary of exposed persons.

Key words: asbestos, asbestos ban, asbestos-related diseases, unrecognised occupational diseases, work categorization

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INTRODUCTION

Environmental and occupational exposure to asbestos and their associated health consequences remain a significant public health issue, both globally and on a local scale in the Czech Republic. The legislation prohibiting the use of asbestos did not apply to the removal of asbestos products already fixed in the buildings in the past, such as insulation materials or roofing; thus, it does not protect demolition crews or the general population. The persistence of asbestos fibres in the lungs explains the long latency period between exposure and outbreak of asbestos-related malignant diseases, including their most serious forms such as mesothelioma and lung cancer. This is a consequence of the massive use of asbestos from the 1970s to the 1990s.

Asbestos occurs naturally as the amphibole and serpentine minerals (1) and is a covering term for six fibrous silicate minerals (amphibole class actinolite CAS 77536-66-4, amosite (grunerite) CAS 12172-73-5, anthophyllite CAS 77536-67-5, crocidolite CAS 12001-28-4, tremolite CAS 77536-68-6, and serpentine class chrysolite CAS 12001-29-5). These materials range from

white to dark green colour and are formed from thin microscopic fibres, which are insoluble in water and resistant to acids and alkalis. They may be released into atmosphere via aerial erosion from natural deposits and during the demolition or renovation of buildings containing asbestos materials. Airborne concentration of asbestos in indoor spaces also depends on the deterioration of these materials by age.

Asbestos has certain properties that have made it desirable as a material. The earliest mention of its use dates back to antiquity. Its name comes from the Greek "asbestos" meaning "inextinguishable" or "indestructible". The ancient Greeks had a wide range of uses for asbestos, including wicks for lamps, woven tablecloths, fireproof clothing, and cremation apparel for royalty. Tablecloths containing asbestos were apparently cleansed by throwing them into a fire to remove food remains and dirt. Asbestos was likewise used in building materials due to its fire-resistant properties (2). One of the ways that the heat-resistant and insulation properties of asbestos were applied in consumer products was its use in the first filters of certain brands of cigarettes in 1952. These cigarettes used carcinogenic crocidolite, which was directly inhaled by smokers (3).

Exposure to dust containing all types of asbestos fibres is directly associated with six diseases: pleural hyalinosis (or pleural thickening), asbestosis, mesothelioma, lung cancer, laryngeal cancer, and ovarian cancer (1, 4). The most significant characteristics of asbestos fibres associated with the frequency and severity of asbestos-related diseases are the length and diameter of the fibres, their specific type, and their ability to deposit and persist in body tissues. Longer asbestos fibres are more hazardous than shorter ones; the most dangerous parameters are fibres longer than 5–8 μm and thinner than 1.5 μm. The same type of fibres can be associated with various industrial processes with varying types of risk (5). The presence of respirable fibres should be measured in the workplace air, i.e., fibres thinner than 3 μm, longer than 5 μm, with length to diameter ratios greater than 3:1, which can penetrate into the airways and cause breathing difficulties.

Asbestos fibres can be studied in the lung tissue as so-called asbestos bodies, covered with hemosiderin. They have been detected in the lungs in the healthy population in low quantities but are ~100 times more frequent in patients with lung cancer or mesothelioma and ~1,000 time more frequent in patients with asbestosis (6).

Pleural hyalinosis is a local reaction to the presence of asbestos fibres in the pleural cavity, either carried directly or by the lymphatic system from the alveoli. It affects the pleura and visceral pleura, causing hyaline thickening that is either bordered by calcified plaques or extends further into the pleura in both lungs. Health effects involving deterioration of pulmonary functions occur after extensive changes, including pleuritis (sometimes subclinical) (2).

Asbestosis is caused by inhalation of large amounts of minute asbestos fibres, resulting in inflammatory changes, diffuse interstitial fibrosis and finally "honeycomb lung". This is followed by uncontrollable deterioration of pulmonary function, right heart failure and death. Asbestosis manifests itself in workers with long-term heavy exposure to asbestos dust. In a milder form, it has also been observed within populations living in the vicinity of heavy and unconstrained asbestos emission sources (2, 7).

Lung cancer cases were first described in the 1930s in asbestosis patients. The latency period between exposure to asbestos fibres and the outbreak of the disease is usually in the range of 20–40 years. Smokers exposed to asbestos are at considerably higher risk of contracting lung cancer than non-smokers with equivalent exposure history. Asbestos in combination with the chemicals present in tobacco smoke has a joint effect in the development of lung cancer that is higher than in cases of single or individual exposure (8, 9).

Mesothelioma is a malignant tumour of the lining of the lungs and the chest wall, the peritoneum, and less commonly the pericardium. The majority of mesothelioma cases are caused by the presence of asbestos in the pleura. The development of this cancer with a bad prognosis commonly takes over 30 years. In addition to occupationally exposed workers, increased incidence has been recorded in household members of the "asbestos workers" or in persons living in the vicinity of asbestos emissions. Its main cause is asbestos (1).

In the Czech Republic, laryngeal cancer must be associated with the initial stages of asbestosis or hyalinosis to be reported as an occupational disease. This is because unlike mesothelioma, it may also be triggered by other factors, including smoking (10).

Ovarian cancer is predominantly of unknown aetiology and is associated with genetic load. However, it has been shown that inhaled asbestos fibres may enter the lymphatic system, and they have been found in the ovaries of women with asbestos exposure (11).

In 2012, the International Agency for Research on Cancer (IARC) documented a significant association of ovarian cancer with asbestos exposure (1). As is the case with laryngeal cancer, Czech legislation requires an initial stage of asbestosis or hyalinosis to acknowledge ovarian cancer as an occupational disease. The Czech Republic classified asbestos as a proven human carcinogen in 1984 (Directive No. 64/1984 of Ministry of Health CR – Chief Public Health Officer, Hygiene Regulations). The use of asbestos (including chrysotile) products was limited to cases where no other material is suitable. The application of asbestos in spray form was prohibited. Since 1997, the manufacture of asbestos products has been forbidden and asbestos should no longer be used in the construction of new buildings, including asbestos-cement and other materials. In 1999, Act No. 157/1998 Coll. on chemical substances and products banned the import, manufacture and distribution of the amphibole fibres of crocidolite, amosite, anthophyllite, actinolite, and tremolite in the Czech Republic. However, there still remains the possibility of exposure during demolition and reconstruction of buildings. A novel risk is the quarrying of asbestos-containing aggregate and its subsequent use (road grit, crushed aggregate for surface treatment of public areas, etc.); for example, the use of actinolite in Litice in the Pilsen Region.

Since 2001, the Public Health Authorities have registered categories of work activities in the Registry of Work Activities Categorization. This information system enables the numbers of people occupationally exposed to the individual risk factors to be monitored according to risk severity: 2, 2R, 3 and 4. Classification of work at risk from exposure to asbestos into a particular category is based on the relationship between the concentration of respirable fibres in the workplace and the permissible exposure limit (PEL), defined for asbestos by government regulation No. 361/2007 Coll. in Annex 3, Table 5, as the number of respirable fibres 0.1/cm^3.

Analyses of the incidence of asbestos-related diseases in WHO/Europe member states resulted in the fifth (Parma Declaration, 2010) and sixth Ministerial Conference on Environment and Health (Ostrava Declaration, 2017), targeted at minimising asbestos exposure in WHO/Europe member states. Following WHO and ILO recommendations, the National Institute of Public Health, in collaboration with the Ministry of Health, has profiled the asbestos issue in the Czech Republic, which catalogues environmental and occupational asbestos load, leading to the development of a primary, secondary and tertiary system of asbestos exposure-related disease prevention (12).

In 2007, an analysis of occupational exposure to asbestos and related diseases in the Czech Republic during the period of 1991–2005 was published (13). As an extension of that study, we herein present an update up to 2020. The aim of our work is to describe and evaluate asbestos use in this country in terms of its history, legislation and occupational exposure, including the current risk and trends in asbestos-related diseases.

MATERIALS AND METHODS

Our study is a retrospective descriptive study covering the period of 1991–2020. The analysis consisted of data collection, making, expressing as percentages, and drawing conclusions. This period of the last three decades was chosen according to the intersection of the availability of data from the various databases. The number of people occupationally exposed to asbestos was taken from the Registry of Work Activities Categorization, performed by industrial hygienists from the regional Public Health Authorities, which started in 2001.

The PEL for asbestos fibres of all types of asbestos, i.e., the number of respirable fibres 0.1/cm^3, was used in the classification of the occupational exposure category:

Category 2: Exposure to asbestos fibres, where average whole-shift concentration in the working atmosphere reach 30–100% of the PEL value.

Category 2R: The concentrations of asbestos fibres in the same range; however, the risk is higher according to the decision of the Public Health Authority.

Category 3: Concentration in the range of 100–300% of the PEL value.

Category 4: Concentrations above 300% of the PEL value.

The number and structure of occupational diseases was retrieved from the Czech National Registry of Occupational Diseases. Data on the total number of mesothelioma cases in the Czech Republic recorded in the Czech National Cancer Registry was provided by the Institute of Health Information and Statistics of the Czech Republic.

RESULTS

Categorization of Work Activities with Exposure to Asbestos

Table 1 shows the number of persons occupationally exposed to asbestos in Categories 2, 2R, 3 and 4 in the years 2001–2020. Total number was 13,112 workers. It should be noted that the increase in numbers of the persons recorded in the first few years after the establishment of the Work Activities Categorization Registry reflects the database's gradual acquisition of data. As can be observed, exposure is predominant in Category 3, with 50.3% of exposed workers, followed by Category 2, where PEL is not exceeded. The numbers of workers classified as Category 4 (0.9%) have been reduced but are still present. Overall, the downward trend in most categories is not readily apparent, and the reduction in numbers is not clearly obvious.

Table 1. *Development of counts of workers exposed to asbestos in individual risk categories according to the Registry of Work Activities Categorization (N = 13,112)*

Year	Category				Total
	2	2R	3	4	
2001	20	0	26	0	46
2002	134	26	121	13	294
2003	203	52	146	19	420
2004	222	42	127	12	403
2005	236	40	173	12	461
2006	125	33	160	12	330
2007	138	30	160	12	340
2008	179	35	177	6	397
2009	212	21	207	0	440
2010	216	16	218	0	450
2011	217	21	271	0	509
2012	248	21	314	0	583
2013	294	18	399	0	711
2014	375	31	493	3	902
2015	411	36	573	8	1,028
2016	441	36	577	8	1,062
2017	451	33	604	3	1,091
2018	489	50	606	3	1,148
2019	603	52	650	3	1,308
2020	549	50	587	3	1,189
Total	5,763 (43.9%)	643 (4.9%)	6,589 (50.3%)	117 (0.9%)	13,112 (100.0%)

Analysis of Incidence of Diseases Associated with Asbestos Exposure

Diseases caused by asbestos first appeared in the Czech List of Occupational Diseases, which was the Annex to Act No. 46/1947 Coll., on National Insurance, as an item No. 29: disease caused by inhaled asbestos dust (asbestosis), in which

a) clinical/functional manifestations are supported by typical X-ray findings; and
b) are associated with lung cancer.

The issue remained unchanged until 1996, when the new List of Occupational Diseases was adopted as the Annex to Government Regulation No. 290/1995 Coll., in which asbestos-related diseases are referred to in Chapter III, item No. 2. In contrast to the earlier legislation, X-ray criteria for asbestosis are classified according

to ILO classification and two diagnoses have been added: pleural hyalinosis and pleural or peritoneal mesothelioma. The Government Regulation No. 114/2011 Coll. has added laryngeal cancer as being caused by asbestos. The latest amendment by Government Regulation No. 168/2014 Coll. also includes ovarian cancer (14).

Government Regulation No. 168/2014 Coll.: LODs, Chapter III, item No. 2 Diseases of the respiratory tract, lungs and pleura or peritoneum caused by asbestos dust:

a) asbestosis with irregular X-ray opacities at s2, t2, u2 and higher profusion according to ILO classification;
b) pleural hyalinosis with restrictive ventilation disorder;
c) mesothelioma;
d) lung cancer, laryngeal cancer or ovarian cancer associated with asbestosis with irregular opacities with profusion from s1/1, t1/1, u1/1 according to ILO classification or with pleural hyalinosis.

Although asbestos-related diseases have been recognised as occupational diseases since 1947, valid data on incidence have only been available since 1991, with the introduction of the Czech National Registry of Occupational Diseases. Since building of this information system has been a gradual process, the reliability of contained data increases with time.

Figure 1 shows the "benign" forms of asbestos-related diseases – asbestosis and pleural hyalinosis, and Figure 2 the malignant diseases – mesothelioma, lung cancer and laryngeal cancer, acknowledged as occupational in the past 20 years. In the last decade, the incidence of asbestos-induced cancer has been around 20 cases per year.

However, the incidence of asbestos-related occupational diseases does not show a monotonic trend. The long-term trend shows a relative decline in the number of benign forms of asbestos-related diseases – asbestosis and pleural hyalinosis in the last 10 years. On the other side, the number of malignant diseases, especially mesotheliomas, is not decreasing. Similarly, the incidence of lung cancer remains relatively stable during the three decades. The two last asbestos-related cancers did not influence the statistics – occupational laryngeal cancer has only been acknowledged in one case in 2019, and ovarian cancer has never been reported as an occupational disease.

As shown in the Table 2, only ~11% of mesothelioma cases reported to the Czech National Cancer Registry were given occupational status in the 1991–2018 period.

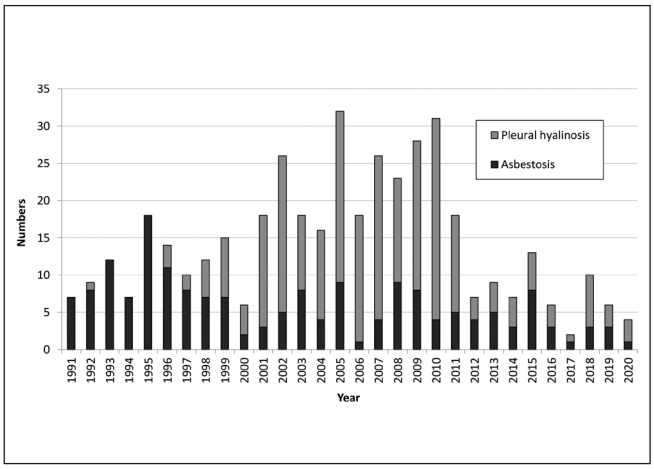

Fig. 1. *Pleural hyalinosis and asbestosis acknowledged as occupational diseases in the Czech Republic 1991–2020.*

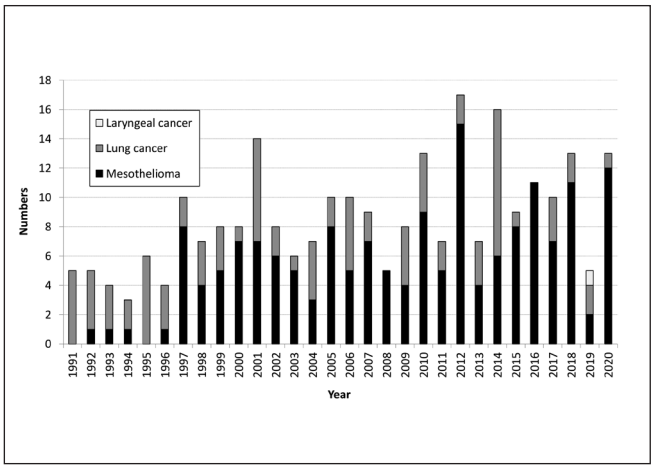

Fig. 2. *Mesothelioma, lung and laryngeal cancer acknowledged as occupational diseases in the Czech Republic 1991–2020.*

DISCUSSION

In the Czech Republic, asbestosis incidence has slowly decreased since the mid-1990s, due to gradual phasing out of high exposures in workplaces during the 1970s and 1980s. Pleural hyalinosis peaked later, during the first decade of the 21st century, as this disease can also occur following milder exposures, which took longer to eradicate. Interestingly, counts of mesothelioma continue to rise even in the most recent decades, i.e., up to 50 years since the last occupational exposure. This can be explained by the persistence of the fibres in the lungs. The numbers for lung cancer remain relatively stable over the three decades. This may be related to the decreased incidence of asbestosis and pleural hyalinosis, which are necessary conditions for acknowledging occupational lung and laryngeal cancer in patients.

In general, the diagnosis of occupational cancer is very difficult (15). There are several reasons for this, and the most important appears to be the several decades of latency (up to 50 years) from exposure to the disease. There is also the necessity to confirm exposure to asbestos after such a delay, coupled with the low awareness of both patients and healthcare personnel regarding the causality. In addition, all cancers, excluding mesothelioma, can also appear in subjects without asbestos exposure.

According to the WHO and foreign literature sources, the majority of mesothelioma cases (according to some sources up to 90%) are the result of asbestos exposure (16). In the Australian Mesothelioma Registry, an occupational origin was detected in 60% of cases (17).

In the Czech Republic, however, mesothelioma cases acknowledged as occupational represent only ~11% of the country's cases registered in the Czech National Cancer Registry, for the period of 1991–2018. Obviously, the real figures are likely to be far higher and the numbers of other asbestos-linked cancers are even more underestimated. Laryngeal cancer was acknowledged as occupational only in one single instance from 2019, and no case of asbestos-linked ovarian cancer has been recognised up to 2021. Since the possibility of compensation for occupational diseases is not limited by retirement age, general practitioners, pulmonologists and gynaecologists should focus on the occupational history of patients with these diagnoses, bearing in mind the previous

Table 2. *Mesotheliomas in the Czech Republic 1991–2018: comparison between the Czech National Cancer Registry and the Czech National Registry of Occupational Diseases*

Year	Number of mesotheliomas in the Czech National Cancer Registry	Number of mesotheliomas in the Czech National Registry of Occupational Diseases	Proportion of occupational mesotheliomas in the Czech Republic (%)
1991	37	0	0.0
1992	49	1	2.0
1993	38	1	2.6
1994	53	1	1.9
1995	39	0	0.0
1996	42	1	2.4
1997	47	8	17.0
1998	43	4	9.3
1999	41	5	12.2
2000	54	7	13.0
2001	59	7	11.9
2002	74	6	8.1
2003	63	5	7.9
2004	60	3	5.0
2005	57	8	14.0
2006	40	5	12.5
2007	47	7	14.9
2008	41	5	12.2
2009	48	4	8.3
2010	52	9	17.3
2011	39	5	12.8
2012	49	15	30.6
2013	42	4	9.5
2014	56	6	10.7
2015	57	8	14.0
2016	53	11	20.8
2017	51	7	13.7
2018	58	11	19.0
Total	1,389	154	Mean (SD) 10.8 (6.9)

40–50 years retrospective work history. If there is a possibility of previous exposure to asbestos, the patients should be referred to the Regional Occupational Disease Centres for assessment and potential compensation of these occupational diseases.

According to the most recent WHO estimates available to us, more than 107,000 people die each year from asbestos-related lung cancer, mesothelioma and asbestosis as a result from exposure at work, however, the numbers of acknowledged occupational diseases are much lower (16, 18). In 1995, EU mortality statistics for men revealed approximately 3,600 deaths from mesothelioma, 1,400 of which were attributed to occupational exposure (19). Incidence across the EU is variable. National epidemiological studies in Poland analysing the incidence of asbestos-related diseases in the period of 1970–2015 revealed a decline in cases (20), whereas in Greece there was an increasing trend (21). A possible explanation is that the use of asbestos was banned at different times (22, 23). According to IARC, the age-standardised mortality attributed to mesothelioma per 1,000,000 persons aged 15 years or more in 2016 was highest in the UK, with 26 men and 5 women. In Germany, the Mesothelioma Register has recorded a 13% increase in incidence of this cancer between 2010 and 2016 (24).

The Czech Republic, with about 5 cases of the mesothelioma per 1,000,000 persons belongs to the group of countries with lowest incidence of this disease, not only in the Europe but also worldwide (1, 16, 25). However, similar to other countries, these counts are underestimated. Patients have frequently been pensioners treated by general practitioners for a number of co-morbidities, and the autopsies that could confirm the diagnosis are only rarely performed (15). A far clearer picture is seen in states with specific registries for mesothelioma – the first registry was founded in Australia in 1980. Currently, such registries exist in Italy, France, Belgium, Germany, Japan, South Korea, Turkey, and the UK (26).

CONCLUSION

Although the use of asbestos in the Czech Republic was gradually decreasing for decades, and completely banned by law in 1999, there remains a considerable amount of used roofing materials with asbestos content still in place. Workers who reconstruct older buildings and those handling hazardous waste containing asbestos are at risk. According to the latest Eurostat data, there was a 7% decrease in occupational mesothelioma cases in the EU from 2013 to 2018 for the first time following a long period of stagnation (27). Nevertheless, this asbestos-linked malignancy will continue to occur in the future, albeit, hopefully with decreasing incidence (28). British authors have estimated that mesothelioma mortality in the UK will decline until about 2055, when persons born prior to 1965 will reach their nineties (29).

Improved preventive strategies should be prioritised by the national health policy (25) and the Asbestos National Profile of the Czech Republic from 2019 presents basic suggestions for the prevention of environmentally and occupationally acquired asbestos-linked diseases (12). Asbestos is still of relevance and interest and remains the subject of research. For example, a timely diagnosis of mesothelioma could be assisted by the determination of mesothelial markers as part of preventive examinations in persons with an occupational history of asbestos exposure (30). Underreporting may be even more pronounced in other asbestos-related malignant diseases, i.e., lung cancer, laryngeal cancer and ovarian cancer, where the link to asbestos is not well known among the population and healthcare specialists.

The problem of asbestos exposure is still topical given the ongoing demolition of buildings in which asbestos was used, or possible exposure in quarries. It is therefore beneficial to continue to monitor the trend in the number of cases of asbestos-related diseases and to draw attention to this issue, because, as the data suggest, the occupational aetiology seems to be underestimated. In addition, the numbers of reported cases are low compared to the incidence of the disease in the population or compared to the situation in other regions. Awareness of the professional community of the asbestos risk is crucial, not only for the possibility of compensation for those affected, but also for the possibility of early detection of the disease, through the dispensary and follow-up of exposed subjects.

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Conflict of Interest

None declared

REFERENCES

1. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Asbestos (chrysotile, amosite, crocidolite, tremolite, actinolite and anthophyllite). IARC Monogr Eval Carcinog Risks Hum. 2012;100C:219-309.
2. Pelclova D. Pneumoconiosis - a disease of mineral dusts. Olomouc: Solen; 2018. (In Czech.)
3. Longo WE, Rigler MW, Slade J. Crocidolite asbestos fibers in smoke from original Kent cigarettes. Cancer Res. 1995;55(11):2232-5.
4. King D. History of asbestos [Internet]. Orlando: The Mesothelioma Center; 2021 [cited 2021 Sep 3]. Available from: https://www.asbestos.com/asbestos/history/.
5. U.S. Department of Health and Human Services. Asbestos fibers and other elongate mineral particles: state of the science and roadmap for research. Curr Intell Bull. 2011;(62):1-153.
6. De Vuyst P, Karjalainen A, Dumortier P, Pairon J-C, Monsó E, Brochard P, et al. Guidelines for mineral fibre analyses in biological samples: report of the ERS Working Group. Eur Respir J. 1998;11(6):1416-26.
7. Selby K. Asbestosis [Internet]. Orlando: The Mesothelioma Center; 2021 [cited 2021 Sep 3]. Available from: https://www.asbestos.com/asbestosis/.
8. Markowitz S. Asbestos-related lung cancer and malignant mesothelioma of the pleura: selected current issues. Semin Respir Crit Care Med. 2015;36(3):334-46.
9. Klebe S, Leigh J, Henderson DW, Nurminen M. Asbestos, smoking and lung cancer: an update. Int J Environ Res Public Health. 2020;17(1):258. doi: 10.3390/ijerph17010258.
10. Oksa P, Wolff H, Vehmas T, Pallasaho P, Frilander H, editors. Asbestos, asbestosis, and cancer: Helsinki criteria for diagnosis and attribution 2014. Helsinki: Finnish Institute of Occupational Health; 2014.
11. Langseth H, Johansen BV, Nesland JM, Kjaerheim K. Asbestos fibers in ovarian tissue from Norwegian pulp and paper workers. Int J Gynecol Cancer. 2007;17(1):44-9.
12. Kazmarova H, Kotlik B, Lipsova V, Urban P, Vit M. Asbestos National Profile of the Czech Republic. Prague: National Institute of Public Health; 2019. (In Czech.)
13. Pelclová D, Fenclová Z, Urban P. Asbestos exposure, legislation and diseases in the Czech Republic. Cent Eur J Public Health. 2007;15(3):99-102.
14. Government Decree No. 290, 1995, wherein is set the list of occupational diseases, as amended. Sbírka zákonů ČR. 1995 Dec 15; Pt 76:3969-78. (In Czech.)
15. Pelclova D, Fenclova Z, Urban P. Occupational cancer in the Czech Republic - a tip of the iceberg? Eur J Oncol. 2011;16(3):149-61.
16. International Agency for Research on Cancer. IARC cancer mortality database [Internet]. Lyon: IARC; 2019 [cited 2021 Sep 3]. Available from: https://www-dep.iarc.fr/WHOdb/WHOdb.htm.
17. Soeberg MJ, Leigh J, van Zandwijk N. Malignant mesothelioma in Australia 2015: current incidence and asbestos exposure trends. J Toxicol Environ Health B Crit Rev. 2016;19(5-6):173-89.
18. Takala J. Eliminating occupational cancer in Europe and globally: working paper 2015.10. Brussels: ETUI; 2015.
19. European Communities. Work and health in the EU: a statistical portrait: data 1994-2002. Luxembourg: Office for Official Publications of the European Communities; 2004.
20. Swiatkowska B, Szeszenia-Dabrowska N. Long-term epidemiological observation of asbestos-related diseases in Poland, 1970–2015. Occup Med (Lond). 2017;67(3):182-7.
21. Gogou E, Hatzoglou C, Zarogiannis SG, Malli F, Jagirdar RM, Gourgoulianis KI. Mesothelioma mortality rates in Greece for the period 2005–2015 is increased compared to previous decades. Medicina (Kaunas). 2019;55(8):419. doi:10.3390/medicina55080419.
22. Marinaccio A, Binazzi A, Gauzillo G, Cavone D, Zotti RD, Ferrante P, et al. Analysis of latency time and its determinants in asbestos related malignant mesothelioma cases of the Italian register. Eur J Cancer. 2007;43(18):2722-8.
23. Hilliard AK, Lovett JK, McGavin CR. The rise and fall in incidence of malignant mesothelioma from a British Naval Dockyard, 1979–1999. Occup Med (Lond). 2003;53(3):209-12.
24. Tischoff I, Tannapfel A. Mesotheliom. Pathologe. 2017;38(6):547-60. (In German.)
25. Janosikova M, Nakladalova M, Stepanek L, Borikova A, Vildova H, Fosum M. Occurrence of asbestos-related occupational diseases in the Czech Republic in the last 20 years. Cent Eur J Public Health. 2020;28(Suppl):S37-42.
26. Van Gerwen M, Alpert N, Flores R, Taioli E. An overview of existing mesothelioma registries worldwide, and the need for a US Registry. Am J Ind Med. 2020;63(2):115-20.
27. Eurostat. Occupational diseases statistics [Internet]. Luxembourg: Eurostat, Statistics Explained; 2020 [cited 2021 Sep 3]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Occupational_diseases_statistics.
28. Wilk E, Krówczyńska M. Malignant mesothelioma and asbestos exposure in Europe: Evidence of spatial clustering. Geospat Health. 2021;16(1). doi: 10.4081/gh.2021.951.

29. Gilham C, Rake C, Hodgson J, Darnton A, Burdett G, Peto Wild J, et al. Past and current asbestos exposure and future mesothelioma risks in Britain: The Inhaled Particles Study (TIPS). Int J Epidemiol. 2018;47(6):1745-56.
30. Jakubec P, Pelclova D, Smolkova P, Kolek V, Nakladalova M. Significance of serum mesothelin in an asbestos-exposed population in the Czech Republic. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2015;159(3):472-9.

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