Features of overall and occupational morbidity rates among mine workers of marble and granite quarries of the Irkutsk Region

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Abstract. In connection with the active development of the mining sector of the economy, there is an important task of labor rate setting of mine workers and reliable records of occupational morbidity rate associated with dust emissions. The review is based on the scientific literature on occupational lung diseases in the mining industry that focuses on the recording and identification of occupational diseases associated with the silica dust (SiO₂) exposure. The article addresses both "traditional" and "emerging" concerns regarding occupational diseases of the respiratory system in mine workers, incorporating the data on evidence-based practices of practitioners in developed and developing countries. The data is devoted to deciphering the types of occupational diseases that are given the least attention, which results in the fact that many workers put themselves at risk due to a lack of knowledge about the consequences of inhaling stone dust while performing their duties. The SiO₂ dust resulted from the quarrying of marble and granite is underestimated. Its contribution to the development of occupational diseases of mine workers is significant and requires focused attention and an integrated approach to the prevention and control of occupational lung diseases associated with mining. The study has been carried out with the financial support of the Russian Foundation for Basic Research within the framework of scientific project No. 19-31-27001.

1. Introduction
The deposits of marble and granite stone in the Irkutsk region are among the largest in the region and the country as a whole. Quarrying is carried out in an open way and has varying degrees of production automation and exclusion of men from the technological cycle. The technology for the extraction of stone material is constantly being improved and modernized, the level of labor safety is moving towards, reducing the potential risks of mining hazards. Considering the positive aspects of this process, the workers of these quarries are in any case exposed to harmful and hazardous production factors, namely: the cooling microclimate of workplaces, general and local vibration, noise, dust and gas mixtures, and physical overloads [1-2]. The paper considers such a harmful and dangerous production factor as dust mixtures, as well as dust-gas mixtures. It is known that in addition to the
harsh natural and climatic conditions of Siberia, the impact of dust particles on the development of occupational morbidity has a high potential. The risk of occupational morbidity is very high, and first of all, the authors consider occupational diseases associated with the penetration of stone dust from marble and granite quarries into the innards.

The aim of the research is to study the frequency rate, structure and features of the formation of occupational diseases associated with the penetration of dust into the respiratory organs of mine workers of granite and marble quarries of the Irkutsk region.

According to the Irkutsk Region Federal Supervision Service for Consumers' Rights and Human Welfare, compared to the year of 2018, there is an increase in the level of occupational morbidity by 6.7% in the region in 2019. The largest number of victims is registered in the mining industry (44), in the production of other vehicles (aircraft) (25), in air transport (17), in the production of paper (15), in metallurgical production (14), logging (9), provision of electricity, gas and steam (7), and wood processing (6).

Among the nosological forms, diseases of the hearing organs prevailed - 47.5% (46.1% in 2018), vibration disease - 31.5% (33.7%), respiratory diseases - 14% (14.0%), allergic diseases - 3% (0.6%), and diseases of the musculoskeletal system - 2.5% (4.5%).

As can be seen from the official data, the level of diseases in the respiratory system is at a high level (14%), and the largest number of victims in the mining industry (44) occupies a leading position, despite the fact that from 50 to 3592 staff members work at the region's mining enterprises. In comparison with the leaders of the mining industry, for example, such as MMC Norilsk Nickel with a staff of 83 thousand people or ALROSA Stock Company with a staff of 39 thousand people.

2. Main part
The growth of occupational morbidity associated with diseases in respiratory system at the mining enterprises of the Irkutsk region is facilitated by harmful and unfavorable factors present in the working area, and one of such factors is stone dust.

Deciphering the types of occupational diseases is given minimal attention, and many workers put themselves at risk due to a lack of knowledge about the consequences of inhaling stone dust while performing their duties. Dust resulted from marble and granite mines causes lung diseases. Hereunder, the authors dwell on them in more detail.

According to the international classification described in the guidelines of the International Labor Organization (ILO), which is based on the coding of radiological signs of the disease, diseases of mine workers in the Irkutsk region belong to the group of pneumoconiosis. Pneumoconiosis is a parenchymal lung disease resulting from the inhalation of inorganic dust (usually) during work related to the processing of stone materials [3]. In particular, one of the common diseases among mine workers in the Irkutsk region is silicosis. Silicosis is the most common pneumoconiosis, which occurs from inhalation of silica dust containing free silicon dioxide (SiO₂) [4]. The marble and granite dust of the mining quarries of the Irkutsk region contains from 40 to 80% silicon dioxide (SiO₂) [5].

Silicosis results from the accumulation of the inhaled crystalline silica (SiO₂) particles in the lungs. The complaints of patients with silicosis are nonspecific and scanty: cough, sputum and shortness of breath on exertion. With the formation of large fibrous nodes and changes in the pleura, complaints of pain in the chest, tingling under the shoulder blades appear. On medical examination, hard breathing is heard, which is replaced by weakened breathing as emphysema grows, and wheezing appears [6].

Silicosis is divided into slowly progressive and rapidly progressive, as well as late-onset and regressive. Slowly progressive silicosis can move from one stage of the disease to another, and the transition time can be from 10 to 30 years, and sometimes, signs of progression of the fibrous process are not observed. Within 5-6 years or less, rapidly progressive silicosis develops, and over time it can be complicated by chronic bronchitis, breathlessness, pulmonary emphysema, tuberculosis, lung cancer, rheumatoid arthritis, etc. Late-onset silicosis can develop with relatively short dust exposure, for example, if an employee performed duties in hazardous working conditions (high concentration of
dust in the air of the working area) for 4-5 years, then the employee will show a belated reaction to dust, only 20-30 or more years after stopping work with dust. Very often, in such situations, the disease is asymptomatic, and the disease is detected too late, excluding timely preventive measures to combat the disease.

There are 4 main mechanisms of human exposure to silicosis:

1) direct cytotoxicity of stone dust leading to damage of lung cells, the release of water-soluble enzymes and enzymes that break down proteins, as well as to the possible scarring of the lungs;
2) activation of oxidant production by lung phagocytes, which suppresses antioxidant defense and leads to lipid peroxidation, protein replacement, cell damage and scarring of the lungs;
3) activation of the release of the transmission of a nerve impulse from one cell to another from alveolar macrophages and epithelial cells, which leads to the involvement of white leukocytes and macrophages in the production of pro-inflammatory molecules and reactive species for further damage to the lungs and their scarring;
4) the secretion of growth factors from alveolar macrophages and epithelial cells, stimulating the final phase of development of fibroblast inflammation and possible scarring of the lungs [7].

Table 1 presented below shows the structure and prevalence of the general pathology of mine workers of granite and marble mines of the Irkutsk region (cases) over the past 20 years (according to the East-Siberian Institute of Medical and Environmental Research).

Table 1. Structure and prevalence of the general pathology of mine workers of granite and marble mines of the Irkutsk region (cases) over the past 20 years.

| Nosological classes, International Classification of Diseases, 10th Revision (ICD-10) | Granite quarry (n=1027) | Marble quarry (n=1214) |
|---|---|---|
| Diseases of the respiratory system | 189 (18.4) | 194 (15.9) |
| Diseases of the musculoskeletal system and connective tissue | 157 (15.2) | 163 (13.4) |
| Diseases of the eye and adnexa | 149 (14.5) | 138 (11.3) |
| Diseases of the skin and subcutaneous tissue | 138 (13.4) | 141 (11.6) |
| Diseases of the circulatory system | 124 (12.0) | 133 (10.9) |
| Diseases of the endocrine, nutritional, and metabolic diseases | 91 (8.8) | 89 (7.3) |
| Diseases of the ear and mastoid process | 64 (6.2) | 71 (5.8) |
| Diseases of the nervous system | 51 (4.9) | 49 (4.0) |
| Diseases of the digestive system | 44 (4.2) | 38 (3.1) |
| Diseases of the genitourinary system | 12 (1.1) | 14 (1.1) |
| Diseases of other organs and systems | 8 (0.7) | 6 (0.4) |

Table 2 presents the most common occupational diseases of workers in marble and granite quarries.

Interpretation of the data in Tables 1 and 2 and the data on morbidity in recent years leads to an obvious question: why the growth of occupational morbidity among workers in the mining sector is only increasing, despite all the improvements that are applied in this sector of the economy? According to the reporting data of the Territorial Body of the Federal State Statistics Service for the Irkutsk Region, at enterprises dealing with the development of marble and granite quarries in the Irkutsk Region, the level of work automation is increased by excluding men from the technological process, mechanisms to reduce vibration and noise levels, as well as dustiness are used, personnel is provided with more effective means of personal protection, modern medical methods for preventive health care of personnel are used (conducting initial and periodic medical examinations, taking
organizational measures to attract personnel to sports and a healthy lifestyle, taking rehabilitation measures, creating prerequisites for early diagnosis of health disorders). And despite all these, the occupational morbidity rate does not decrease. Hence, it follows that there are other factors that provide the observed significant increase in the statistical indicators of occupational morbidity, which may be associated with a low awareness of staff regarding the consequences of not using personal safety apparel or the consequences of diseases, as well as a condescending attitude towards their health, poor lifestyle and bad habits.

Table 2. Common (to a greater extent) occupational diseases of workers in marble and granite quarries.

| Diseases                                    | Granite quarry (n=1027) | Marble quarry (n=1214) |
|---------------------------------------------|-------------------------|------------------------|
|                                             | abs.% per 100 mine workers | abs.% per 100 mine workers |
| Chronic bronchitis                          | 54 (5.2)                | 61 (5.0)               |
| Silicosis                                   | 42 (4.0)                | 39 (3.2)               |
| Pneumatic hammer disease                    | 31 (3.0)                | 44 (3.6)               |
| Osteoarthritis deformans                    | 19 (1.8)                | 28 (2.3)               |
| Crooked nasal septum with impaired breathing | 29 (2.8)                | 19 (1.5)               |
| Spinal osteochondrosis                      | 21 (2.0)                | 18 (1.4)               |
| Cataract                                    | 23 (2.2)                | 34 (2.8)               |
| Chronic radiculopathy                       | 28 (2.7)                | 24 (1.9)               |
| Sensorineural hearing loss                  | 38 (3.7)                | 23 (1.8)               |

When silicosis is considered as one of the common occupational diseases of mining workers, it remains the main disease both throughout the world and in the country, and in the region in particular, affecting the professions engaged in mining not only in granite and marble quarries. This preventable disease remains a significant cause of morbidity and mortality [8]. In addition, cases have been reported where the disease is a gross underestimate of the total number of cases [9], and in some cases the prevalence of silicosis is growing inexorably [10].

One conclusion that can be drawn from all of this is that silica dust (dust with a content of 40 to 80% silicon dioxide (SiO₂) in a free state [5]) is one of the most common reasons for the development of silicosis, including in granite and marble quarries of the Irkutsk region. But there is disagreement about the connection of inhalation of the amount of dust with the time the disease progresses. Scientific research is increasingly demonstrating the fact of dust exposure during the working experience of a mining worker, that 0.1 mg/m³ is sufficient for the onset of the development of the disease and, with prolonged exposure, for the transition from silicosis to lung cancer [11]. But these data are not enough to suggest, that if the inhaled dust is reduced to 0.05 mg/m³ or less, this will ensure the exclusion of the development of occupational lung disease.

The main determinant of silicosis is the lightness of dust. There is evidence that different physical states of dust, such as freshly destroyed granite or marble, admixtures of other destroyed minerals that make up marble and granite, may act as peak factors in the development of the disease [12]. Due to SiO₂ dust exposure, the disease progress leads to the development of inflammation and fibrogenesis in the lungs and, due to this, silicosis continues to be the most common disease among mine workers. But recent scientific research is drawing attention to other silica-related diseases, which is lung cancer. Recent authoritative reviews conclude that there is sufficient evidence worldwide to support a connection between silicosis and lung cancer [13, 8, 14]. At the same time, the risk of cancer can be increased by bad habits and other carcinogens (diesel combustion products, equipment operation) in the workplace [15].
The SiO₂ dust resulting from the quarrying of marble and granite is underestimated. Its contribution to the development of occupational diseases of mine workers is significant. At present, a transition to the standardization of the content of dust particles in the air with sizes of no more than 2.5 microns or up to 10 microns has been made in a number of countries. The most harmful are particles with a size less than 10 microns, which are retained by the upper respiratory tract, and particles with a size of 0.5-5 microns, which penetrate into the lungs and stay there. Another professor E.A. Vidgorchik confirmed empirically that up to 90% of fine dust (0.5 microns and less) is retained in the lungs. In the Russian Federation, standardization of the dust content of the air is carried out without taking into account the dispersed composition of dust [16].

To reduce the development of diseases associated with dust particles of granite and marble in mining quarries, it is necessary to consider:

1) individual susceptibility to the disease, which, at present, can be determined by biomarkers and can play a significant role in detecting the disease at an early stage [17];

2) the use of therapeutic agents for the silicosis treatment and lavage of the lungs to remove dust particles from the lung, which may favorably affect the regression of acute or chronic silicosis [18];

3) treatment of all forms of silicosis should be aimed at combating microbacterial diseases (nicotine addiction, tuberculosis). It is advisable for all workers with a confirmed diagnosis of silicosis to undergo a tuberculin skin test and, if it is positive, to offer treatment taking into account the possible development of tuberculosis (transition from silicosis to tuberculosis) [8].

4) attracting staff to social programs to stop smoking and improve their health behaviors;

5) informing staff about retirement when they are diagnosed with silicosis, taking into consideration the fact that companies in the mining sector of the economy do not want to re-hire people with such a diagnosis, but they should provide alternative work for this contingent of workers.

6) employees can apply for incentives, financial support from management and information about seeking legal advice in order to file a civil claim on the occurrence and establishment of an occupational disease.

3. Conclusion

The mining industry accounts for a sufficient amount of the gross industrial product in Russia and in the Irkutsk region. Chronic lung diseases caused by mining dust currently account for the largest relative share (32.11%) of occupational morbidity in the Irkutsk region, and the number of such cases is increasing annually. Lung disease and other health risks in the mining sector pose major challenges to the region. The mining activity, both formal and informal, contributes significantly to economic growth, but the prevalence of lung-related occupational diseases is high and access to health care is limited.

Lack of knowledge about the exact content of materials and misuse of toxic chemicals lead to occupational morbidity, and the occupational morbidity rate is usually underestimated. The main documented occupational diseases in the Irkutsk region are pneumoconiosis (silicosis, chronic dust and bronchitis). The second most common occupational disease is carbon monoxide toxicity, followed by lead poisoning and noise-induced hearing loss. Less than five percent of occupational morbidity are due to other causes, including decompression syndrome, heatstroke, toxic hepatitis, neurologic disorders, and hematologic disorders. The occupational morbidity rate and the impact of dust emissions in the region's mining quarries is considered seriously underestimated. The primary attention should be given to the prevention of occupational morbidity in the mining sector through training industrial hygienists and doctors in recognizing health hazards in the workplace and diagnosing occupational diseases, as well as raising awareness among mine workers about the negative effects of SiO₂ dust. Recognition of occupational morbidity as one of the important components of negative impact on human life can subsequently highlight the health risks in the workplace and prevent their occurrence.
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