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Reviews

Patterns in medical surveillance of workers exposed to lung carcinogens

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Abstract

One of the most common causes of lung cancer is exposure to occupational carcinogens. Free silica, diesel exhaust fumes, dyes, radon and with asbestos at the top of the list, differ by percentage according to the predominant professional activities in each country. The occupational health doctor is directly involved in the surveillance of the exposed worker, during work or post exposure, in the diagnosis and reporting of occupational cancers. Efficient screening followed by reporting and monitoring cases of occupational lung cancer and, last but not least, reintegration into professional activity are important steps in the medical surveillance of the worker exposed to occupational lung carcinogens. Standardised information collected at the level of occupational exposure monitoring systems, separated by carcinogen category and profession, may form the basis of control and prevention plans. Harmonising medical surveillance at European and global level can lead to a decrease in the incidence and mortality of work-related lung cancer.

Keywords: *lung cancer, occupational carcinogens, screening, medical surveillance*

Introduction

Lung cancer is the second most common cancer in the world. Beside smoking, occupational carcinogens are the most frequent etiological factors. Statistics from 2019 in the UK reach a percentage of 13% [1], with similar values being found in other countries. The main carcinogenic agent is asbestos. Other carcinogenic factors are responsible for more or less cases according to the economic fields specific to each country. Overall, the most frequently encountered are crystalline silica dust, diesel engine exhaust, paints, radon, mineral oils, arsenic and inorganic compounds, and welding fumes.

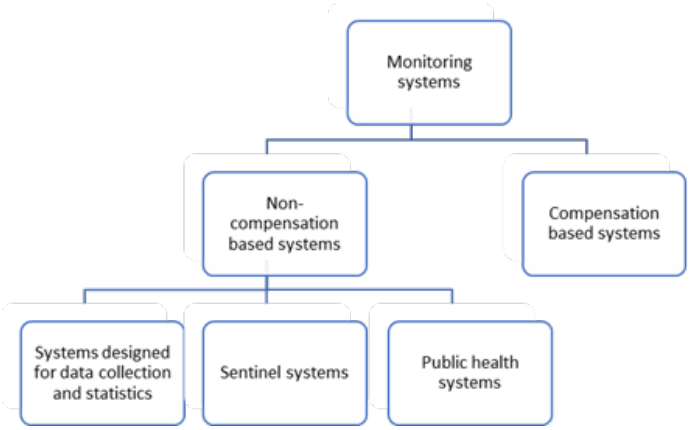
All over the world, the diagnosis and reporting of occupational lung cancer cases is greatly underestimated. The difference between the estimated number and the reported number of occupational lung cancers has several possible causes: the lack of effective screening, the non-correlation of the lung cancer diagnosis with exposure to occupational carcinogens, the patient's disinterest in following the steps necessary to declare the occupational disease due to the precarious health status and/or limited benefits.

Monitoring systems

The occupational medicine doctor has an important role in reducing this difference by medically supervising the worker both during and after exposure. This medical surveillance is carried out with the help of monitoring systems for occupational lung cancer, which overlap monitoring systems for occupational diseases. These systems include several subtypes of systems with specific actions [2] (Figure 1).

Compensation-based systems, for example - Fund for Occupational Diseases (Belgium), Finnish Register of Occupational Diseases - FROD (Finland), The Washington Safety & Health Assessment & Research for Prevention - SHARP (USA), Statutory Health Surveillance for Occupational Diseases - SUVA (Switzerland), are well regulated and offer compensation for the confirmed occupational cancers. The cases are reported mainly by doctors, but some systems also accept requests from the employee (Belgium) [4], the employer (Finland) [4] or the trade union delegates (Spain) [2]. In these countries, illnesses are analysed and registered as occupational based on a closed or open list, by occupational medicine doctors or medical boards. The US SHARP system has no such list. They have a program for monitoring groups of diseases (like asthma) and after registration in the system, it is verified by specialists. Within open lists the main system is helped by complementary systems for the analysis of new diseases with an occupational main factor. In Spain, which has a closed list, these new cases can be recognized as occupational accidents. A single system also collects data that will lead to the implementation of prevention measures – SUVA in Switzerland.

Figure 1. Monitoring systems for occupational cancer



Systems designed for data collection and statistics collect and analyse data to calculate the incidence and prevalence of occupational diseases. There are systems that track all occupational diseases such as: The Health and Occupation Reporting Network for General Practitioners - THOR-GP (UK), Registry of Work-related Diseases - RAS (Norway), French National Occupational Diseases Surveillance and Prevention Network - RNV3P (France), Malattie Professionali - MALPROOF (Italy) or are differentiated by category, such as - Surveillance of Work-Related and Occupational Respiratory Disease (SWORD - UK) for respiratory diseases, Work-related and occupational skin disease (EPIDERM - UK) for skin diseases, The French Registry Of Workers Handling Engineered Nanomaterials (EPINANO - France) for diseases due to nanoparticles, The Italian Occupational Cancer Monitoring (OCCAM - Italy) for occupational cancers[2][3]. Reporters are mainly doctors and the final statement differs in procedure. Based on the data collected, it makes prevention plans at different levels (company, region) and communicates with the government for national prevention plans. Unfortunately, in many countries the reporting of occupational diseases is insufficient and registered cases are needed to be able to take preventive measures more easily and quickly.

Sentinel systems collect, through the voluntary participation of doctors, new information about occupational diseases not included in the lists or about already known occupational diseases. The sentinel system collects quality information from

carefully selected centres that may draw attention to an increased occupational risk factor in a certain field and the need for scientific research in that field. Only then can this information be disseminated and direct interventions and protective measures initiated. Any affected intermediate element leads to a decrease in the effectiveness of the sentinel system and ultimately to an ineffective or non-existent prevention. They are systems focused on all occupational diseases or on categories of occupational diseases. Italy is the only European country that has such a system for occupational cancers - OCCAM. New Zealand has the Notifiable Occupational Disease System (NODS) which focuses on 4 different categories: Cancers, Respiratory Diseases, Solvents, Chemicals. There are also several international systems that have online platforms for expert discussions: The Signalling New Occupational Disorders (SIGNAAL) in Belgium and the Netherlands and the Occupational Diseases Sentinel Clinical Watch System (OccWatch) – a pilot program for occupational medicine doctors in France and Belgium, but which also includes experts from other countries - Germany, Finland, Norway, Holland [5].

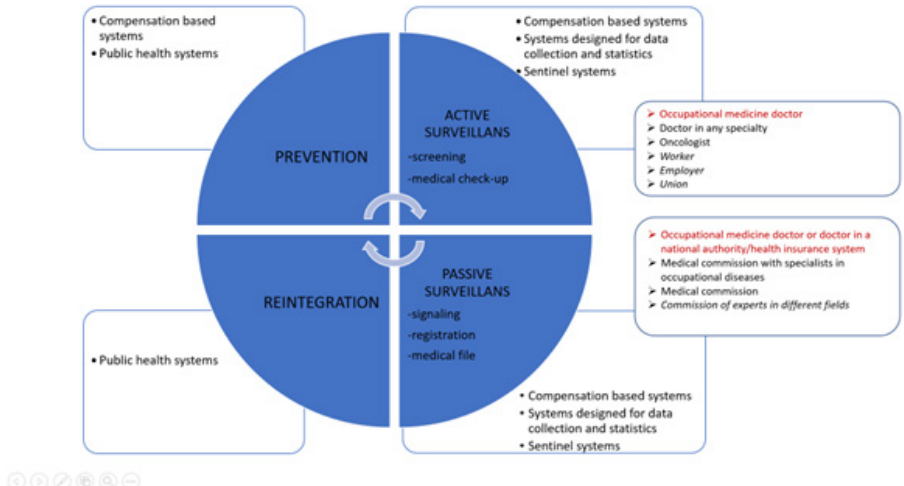
Public health systems address the general population or some population categories. Worker-focused systems initiate, based on information related to the prevalence and incidence of occupational cancer cases, prevention and control strategies applied to groups exposed to increased risks.

Medical surveillance

Medical surveillance of the worker involves following up his health from the moment of first employment until the moment of retirement, in correlation with the occupational history and therefore with the exposure to possible carcinogens. It can be divided into two stages of surveillance: active and passive (Figure 2).

Active surveillance is carried out by the occupational medicine doctor within the pre-employment or periodically check-ups or through the spontaneous consultation initiated by the worker. It starts with the identification of occupational carcinogens and with the workers exposed. In general, the list of carcinogens derives from the classification of the International Agency for Research on Cancer (IARC). Some countries adapt this list according to the presence of these carcinogens at the national level – like Australia, and others have correlated this IARC list with other classifications (American Conference of Governmental Industrial Hygienists - ACGIH, US National Toxicology Program - NTP) [6] – like in Canada, USA or UK. In the vast majority of countries, a correlation is made between carcinogenic agents and the occupations or technological processes with a risk of exposure. The list is updated based on IARC Monographs, in accordance with European Directives or by a national authority.

Figure 2. Medical surveillance for occupational diseases



Screening

A very important first step in the medical surveillance of the worker exposed to carcinogenic agents is screening. It identifies lung cancer early and can help institute evidence-based prevention measures. For lung cancer screening, the guidelines recommend low-dose computed tomography, performed annually in the following categories: people aged between 55 and 74 years, smokers of 30 packs/year or ex-smokers who have been abstinent for up to 15 years [7]. Following recently concluded studies, in the USA the screening criteria were changed in 2021 by increasing the age range from 50 to 80 years, and by lowering the threshold from 30 to 20 packs/year, for smokers [8].

Active worker surveillance involves periodical clinical consultation and occupational lung cancer screening. The interval between consultations should be defined on evidence- based data, which is missing for many occupations and sometimes is defined by an expert consensus. The lack of clear epidemiological data related to the carcinogen-lung cancer pair does not provide generally valid criteria for screening. In 2011, in the USA, some screening criteria were proposed for workers with exposure to lung carcinogens: age > 50 years, smokers with no. of packages/year ≥ 20, exposure to 1 risk factor of the type: minimum 5-year exposure to an occupational lung carcinogen, pulmonary fibrosis or COPD [9]. Surveillance continues even after the worker ends his professional activity. In France, low-dose chest CT scan is recommended for workers previously exposed to high levels of asbestos ≥ 5 years or to intermediate exposure for ≥ 10 years. It is also recommended for exposure to other occupational lung carcinogens with a cumulative exposure over 10 years. Smoking is also taken into account, the increased number of packs/ years equating exposure to another carcinogen or intensity of exposure [10].

Starting from epidemiological studies, questionnaire-based screening can be done for occupational lung cancer or for other categories of occupational cancers. The questionnaires can be applied to the general population, to age groups, to regions, fields of activity or even to patients suspected of having occupational cancer. An example would be a study conducted in France between 2017-2019 on 1251 patients with lung cancer in which 462 patients responded to the questionnaire (approximately 1/3 of the total). Of these, 176 were selected following the responses for a specialist consultation. Only 150 people showed up for this consultation and 88 of them (7% of the initial number of participants) were diagnosed with occupational lung cancer [11]. Screening questionnaires are applied, in general, to reduce the number of exposure-workers within a target group to then carry out radiological/ low dose chest CT screening.

Another method is to use information letters from patients who have a diagnosis of cancer and who are known to have worked in an area with increased exposure to occupational carcinogens (Norway, Canada) [12] in order to improve the screening questionnaires.

Screening programs that can lead to earlier diagnosis, together with prevention and more effective treatments, influence the 5-year survival rate, which in the case of lung cancer is among the lowest: between 7.7% Bulgaria and 20.4 % Switzerland in Europe [13]. In USA the survival is 20.5% [14]. Encouraging results were obtained in the International Early Lung Cancer Action Program (I-ELCAP), which showed tremendous progress with annual screening with low-dose CT. The participants in this program reached a 20-year survaival rate of 81% [15].

The findings in the area of screening are very important and necessary. Scientific research has been going on for several years on a new device, Aeonose, which is being studied mainly for lung cancer screening. This portable device analyses in 15 minutes volatile organic components resulting from physiological or pathological processes and which can be detected in a person's exhalation. These volatile organic compounds, in certain concentrations and combinations, create a breath fingerprint that could be used to diagnose cancer. The results obtained show a sensitivity of the test of 95%, a specificity of 51% and a negative predictive value of 94% [16]. Also, studies are still ongoing for its use in the diagnosis of colorectal cancer, tuberculosis or other respiratory infections.

Recognition

Initiation of the recognition is done differently in European countries. Those who initiate the process can be not only occupational medicine doctors, specialist doctors, or different combinations between them, but, as previously mentioned, also the worker or the employer (Scheme 3) [4].

Passive surveillance by national authorities is based on the list of occupational diseases, which includes occupational lung cancer and allows recognition of the occupational disease if exposure is confirmed. By confirming the occupational character, the worker's compensation and reporting can be done at the

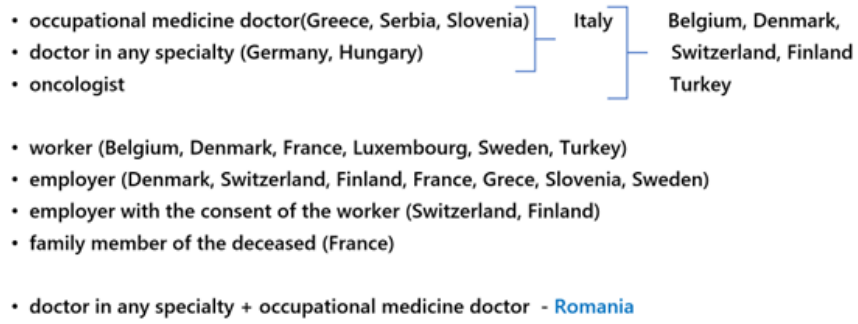
national level. In Europe, 26 countries have adopted, based on European Commission Recommendation 670 from 2003, updated in 2022, a list of occupational diseases into their national legislation. One country (Cyprus) have two separate lists, one for compensation of occupational diseases and one for prevention, and 3 countries do not have such a list - Iceland, the Netherlands and Sweden and treat occupational diseases as ordinary diseases [2].

The recognition is made through special procedures by doctors within a public health authority (Romania) or within the national insurance system (Greece), including the investigation of exposure, or can be made by medical commissions for occupational diseases (Estonia, Latvia).

The reporting criteria that are considered are duration of exposure (Latvia, Serbia), duration of exposure and level of exposure (Belgium, Denmark, Estonia, Germany, Italy, Slovenia), duration between cessation of exposure and diagnosis (Turkey), the level and duration of exposure are included as primary data in an already defined job exposure matrix (Finland), the relationship between occupation and occupational disease associated with duration and level of exposure (France, Switzerland)[4]. These recognition criteria can be established by: the national authority defining exposure criteria (France), the insurance system (Switzerland), expert committees (Hungary), committees made up of employers, workers and experts (Netherlands) [4].

The level of exposure is tracked through databases in which exposure measurements are recorded providing a quantitative assessment and through information systems that estimate the level of exposure and the risk of lung cancer.

Figure 3. Initiators of the recognition process for occupational cancer



Among the databases we can mention ExpoSYN from Germany which covers 18 European countries and Canada analysing 5 carcinogenic factors: asbestos, chromium, nickel, polycyclic aromatic hydrocarbons, free crystalline silicon dioxide powder [17].

The oldest (1990) and most complex information system is CAREX, which includes 19 European countries, Canada, Costa Rica, Nicaragua, Panama. This system tracks 55 industrial sectors by analysing exposure to various lung carcinogens: passive smoking, silica dust, diesel engine exhaust, radon and wood dust [18]. Another type of information systems that use a workplace exposure matrix is The Finnish Job–Exposure Matrix - FINJEM from Finland, MATGENE from France or the Nordic Occupational Cancer Study - NOCCA which includes follows ups in Denmark, Finland, Iceland, Norway and Sweden.

There are also information systems focused on a single carcinogen or targeting different population categories (women, young people under 25). An example is WOODEX – which tracks wood dust by level of exposure, type of wood, industry in which it is used in 25 European countries [19].

SYNERGY from Germany, based on data from ExpoSYN, additionally evaluates radon and the interaction of the 6 carcinogens with smoking. As we know, smoking is the etiological factor in 72% of lung cancers [1], causes respiratory diseases that are themselves risk factors for cancer, or act synergistically with other occupational lung carcinogens (asbestos, crystalline silicon dust) [20]. Second-hand smoke at work is another carcinogenic agent with a high weight until the application of legislative measures related to smoking in public spaces, following the recommendations of the European Council in 2009. Thus, in 2021, Germany included lung cancer due

to exposure to occupational diseases on the list of occupational diseases intensive passive smoking at work. It is considered that the worker who does not smoke or has smoked a maximum of 400 equivalent cigarettes and has been exposed to second-hand smoke at work for about 40 years [21].

Exposure registries

National occupational exposure registries collect information on the total number of occupational cancer cases or may differentiate by carcinogenic factors. In some countries these registers also collect information on workers at risk of exposure and can identify areas of increased risk of exposure where prevention measures can be initiated. Some of these registers are The Finnish Register of Workers Exposed to Carcinogens (ASA Register), the Italian Information System for Recording Occupational Exposures to Carcinogens (SIREP) and the German ODIN Register [16]. In Italy and Germany, there are parallel registers of cancers caused by exposure to asbestos - the National Mesothelioma Registry and the Register of asbestos-exposed workers (GVS). In the USA there is a special registry for firefighters in which occupational cancers are included in this job - National Firefighter Registry for Cancer (NFR) [22]. In Romania, the National Registry of occupationally exposed to carcinogenic or mutagenic agents and pneumoconiogenic dusts should be organized within the National Institute of Public Health, but is not yet functional.

The medical file of the worker exposed to carcinogens is kept for 40, 50 or 60 years, at the occupational health department or at the employer, and in case of liquidation of the company it has to be archived. In Greece the worker can keep a booklet with the results of his paraclinical investigations.

Rehabilitation and return to work

Rehabilitation and return to work after curing cancer is an element that can increase the physical-psychological well-being of the worker and help reduce the economic impact felt by the employer and society. Employees who have recovered from lung cancer may experience long-term physical (fatigue, pain) and mental (depression, anxiety, attention and memory disorders) symptoms, and the process of re-adaptation to the workplace is affected by numerous factors: socio-demographic (advanced age, low standard of living, poor education), factors related to the workplace (demanding work, inflexible schedule, lack of support from the employer), factors related to the location of the cancer (lung cancer decreases the capacity for rehabilitation) or treatment-related factors (extensive surgery).

In a 2020 study in Germany, more than 51% of the cancer survivors did not return to work [23].

In Europe, the USA and Australia there are two types of programs for the return to work of the worker who has recovered from occupational cancer: employee and employer information programs, which provide information about the rights of the returning employee and the necessary adaptations to his health problems and effective work reintegration programs that provide viable solutions. In 12 European countries there are information programs such as “Working through cancer program of Municipality-based occupational rehabilitation program” (Denmark), “In-hospital rehabilitation intervention” (Netherlands), “Work reintegration agency Re-turn” (Netherlands). In 7 European countries reintegration programs at work are available [24].

Conclusions

In Europe and the world, through legislative measures and occupational exposure monitoring systems, an attempt is made to harmonize medical surveillance and effective international collaboration. By reporting and monitoring cases of occupational lung cancer, even without declaration, clear, standardized information can be collected that can later be used as a basis for scientific research to track occupational lung cancer risk factors. From the studies and from the information collected by separate categories of workers, clear criteria can be concluded regarding the type of agent, the existence or not of a threshold level of exposure and the development of prevention and control plans. They also might help in the early detection in order to achieve effective, visible results in treatment and a significant decrease in the incidence and mortality from occupational lung cancer.

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