WORKING CONDITIONS AND OCCUPATIONAL PATHOLOGY IN THE ARCTIC ZONE OF THE REPUBLIC OF SAKHA (YAKUTIA) IN 2007-2019

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Abstract

Relevance. Labor activity takes place in the Arctic under conditions of combined effect of harmful industrial and climatic factors that significantly increase the risk of occupational pathology.

The purpose of the research is to study the working conditions and occupational pathology of people working in the Arctic Zone of the Republic of Sakha (AZRS).

Materials and methods: data of the social and hygienic monitoring report "Working Conditions and Occupational Morbidity of the Population of the Russian Arctic".

Results. It was found out that in 2007-2019 in the AZRS, for the first time, there were diagnosed 27 occupational diseases mainly among employees engaged in extraction of tin ore. No cases of diseases were detected among people engaged in traditional economic activities. Most often, the development of occupational pathology was caused by using fibrogenic aerosols (n=12) with respiratory diseases predominating in its structure (n=14). The annual prevalence of occupational pathology in the AZRS ranged from 0 to 26.7 cases / 10,000 employees, and the risk of obtaining the occupational disease in 2007-2010 was higher than in 2016-2019: RR=4.90; CI 1.44-16.62; p=0.005. The reason for this was the absence of large industrial enterprises in the region and shutdowns of tin ore mining enterprises.

Conclusion. In the AZRS, there is a low level of occupational morbidity, which has had a clear reducing trend in 2007-2019. It is necessary to increase the level of occupational pathological assistance to the AZRS population engaged in reindeer breeding and other types of traditional economic activities.

KEYWORDS working conditions, occupational pathology and morbidity, Arctic zone of the Sakha Republic

Relevance

The Arctic Zone of the Russian Federation (AZRF) is a strategic resource base necessary for socio-economic development of the country, both in the near future and in the long-term prospect [1, 2]. Five ulus settlements of the Sakha Republic located on the coast of the Arctic Ocean (Allaikhovsky, Anabarsky, Bulunsky, Nizhnekolymsky, Ust-Yansky) were included in the AZRF according to the

Decree of the President of the Russian Federation No. 296 dd. 02.05.2014 (ed. dd. 27.06.2017) «On the Inland Territories of the Arctic Zone of the Russian Federation». Eight more northern ulus settlements of the Sakha Republic that do not have access to the Arctic Ocean (Abyisky, Verkhoyansky, Zhigansky, Momsky, Oleneksky, Srednekolymsky, Eveno-Bytantaysky) were included in it in 2019 in accordance with the Decree of the President of the Russian Federation No. 220 dd. May 13, 2019 «On Amendments to the Decree of the President of the Russian Federation No. 296 dd. 02.05.2014 «On the Inland Territories of the Arctic Zone of the Russian Federation» (Fig. 1).

The Arctic Zone of the Sakha Republic formed in such way has got all the characteristic attributes of the Arctic region: harsh cooling climate, remoteness from the central regions of the country, vast hard-to-reach territory, underdevelopment or lack of socio-economic infrastructure, paucity, and low density of the local population [3, 4]. Thus, the territory of the AZRS is 1605.6 thousand km with population of 67.7 thousand people and its density of 0.04 people/km^2 (2019).

Despite the above-mentioned difficulties, in the Russian Arctic there is intensive economic activity based on the extraction and processing of many types of minerals and other natural resources [5, 6]. However, in the AZRS, unlike many Arctic regions of the country, there are no large industrial enterprises, and the local population is mainly engaged in reindeer breeding, horse breeding, fur trapping and fishing (Table 1). Only in the Anabar ulus settlement there is development of alluvial diamond deposits (about 3.4 million karats annually), and there is open-pit coal mining in Verkhnekolymsky ulus settlement (up to 220 thousand tons annually).

It is well known that general and local vibration, noise, physical overstrain, fibrogenic aerosols, unfavorable microclimate of workplaces and some other factors cause harmful working conditions for miners in the Arctic [7-10] and in the Sakha Republic, in particular [11, 12]. At the same time, literature provides only few specific cases on working conditions of people engaged in traditional Arctic economic activities (reindeer breeding, horse breeding, fishery and fur trapping, etc.) [13]. There is general evidence that labor activity in the Arctic is associated with chronic cooling of the body, significant seasonal photoperiodicity, intense ionomagnetic regime and other harmful climatic factors [14,15].

All these natural influences place increased demands on the adaptive capabilities of the body and can cause pathological changes known as «polar stress syndrome» [16, 17]. When combined with harmful production factors, Arctic climatic conditions modify their negative effects on the human body, increasing the expectancy and accelerating the obtainment of occupational pathology [18]. The development of natural resources of the Arctic becomes more active, it raises requirements for working conditions and measures to prevent occupational diseases of workers, especially

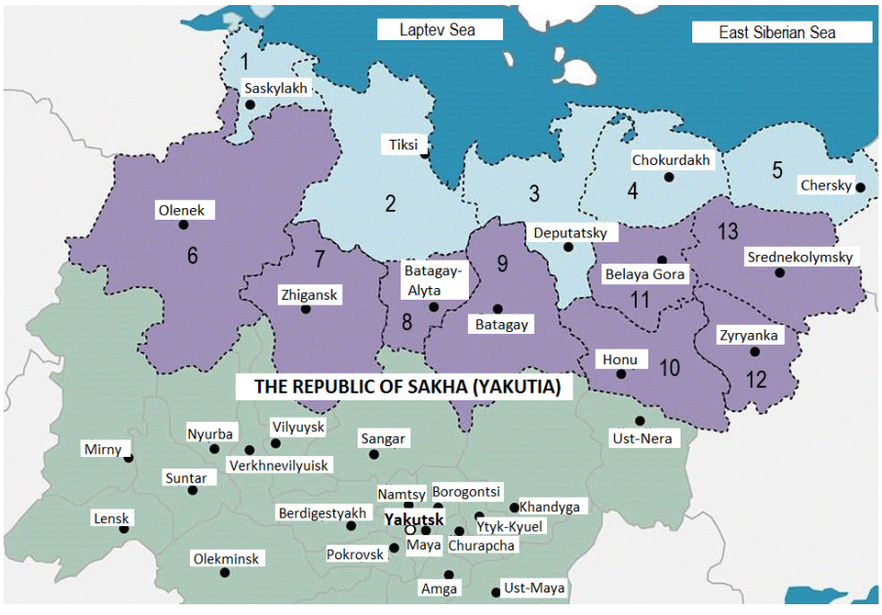

Figure 1. Map of 13 ulus settlements of the Arctic zone of the Sakha Republic (Anabarsky-1; Bulunsky-2; Ust-Yansky-3; Allaikhovsky-4; Nizhnekolymsky-5; Oleneksky-6; Zhigansky-7; Eveno-Batantaysky-8; Verkhoyansky-9; Momsky-10; Abyisky-11; Verkhnekolymsky-12; Srednekolymsky-13)

taking into consideration the increasing shortage of labor resources in the region [18, 19]. The importance of preserving health of the Arctic population is emphasized by provisions of the State Program of the Russian Federation «Socio-economic Development of the Arctic Zone of the Russian Federation» (approved by the Decree of the Government of the Russian Federation No. 484 dd. March 30, 2021). The solution of this problem provides for the study of influence of harmful environmental and industrial factors, it also provides for the scientific evidence of measures aimed at preserving the habitat and working capacity of the population.

The purpose of the research is to study the working conditions and occupational pathology of people engaged in labor activity in the AZRS.

Materials and methods

The data of social and hygienic monitoring report were studied under the section «Working Conditions and Occupational Morbidity» of the population of the Russian Arctic in 2007-2019. Information was provided by the "Federal Center for Hygiene and Epidemiology" of the Federal Service for Supervision of Consumer Rights Protection and Human Wellbeing (Moscow).

Table 1

Basic information about population, territory, and economic activity in the AZRS ulus settlements

Ulus settlement	Population	Area (thousand, km²)	Density (people/ km²)	Main economic activity
Abyisky	4018	69,4	0,06	Reindeer breeding, hunting
Allaikhovsky	2716	107,3	0,03	Fishery
Anabarsky	3567	55,6	0,06	Reindeer breeding, hunting and fishery
Bulunsky	8339	223,6	0,04	Reindeer breeding, hunting and fishery Diamond mining (seasonal)
Verkhne-kolymsky	4049	67,6	0,06	Horse breeding, reindeer breeding, fur trapping Open-pit coal mining
Verkhoyansky	11133	134,4	0,08	Horse breeding, reindeer breeding, fur trapping
Zhigansky	4178	140,2	0,03	Reindeer breeding
Momsky	3973	104,6	0,04	Horse breeding, reindeer breeding, fur trapping, animal breeding
Nizhnekolymsky	4290	87,1	0,05	Horse breeding, reindeer breeding, fur trapping and fishery, animal breeding
Oleneksky	4148	318,0	0,01	Reindeer breeding, animal breeding, hunting
Srednekolymsky	7424	125,2	0,06	Horse breeding, reindeer breeding, fur trapping and fishery, animal breeding
Ust-Yansky	7028	120,3	0,06	Fish processing, reindeer breeding and animal breeding. Tin ore mining (till 2009)
Eveno-Batantaysky	2827	52,3	0,06	Horse breeding, reindeer breeding, fur trapping

The research results were processed using Microsoft Excel 2010 software and Epi Info, v. 6.04d. The following data were determined: Student's t-test for independent samples, odds ratio (OR), relative risk (RR), 95% confidence interval (CI), consent criterion $\chi 2$. The critical significance level of the null hypothesis was assumed to be 0.05.

Results

In order to evaluate the working conditions at the AZRS enterprises, among employees there were three surveillance groups: those of sanitary and epidemiological welfare (Table 2) and those who had contact with harmful production factors. The data of 2008 were taken as the initial level, since only two of the five ulus settlements had had complete information for 2007. It was found that during the studied period of time, the majority (72.3%) of people in the AZRS were employed at the objects of surveillance of the second group (with unsatisfactory indicators of sanitary and epidemiological wellbeing). At the objects of surveillance of the first group (with satisfactory indicators of sanitary and epidemiological wellbeing) and the third group (with extremely unsatisfactory indicators of sanitary and epidemiological wellbeing) the share of employed people was 15.0% and 12.7%, respectively. Over the past 12 years, there have been significant fluctuations in the number and proportion of employees in the three groups of objects of surveillance. It is important that in 2019, compared to 2008, the shares of people employed at the facilities of the first ($p<0.001$) and second ($p<0.001$) groups decreased, while their share increased at the facilities with the most unfavorable working conditions ($p<0.001$).

In 2008, according to the certification of workplaces, employees in the AZRS had an exposure to ten harmful production factors. Among these, 17.1% employees were exposed to the cooling microclimate of workplaces, 16.3% - to noise, 16.1% - to general vibration, 8.6% - to local vibration, 4.4% - to chemical factors, 0.6% - to non-ionizing electromagnetic fields and radiation, 0.3% - to biological factors and 0.3% - to ionizing radiation. The fulfillment of labor duties went with increased severity and intensity of labor processes among 13.7% and 2.8% of employees, respectively. In addition, in 19.8% of cases, there was a combined effect of two or more harmful production factors.

In 2019, special assessment of working conditions of AZRS employees revealed a sharp narrowing of the spectrum of harmful effects. In the presence of exposure to harmful production factors, their combined effect was established in almost all cases (99.6%). Only 0.3% of employees had contact with non-ionizing electromagnetic fields and radiation, as well as 0.08% - with aerosols of mainly fibrogenic action. As a result of the above changes, in 2019, compared with 2008, the risk of exposure to the combined action of harmful factors increased among AZRS employees: RR=5.03; CI 4.79-5.28; $\chi 2=6213.7$; $p<0.001$. In general, the analysis did not reveal any improvement in working conditions at AZRS enterprises in 2008-2019.

Table 2

The number and share (%) of employees at the objects of surveillance of three groups in the AZRS

The group of supervision object	Year				Average annual value
	2008	2011	2015	2019	
First	565 (16,8)	591 (18,5)	356 (14,3)	648 (11,9)	540,0 (15,0)
Second	2532 (75,1)	2274 (71,0)	2007 (80,9)	3591 (66,1)	2601,0 (72,3)
Third	274 (8,1)	237 (7,6)	117 (4,7)	1197 (22,0)	456,3 (12,7)
Total:	3371 (100,0)	3102 (100,0)	2480 (100,0)	5436 (100,0)	3597,3 (100,0)

For the period 2007-2019, there were 27 chronic occupational diseases registered for the first time in the AZRS among 24 employees, including 21 men and 3 women. 21 employees had one nosological disease form, and 3 employees had two disease forms.

The average age of an employee with a newly established occupational pathology was 54.4±1.2 years, and the length of work experience was 21.9±1.4 years. There were significant differences in distribution of sick employees by the years of studied period and by the ulus of residence. Thus, in 2009, 9 cases of occupational diseases were diagnosed, in 2007 – five, in 2010 – three, in 2011, 2012 and 2019 – two cases each, in 2009, 2013, 2014 and 2017 – one case each. In 2015, 2016 and 2018 no cases of occupational pathology were registered. In 2007-2018 (when the AZRS included 5 ulus settlements) 21 out of 25 cases of diseases occurred among residents of Ust-Yansky ulus, 3 cases – in Bulunsky ulus and one case – in Nizhny Kolyma ulus settlement. In 2019 (when the AZRS included 13 ulus settlements) one resident of Verkhny Kolyma ulus settlement was diagnosed to have 2 cases of occupational pathology. Two-thirds (18 out of 27 cases) of occupational diseases happened among employees engaged in the extraction of minerals: tin ore, coal and diamonds. People who provided the production and distribution of electric energy, gas, water and steam were found to have 5 diseases, workers of transport and construction organizations – 2 diseases.

The development of occupational pathology among AZRS employees was caused by exposure to five harmful production factors. In a third of cases, these were aerosols of mainly fibrogenic action, 2 times less often – general vibration and noise, and even less often – chemical factor. The impact of harmful production factors on workers was equally due to the design shortcomings of machines, mechanisms and other equipment, as well as due to the imperfection of technological processes.

Most often, occupational pathology occurred in the class of working conditions 3.2 and two times less often in the classes of working conditions 3.1, 3.2 and 3.4. More than half of all occupational diseases referred to the class of respiratory diseases. The second place was taken by injuries, poisoning and other consequences of external

Table 3

Etiological and clinical characteristics of occupational pathology

Factor	Cases
Factors of development of occupational diseases:	
aerosols of mainly fibrogenic action	12 (44,4%)
general vibration	6 (22,2%)
noise	5 (18,5%)
local vibration	2 (7,4%)
harmful substances of all hazard classes	2 (7,4%)
The circumstances of the development of occupational diseases:	
imperfection of technological processes	14 (51,9%)
design shortcomings of machines, mechanisms, equipment, devices, and tools	13 (48,1%)
Classes of working conditions under development of occupational diseases:	
hazard class 3.1	5 (18,5%)
hazard class 3.2	6 (22,2%)
hazard class 3.3	11 (40,7%)
hazard class 3.4	5 (18,5%)
Classes of diseases:	
respiratory disease	14 (51,9%)
injuries, poisoning and other consequences of external causes	6 (22,2%)
diseases of the ear and mastoid process	5 (18,5%)
diseases of the musculoskeletal system	2 (7,4%)
Most common nosological forms:	
vibration disease	6 (22,2%)
chronic bronchitis	6 (22,2%)
pneumoconiosis	6 (22,2%)

causes, and the third place – by diseases of ear and mastoid process. The most common nosological forms of occupational pathology included chronic bronchitis, pneumoconiosis and vibration disease, each of which accounted for 6 cases (Table 3).

The annual prevalence of occupational pathology in the AZRS ranged from 0 to 26.7 cases/10,000 employees of the objects of supervision of the first-third groups.

At the same time, the highest rates were observed in the first third of the studied period, and the probability of developing of occupational disease in 2007-2010 was higher than in 2016-2019: RR=4.90; CI 1.44-16.62; $\chi 2$=8.00; p=0.005. The indicators of occupational morbidity in the AZRS in 2007-2019 tended to decrease (descending trend line), while in the AZRF – to increase (ascending trend line). In general, in the Russian Federation in 2007-2019, there were consistently low levels of occupational morbidity with a tendency to decrease[1] with a trend line almost parallel to the abscissa axis (Fig. 2). Out of 27 cases of diseases, only four (14.8%) were detected according to the results of periodic medical examinations. The remaining 23 cases (85.2%) were diagnosed during employees' independent requests for medical help.

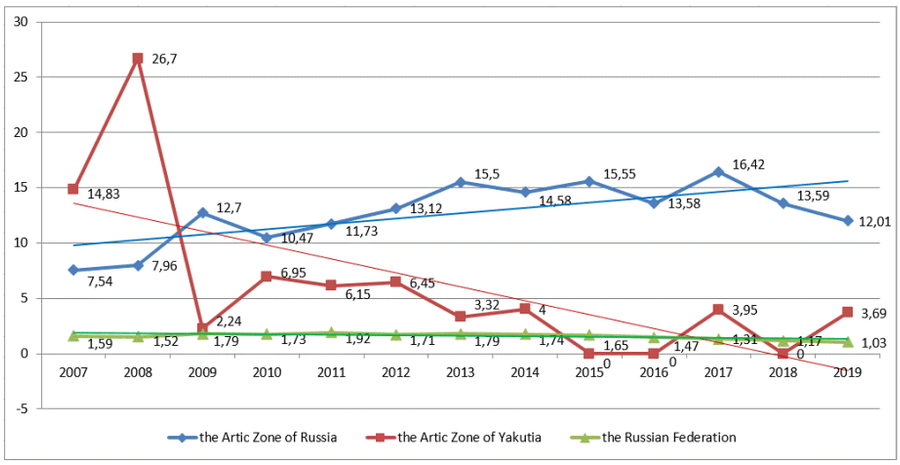

Figure 2. Annual indicators of primary occupational morbidity in the AZRS, AZRF (cases/10,000 employees of all objects of supervision) and the Russian Federation (cases/10,000 working population).

Discussion

The conducted research revealed several noteworthy facts concerning the features of occupational pathology in the AZRS. First of all, it should be noted that in the absence of large mining and metallurgical enterprises, occupational pathology in the region, unlike the Sakha Republic as a whole, is not a priority medical and social problem. This is also evidenced by the fact that in 2019 only two occupational diseases were detected in the AZRS compared to 176 cases in the republic (1.1%)[2].

There are following features of occupational pathology in the AZRS: predominance of aerosols of mainly fibrogenic action among etiological factors, and respiratory diseases - in the structure of occupational diseases. In general, in the Russian Arctic, among the factors causing the development of health disorders of occupational etiology, the increased severity of labor processes dominates, and in the structure of occupational pathology, diseases of the musculoskeletal system are the most common [20, 21].

Attention is drawn to the large fluctuations in the annual number of newly diagnosed occupational diseases in the AZRS, which may be due to the insufficient quality of organization and conduction of medical examinations, incomplete detection of pathology or its diagnosis at late stages of development, different approaches of doctors to the interpretation of identified health disorders [22]. This is also evidenced by the predominant (85.2%) detection of pathology because of employees' independent requests for medical help, and not according to the data of periodic medical examinations. In addition, the high rates of occupational morbidity in 2007-2008 are

1 *"On the State of Sanitary and Epidemiological Wellbeing of the Population in the Russian Federation in 2019": State Report. Moscow: Federal Service for Supervision of Consumer Rights Protection and Human Wellbeing, 2020.*

2 *The State report «On the State of Sanitary and Epidemiological Welfare of the Population in the Russian Federation» for the Republic of Sakha (Yakutia) in 2020. URL: http:/14.rospotrebnadzor.ru/c/document_library*

explained by development of tin ore deposit in Ust-Yansky ulus settlement carried out in those years. During 2007-2019, there was no increase in occupational morbidity among workers engaged in seasonal shift mining of diamonds in Anabarsky ulus settlement and insignificant coal mining volumes in Verkhnekolymsky ulus settlement.

The presented research emphasizes the importance of diagnosing occupational pathology among employees engaged in traditional economic activities of the indigenous peoples of the North (reindeer breeding, fur trapping, fishing, etc.).

Out of 9221 primary occupational diseases revealed in the AZRF in 2007-2019, only one case was registered for an employee from animal breeding farm and another – from livestock farm. It can be assumed that the inaccessibility of places of work, the individual or small-group nature of work, the irregularity of medical examinations and the lack of professional pathologists do not allow for the qualified diagnosis of occupational pathology in this category of workers in the Arctic regions.

Conclusion

In the Arctic Zone of the Sakha Republic, in contrast to the Arctic Zone of the Russian Federation, there is a low level of occupational morbidity, which also had significant downward trend in 2007-2019. This fact is explained by the absence of large industrial enterprises in the region and the cessation of tin ore mining. The absence of cases of occupational pathology among employees engaged in reindeer breeding and other traditional economic activities indicates an insufficient level of occupational pathology assistance to the population of the Arctic zone of the Sakha Republic.

REFERENCES

1. Shchegolev I.B. O roli Arktiki v ekonomicheskom razvitii Rossii v 21 veke [On the role of the Arctic in the economic development of Russia in the 21st century]. Arktika i Antarktika [Arctic and Antarctic], 2016, no. 2, pp. 138 - 145. DOI: 10.7256/2453-8922.2016.2.20164. Available: https://nbpublish.com/library_read_article.php?id=20164. (in Russian).
2. Ignatyeva V., Kiushkina V., Samsonov R., et al. Arkticheskie strategii: energetika, bezopasnost', ekologiya i klimat [Arctic Strategies: Energy, Security, Environment and Climate]. [Research Report]. Skolkovo Energy Center. 2020. ⟨hal-02938923⟩. Available: https://hal.archives-ouvertes.fr/hal-02938923. (in Russian).
3. Samarina V. P., Skufina T. P., Samarin A. V. Russia's North regions as frontier territories: Demographic indicators and management features. European Research Studies Journal. 2018, vol. XXI, no. 3, pp. 705–716.
4. Social'no-ekonomicheskoe razvitie severo-arkticheskih territorij Rossii/ pod red. T. P. Skuf'inoj, E. E. Emel'yanovoj. [Socio-economic development of the North-Arctic territories of Russia / ed. T.P.Skufina, E.E. Emelyanova]. - Apatity: FRC KSC RAS, 2019. 119 p. (in Russian).
5. Smirennikova E.V., Ukhanova A.V., Voronina L.V. Sistema modelej dlya prognozirovaniya social'no-ekonomicheskogo razvitiya regionov Arkticheskoj zony Rossijskoj Federacii [System of Models of Forecasting of Social and Economic Development of Regions of the Arctic Zone of the Russian Federation]. Upravlencheskoe konsul'tirovanie [Administrative Consulting]. 2019, vol. 12, pp. 142-157. DOI: https://doi.org/10.22394/1726-1139-2019-12-142-157. (in Russian).
6. Krutikov A.V., Smirnova O.O., Bocharova L.K. Strategiya razvitiya rossijskoj Arktiki. Itogi i perspektivy [Strategy for the development of the Russian Arctic. Results and prospects]. Arktika i Sever [Arctic and North], 2020, no. 40, pp. 254–269. DOI: 10.37482/issn2221-2698.2020.40.254. (in Russian).
7. MineHealth 2012-2014: Guidebook on cold, vibration, airborne exposures and socioeconomic influences in open pit mining / A. Paloste, A. Rönkkö ed. Publications of Lapland UAS Serie C. Study Materials 5/2014. URL: http: //minehealth.eu/final-report.

8. Gendler S. G., Rudakov M. L., Falova E. S. Analysis of the risk structure of injuries and occupational diseases in the mining industry of the Far North of the Russian Federation. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu. 2020, vol. 3, pp. 81-85. Available at: http://nvngu.in.ua/index.php/en/archive/on-the-issues/1844-2020/contens-3-2020/5341-analysis-of-the-risk-structure-of-injuries-and-occupational-diseases-in-the-mining-industry-of-the-far-north-of-the-russian-federation
9. Syurin S.A., Gorbanev S.A. Usloviya truda i professional'naya patologiya gornyakov Kol'skogo Zapolyar'ya [Working conditions and occupational pathology of miners in the Kola Polar region] Meditsina Truda i Promyshlennaya Ecologiya [Occupational medicine and industrial ecology]. 2020, vol. 60, no. 7, pp. 456-461. DOI: 10.31089 / 1026-9428-2020-60-7-456-461. (in Russian).
10. Burström L., Aminoff A., Björ B. et al. Musculoskeletal symptoms and exposure to whole-body vibration among open-pit mine workers in the Arctic. International Journal of Occupational Medicine and Environmental Health. 2017, vol. 30. № 4. P. 553-564. doi: 10.13075/ijomeh.1896.00975.
11. Alekseev A.M., Petrova L.V., Sivtseva A.I. Analiz sostoyaniya uslovij truda v gornodobyvayushchem komplekse respubliki Saha (YAkutiya) [Analysis of the state of working conditions in the mining complex of the Republic of Sakha (Yakutia)]. Gornyj informacionno-analiticheskij byulleten' (nauchno-tekhnicheskij zhurnal) [Mining information and analytical bulletin (scientific and technical journal)]. 2017, vol. 12, pp. 207-214. (in Russian).
12. Sleptsova L.A., Tolstykh G.V. Sostoyanie ohrany truda v respublike Saha (Yakutiya) [The state of labor protection in the Republic of Sakha (Yakutia)]. Economics. 2019, vol. 3, no. 41, pp. 5-7. (in Russian).
13. Health transitions in Arctic populations /Ed. by T. Kue Young and P, Bjerregaard. University of Toronto Press. 2008. 485 p.
14. Petrova P.G. Ekologo-fiziologicheskie aspekty adaptacii cheloveka k usloviyam Severa [Ecological and physiological aspects of human adaptation to the conditions of the North]. Vestnik Severo-Vostochnogo federal'nogo universiteta imeni M.K. Ammosova. Seriya «Medicinskie nauki». [Bulletin of the North-Eastern Federal University named after M.K. Ammosov. Series «Medical Sciences»]. 2019, vol. 2, no. 15, pp. 29-38. DOI 10.25587 / SVFU.2019.2 (15) .31309. (in Russian).
15. Saltykova M.M., Bobrovnitsky I.P., Yakovlev M.Yu. et al. Novyj podhod k analizu vliyaniya pogodnyh uslovij na organizm cheloveka [A new approach to the analysis of the influence of weather conditions on the human body]. Gigiena i sanitariya [Hygiene and sanitation]. 2018, vol. 97, no. 11, pp. 1038-1042. DOI: 10.18821/0016-9900-2018-97-11-1038-42. (in Russian).
16. Khasnulin V.I., Khasnulin P.V. Sovremennye predstavleniya o mekhanizmah formirovaniya severnogo stressa u cheloveka v vysokih shirotah [Modern concepts of the mechanisms of northern stress formation in humans at high latitudes]. Ecologiya cheloveka [Human ecology]. 2012, no. 1, pp. 4-11. (in Russian).
17. SoloninYu.G., Boyko E.R. Mediko-fiziologicheskie aspekty zhiznedeyatel'nosti v Arktike [Physico-physiological aspects of life in the Arctic]. Arktika: ekologiya i ekonomika [Arctic: ecology and economics]. 2015, vol. 17, no. 1, pp. 70-75. (in Russian).
18. Syurin S.A., Kovshov A.A. Usloviya truda i risk professional'noj patologii na predpriyatiyah Arkticheskoj zony Rossijskoj Federacii [Working conditions and the risk of occupational pathology at the enterprises of the Arctic zone of the Russian Federation]. Ekologiya cheloveka [Human ecology]. 2019, no. 10, pp. 15-23. DOI: 10.33396/1728-0869-2019-10-15-23 (in Russian).
19. Govorova N.V. Chelovecheskij kapital – klyuchevoj aktiv hozyajstvennogo osvoeniya arkticheskih territorij [Human capital is a key asset in the economic development of the Arctic territories]. Arktika i Sever [Arctic and North]. 2018, vol. 31, pp. 52-61. DOI: 10.17238/issn2221-2698.2018.31.52. (in Russian).
20. Fauser VV, Smirnov AV. Mirovaya Arktika: prirodnye resursy, rasselenie naseleniya, ekonomika [World Arctic: natural resources, population distribution, economy]. Arktika: ekologija i ekonomika [Arctic: ecology and economics. 2018, vol. 3, no. 31, pp. 6-22.
DOI: 10.25283 / 2223-4594-2018-3-6-22. Available at: http://www.ibrae.ac.ru/docs/3(31)2018. (in Russian).
21. Skripal B. A. Sostoyanie zdorov'ya i zabolevaemost' rabochih podzemnyh rudnikov gorno-himicheskogo kompleksa Arkticheskoj zony Rossijskoj Federacii [Status of health and diseases in workers of underground mines of a mining complex in the Arctic zone of the Russian Federation]. Meditsina truda i promyshlennaya ekologiya [Occupational medicine and industrial ecology]. 2016, no. 6, pp. 23–26. (inRussian).
22. Talykova L.V., Gushchin I.V. Svyaz' patologii kostno-myshechnoj sistemy s professiej rabochih

podzemnyh rudnikov Arkticheskoj zony Rossijskoj Federacii [The relationship of pathology of the musculoskeletal system with the profession of workers in underground mines in the Arctic zone of the Russian Federation]. Ekologiya cheloveka [Human ecology]. 2017, no. 7, pp. 11-15. DOI: https://doi.org/10.33396/1728-0869-2017-7-11-15. (in Russian).

23. Syurin S.A. Povyshennaya tyazhest' truda – vazhnejshij faktor riska professional'noj patologii na predpriyatiyah v Arktike [The increased severity of work is the most important risk factor for occupational pathology at enterprises in the Arctic]. Sanitarnyy vrach [Sanitary doctor]. 2020, no. 10, pp. 26-34. DOI 10.33920 / med-08-2010-03. (in Russian).
24. Chebotarev A.G. Sostoyanie uslovij truda i professional'noj zabolevaemosti rabotnikov gornodobyvayushchih predpriyatij [The state of working conditions and occupational morbidity of workers in mining enterprises]. Gornaya promyshlennost' [Mining]. 2018, vol.137, no. 1, pp. 92-95. DOI: http://dx.doi.org/10.30686/1609-9192-2018-1-137-92-95. (in Russian).