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RISKS AND SPECIFIC FEATURES OF BRONCHOPULMONARY PATHOLOGY IN APATITE-NEPHELINE ENTERPRISE WORKERS IN KOLA HIGH ARCTIC

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The study was carried out in Kirovsk, Murmansk oblast, Russia

A medical examination of 3871 employees of mining and chemical industry engaged in the production, transportation and processing of apatite-nepheline ore in the Kola High Arctic showed the worst state of respiratory health in open pit miners. They have higher risk of chronic bronchopulmonary diseases than miners of underground mines (RR = 1.30), enrichment plant workers (RR = 1.81) and the rail shop workers (RR = 3.80). The findings stress the need for improved working conditions and more effective personal respiratory protection devices in this group of workers.

***Key words**: apatite-nepheline production, bronchopulmonary pathology, Kola High North.*

The largest apatite-nephelinic ore deposit in Russia is located in the Kola Peninsula which determines harsh production conditions due to the arctic climate and poor infrastructure. Most of the workers involved in the production, transportation and processing of apatite-nephelinic ore in the Kola High Arctic are exposed to harmful working conditions including general and local vibration, noise, lower temperature, dust-gas mixture, and uncomfortable working position [2, 4, 5]. Exposure to those factors is known to create a higher risk of musculoskeletal diseases, nervous disorders and impaired hearing [1, 3, 7]. There is also evidence to a high rate of chronic bronchopulmonary diseases (CBPD) among such workers the medical and social significance of which is underestimated [8, 9].

The purpose of the research is to analyze the risk factors, structure and prevalence of chronic bronchopulmonary diseases (CBPD) in the workers involved in the production, transportation and processing of apatite-nephelinic ore in the Kola High Arctic

Materials and methods. Within the course of the research, we conducted an in-depth medical examination of 1,777 underground miners and 503 workers of open-pit apatite-nepheline mines, 790 workers of the rail shop (RS) and 801 workers of apatite-nepheline dressing plants (ANDP) comprising "Apatit" open joint-stock company. The research program included a medical examination by a pulmonologist and assessment of the respiratory function using the method of spirography and bronchodilatatory test (400 µg of salbutamol). The diagnostics of chronic bronchitis (CB), chronic obstructive pulmonary diseases (COPD) and bronchial asthma (BA) was conducted in accordance with the acknowledged international criteria. The persons with individual symptoms of a respiratory pathology which were not sufficient to diagnose any specific CBPD were referred to the CBPD "risk group". The persons with no clinical, functional or radiographic symptoms of a CBPD were referred to the "healthy group".

The obtained data was processed with Epi Info, v. 6.04d recommended by the WHO; we measured the relative ratio (RR), 95% confidence interval (95% CI), goodness-of-fit test, and Student's t-test. The differences were considered significant at $p<0, 05$.

Results of the research. Assessment of the workplace conditions [6] showed that apatite

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ore extraction, loading and hauling in the underground mines are carried out in a relatively stable cooling microclimate: subnormal temperature (3-80^{0}C in summer and 5-120^{0}C in winter), high humidity (up to 100%) and air motion (up to 2.0-4.0 m/s). The microclimate in the open-pit mines is characterized by rapid changes in meteorological factors. Thus, the air temperature in winter ranges from 0^{0}C to - 30^{0}C, and in summer - from + 50^{0}C to + 25^{0}C. The air in the working area of open-pit mines is affected by the calm air and inversion frequently observed in the North; these conditions increase the level of contamination of the surface layer of the atmosphere. [10].

Drilling, blasting and load-haul operations using self-propelled drilling, loading and delivery of diesel equipment result in high concentrations of toxic components of gaseous and particulate aerosols. The level of nitrogen oxides in the air exceeds the MAC by 5.5 times, carbon monoxide and TNT – by up to 1.5-2.0 times. Mean shift concentrations of dust are in the range of 2.45-8.65 mg/m3 (MAC = 6.0 mg/m3), though during drilling, the dust levels may reach 30.8 mg/m3 (exceeding the MAC by 5.1 times). The main components of the dust (in weight %) are SiO_2 – 30.2; CaO – 18.2; Al_2O_3 – 15.2; P_2O_5 – 12.7; Na_2O – 7.7; Fe_2O_3 – 3.7.

The rail shop workers are exposed to the cooling microclimate with alternating parameters (air temperature from -30^{0}C to +25^{0}C, relative air humidity up to 100%, air mobility – up to 18 m/s). During railway repairs and cooling, the maximum exceedance of the permissible concentration of dust totals 9.3.

During ore processing at the apatite-nepheline dressing plants, dustiness (exceedance of the MAX by up to 4-5 times) is one of the main harmful industrial factors. The highest dust content is faced by crush operators, assembly line operators at the crushing plant, concentrate shipmen, mill and assembly line operators at the shipping department.

The analysis of the demographic indicators revealed significant differences in the above groups of workers. Among the underground and open-pit deposit workers, there are less women than at the rail shop or dressing plants ($p<0.01$-0.001). The mean age of the underground miners is lower ($p<0.05$), and the length of service of the open-pit deposit workers is higher ($p<0.05$) as compared to other divisions of "Apatit" (see Table 1 below).

A clinical and instrumental examination showed that the symptoms of bronchopulmonary pathology were not registered in 57.2-73.5% of the examined patients. The number of healthy workers among the rail shop workers was higher than among miners ($p<0.001$) and ANDP workers ($p<0.01$). Individual symptoms of respiratory pathology were registered in 19.6-23.8% of workers who constituted the "risk group" for CBPD. The most frequently diagnosed disease was CB (4.3-16.1%). The incidence of CB among open-pit deposit workers was higher than among underground workers ($p<0.05$), rail shop workers and ANDP workers. The incidence of CB among the workers involved in underground mining was also higher as compared to the rail shop workers ($p<0.001$) and ANDP ($p<0.05$).

CBPD and BA were registered less frequently since they are not determined by the labor conditions. All the cases of BA were mild and characterized with high sensibility to the household and/or animal allergens, not related to employment at "Apatit" (see Table 2 below).

Table 1

General description of the apatite-nepheline workers

Parameter	Underground mines	Open-pit deposits	Rail shop	ANDP
Gender: men, % women, %	88.9 11.1	94.8 5.2	76.6 23.4	67.5 32.5
Age, years	38.8±0.3	39.7±0.8	40.7±0.4	40.4±0.4
Length of service, years	12.0±0.4	15.1±0.8	12.5±0.3	12.0±0.5

Table 2

Respiratory health parameters among apatite-nepheline workers (%)

Clinical group	Underground mines	Open-pit deposits	Rail shop	ANDP
Healthy workers	59,0	57,2	73,5	66,9
Risk group	23,8	22,5	19,6	20.7
Workers with CB	12,3	16,1	4,3	9,0
Workers with CBPD	3,1	3,2	1,5	2,4
Workers with BA	1,8	1,0	1,1	1,0

The risk of CB among open-pit deposit workers was higher than among underground miners (RR=1.30; 95% CI = 1.03-1.65; χ^2=4.80; p=0.02854), ANDP workers (RR=1.81; 95% CI = 1.34-2.43; χ^2=15.6; p=0.00008) and rail shop workers (RR=3.80; 95% CI = 2.59-5.58; χ^2=54.4; p=0.0000001).

Respiratory health of the workers involved in open-pit mining is impacted by the time of exposure to harmful industrial factors (length of service). In the first 10 years, CB develops in 9.3% of employees, CBPD – in 3.1% of employees; according to the results of a preliminary medical examination, those employees were considered healthy. With every 10 years of service, the number of employees without any respiratory pathology is decreasing, and the number of people in the CBPD risk group (with the growth from ≤ 10 years to 11-20 years) and the number of employees with CB are growing. The incidence of CBPD does not change depending on the length of service, and the number of employees with BA, unlike employees with CB, has significantly decrease with longer service (see Table 3).

With the length of service of 11-20 year, the risk of CB increased to 1.59 (95% CI 1.21–2.09; χ^2 = 11.5; p = 0.00068), with the service of 20 лand longer – up to 2.01 (95% CI 1.56–2.59; χ^2 =30.2; p = 0.0000001) as compared to the length of service of 10 years and less. No connection between the length of service and the state of health was revealed in the rail shop and ANDP employees, as compared to the miners.

Table 3

The impact of the length of service on the respiratory health of employees

Clinical group	Length of service		
	≤ 10 years (n=1502)	11–20 years (n=1159)	> 20 years (n=1210)
Healthy workers	954 (63,5%)	594 (51,3%)[1]	578 (47.8%)[2, 3]
Risk group	315 (21.0%)	352 (30.4%)[1]	355 (29.3%)[2]
Workers with CB	139 (9.3%)	176 (15.2%)[1]	230 (19.0%)[2, 3]
Workers with CBPD	47 (3.1%)	28 (2.4%)	46 (3.8%)
Workers with BA	47 (3.1%)	9 (0.8%)	1 (0.1%)[2]

Note: [1]– differences (p<0.05) between the groups of employees with the length of service of ≤ 10 years and 11-20 years;
[2] – differences (p<0.05) between the groups of employees with the length of service of ≤ 10 years and > 20 years;
[3] differences (p<0.05) between the groups of employees with the length of service of 11-20 years and > 20 years.

The highest incidence and risk of CBPD were revealed in open-pit apatite miners as compared to the rest of "Apatit" employees which can be explained to the highest level of exposure to dust, explosive gases, diesel fuel combustion products, and unfavorable microclimate [5, 8]. Additionally, underground miners work in the conditions of cooling microclimate but it is stable [4]. Exposure to the dust-and-gas mixtures is lower due to a wide use of electrically-powered loading-and-delivery equipment. The length of exposure to harmful industrial factors (length of service) significantly increases the risk of CB.

The respiratory health indicators in the rail shop and ANDP workers are significantly better due to the lack of combined exposure to the dust-and-gas mixtures and cooling microclimate. It is important to keep in mind that there are more men

among miners, consequently, higher exposure to tobacco smoke – the main non-industrial risk factor contributing to the development of CB and CBPD [8]. Decreased number of workers with BA among the employees in training is related to ceasing the career in the mining and chemical industry due to medical reasons.

It is critical to emphasize that no cases of pneumonoconiosis, a common disease among this type of workers, were revealed before the switch from dry drilling to wet dust suppression systems [7].

Conclusion. The impact of combined harmful industrial factor significantly increases the risk of CBPD among the apatite-nepheline workers. CB is the most common among the respiratory diseases developing among the open-pit miners. The obtained results indicate the necessity to improve the labor conditions and individual protection gear to protect the respiratory health of the employees

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