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RISK OF DEVELOPMENT OF DISEASES WITH TEMPORARY DISABILITY IN WORKERS OF THE MINING AND METALLURGICAL INDUSTRY OF UKRAINE

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The purpose of this study was risk assessment of morbidity with temporary disability among workers engaged in mining and processing of iron ore in the mining and metallurgical industry of Ukraine. The risk of developing common diseases in workers of mining and metallurgical industry is lower than in the control group and equals to 0.127 for underground extraction of iron ore, 0,173 for the open-pit mining of iron ore and 0,161 for metallurgical production, and the ratio of the chances of Contracting an occupational disease (OR) is 0,0516, 0,0061 and 0,041 respectively, which correlated with working conditions. The conducted studies prove the need to calculate an individual safe working life and open the prospects for further scientific research aimed at developing and implementing an effective occupational risk management system.

Keywords: working conditions, morbidity, occupational risk, mining and metallurgical industry.

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At the present stage of industry development due to modernization and upgrading of production equipment occupational risks have widely spreaded. From the standpoint of Occupational Medicine, occupational risk is considered in the aspect of the establishment of quantitative regularities of occurrence of occupational diseases of workers and developing of mechanisms for its prevention [1, 2, 3]. Recently increasingly becoming a question about assessment and forecasting possible consequences in case of non-compliance of hygiene standards. Justifying of the need to change of strategy and tactics of occupational health in regards to risks of occupational diseases and their prevention becomes the basis of the practice of modern occupational medicine [4, 5, 6]. And although this trend in the world was launched by World Health Organization (WHO) in the 70th years of XX century, and the main provisions have been described in the documents and standards ISO ST 1999, ST-2631, ST-5349, in Ukraine for a very long time dominated the theory of "zero risk" which was based on the maximum permissible concentration and the maximum permissible level and their observance guarantee the preservation the health of workers [7, 4].

It should be noted, that in many countries of the world the so-called Harvard's model applies, in which the main criterion is oncological mortality (an additional number of deaths per 1 million of the population or employees). At the same time, by the sanitary legislation of United States, Britain and other countries risk assessment can be carried out not only mortality, but also according to other significant health disorders [8, 9]. On the recommendations of the WHO a risk assessment should be conducted by universal indicator - the lost years of working life (DALYs) using weight coefficients for occupational diseases, but this method is very difficult [8]. The methodology, which used in RF and now implemented in Ukraine based on any violations of health, on the basis of medical prognosis and type of disability from occupational diseases, disorder of reproductive health and health of descendants [6, 10]. Kundiyev Yu. and other authors [1, 11] noted that the study of the risk of health disorders should be based on the study of the relationship between working conditions, work experience and health condition. Thus the emergence of pathologies associated not only with exceeding regulatory levels, but also with a quantitative assessment of the health of workers.

Interest in the issue of occupational risk in Ukraine is especially manifested in last years and found its reflection in the "National Program for improving safety, occupational health and the working environment." Management of the system of occupational Medicine, its subsystems and services may be effective if it will be based on the results of a comprehensive analysis of the processes of formation of health and working ability of the working population [12, 13, 14].

So, given the circumstances set out above, the choice of the strategy of medical care for the working population needs an objective assessment of dangerousness production, which is possible only on the basis of quantitative risk assessments of health in specific professions on specific production, that will make health "control element", evaluate it according to economic criteria and have leverage for real management of occupational risk. Therefore, the study of occupational risk of emergence of diseases of the cardiovascular system in the workers in modern metallurgical enterprises is an urgent problem of the present and needs an immediate solution.

The purpose of the work was to assess risks of morbidity with temporary disability on the basis of studying working conditions and the level and structure of morbidity with temporary disability among workers engaged in mining and iron ore processing in the mining and metallurgical complex of Ukraine.

Materials and methods. Hygienic, epidemiological, and statistical methods of research were used to solve this purpose. Professional risk of disease development was determined according to the methodology for assessing occupational risk for worker's health [11] by the main technological processes in mining and metallurgical complex. On the basis of the results of hygienic assessment of working conditions on indicators of harmfulness and danger factors of the production environment, severity and intensity of the work process pre-determined professional risk for specific professional groups of employees. Assessment of the degree of cause-effect relationship of health disorders and working conditions was conducted by the research and study of morbidity with temporary disability. As a control group were examined workers of repair and mechanical shops.

Material handling was performed using the standard Microsoft Office Excel program package. The number of observations was sufficient to obtain unmatched estimates of the first two points: the arithmetic mean (M) and the mean square deviation (δ). For comparison of the average values of the quantitative indices, in the normal distribution of the trait used t-criterion of Student. The significance level was considered reliable $p < 0.05$ with reliability of 95 %.

Results of the study and their discussion. Results of analysis of morbidity with temporary disability of workers mining and metallurgical complex of Ukraine became the basis for the calculation of risk parameters and the main indicators of morbidity for in-depth study of the dynamics of morbidity, its causes, peculiarities of progressing and forecasting the efficiency of preventive activities (table 1). Morbidity with temporary disability is not clearly determined. This is numerical series of levels, which fluctuate in time with zero trend, is not present statistical reliability increase or decrease its value. For its analysis is more suitable model of probabilistic process of Markov type by means of which we can predict some of the probable characteristics of disease.

Table 1

Risk parameters of morbidity development with temporary disability of workers in the mining and metallurgical industry of Ukraine ($p < 0.05$)

Risk parameters	Production		
	Underground mining of iron ore	Open mining of iron ore	Metallurgical production
The average number of diseased in the inspected team, n	2.2	3.3	11.3
The average duration of periods between diseases, L	68.3	59.1	61.0
The probability of getting sick (being healthy) during the day, α	0.0146	0.017	0.0162
The probability to recover (being sick), β	0.1	0.081	0.084
Risk of morbidity with temporary disability, R_1	0.127	0.173	0.161
Risk of morbidity with temporary disability in the control group, R_0	0.31	0.31	0.31
The relative risk, RR	0.1	0.13	0.09
Etiological particle of professional selection, EF	89.7%	85.9%	90.8%
The ratio of the chances to get sick of occupational disease, OR	0.0516	0.041	0.0061
Duration of morbidity with temporary disability before transition to occupational disease	5.96	7.98	31.8
Assessment of class of working conditions by indicators of morbidity with temporary disability	3.2	3.2	2-3.1

In the analysis of auxiliary parameters of risks of diseases with temporary disability we determined that the most number of diseased in metallurgical production (11.3) and the average duration of periods between diseases in metallurgical production and the open mining of iron ore are at approximately the same level (61.0 and 59.1), which indicates that a large quantity of somatic diseases, which are short-lived, and periods between them is less than in other industries. Duration of morbidity with temporary disability before transition to occupational disease is the most in the metallurgical industry 31.8. and the smallest in underground mining (5.96), which proves that the metallurgical industry has more diseased for morbidity with temporary disability, periods between them is less, but the risk of transition to occupational disease is very low.

The probability of getting sick is the highest in the open mining of iron ore (0.017) and the smallest in underground mining of iron ore (0.0146), and the probability to recover is the highest in underground mining of iron ore (0.1) and the smallest in open mining of iron ore (0.081), that is connected with the action of professional selection and medical support of workers which are allowed to underground work,

that is they are practically healthy. The risk of development of common diseases is lower than in the control group. Etiological particle of professional selection and preventive measures are quite high from 85,9 to 90,8 %, and therefore the risk of emergence of morbidity with temporary disability is lower than the average population. According to calculated indicators of morbidity with temporary disability they correspond to 3 Class 2 degree of harmfulness for underground and open-pit mining of iron ore and 3 Class 1 degree of harmfulness or permissible for metallurgical production. Table 2 shows the risk parameters by individual nosological units in the main industries.

Table 2

Risk parameters of morbidity development with temporary disability by individual nosological forms for workers of mining and metallurgical industry of Ukraine ($p<0.05$)

Common diseases	Underground mining of iron ore			Open mining of iron ore			Metallurgical production		
	AR at 10^{-6}	RR	EF %	AR at 10^{-6}	RR	EF %	AR at 10^{-6}	RR	EF %
Neoplasms (C00-D48)	0.35	0.35	-	0.157	0.16	-	0.66	0.67	-
Diseases of the nervous system (G00-G99)	1.5	0.37	-	0.22	0.06	-	0.36	0.09	-
Diseases of the circulatory system (I00-I99)	1.45	0.28	-	2.0	0.39	-	2.15	0.41	-
Diseases of the respiratory system (J00-J99)	23.2	0.33	-	27.5	0.4	-	24.7	0.35	-
Diseases of the digestive system (K00-K93)	2.1	0.3	-	2.3	0.34	-	2.0	0.31	-
Diseases of the genitourinary system (N00-N99)	1.0	0.26	-	0.6	0.17	-	0.98	0.26	-
Other etiologies	0.02	0.63	-	2.0	49.5	-	0.19	4.7	78.7
All together of the above disease	40.8	0.34	-	46.8	0.4	-	44.0	0.37	-

When performing the analysis we can see that very low values of relative risk AR and value RR, which do not exceed 1,0 do not allow to define the category of diseases and their connection with working conditions. For identification the peculiarities of influence of working conditions on the structure of morbidity in main industries advisable to compare the individual industries (table 3).

Table 3

Comparing the risk parameters of diseases with temporary disability development by individual nosological forms for workers of mining and metallurgical industry of Ukraine ($p<0.05$)

Common diseases	Underground mining of iron ore and open mining of iron ore		Underground mining of iron ore and metallurgical production		Metallurgical production and open mining of iron ore	
	RR, CI 95 %	EF %	RR, CI 95 %	EF %	RR, CI 95 %	EF %
Neoplasms (S00-D48)	-	-	1.9 1.1-2.7	47.4	4.2 3.1-5.2	76.2
Diseases of the blood and hematopoietic gland and individual disorders with involvement of the immune mechanism (D50-D89)	5.0 4.8-5.2	80	-	-	2.7 2.1-3.3	63.0
Endocrine disease, eating disorders and metabolism (E00-E90)	1.6 1.5-1.7	37.5	-	-	2.5 1.9-3.1	60.0
Disorders of phren and behavior (F00-F99)	22.0 21.2-22.9	95.5	11.8 6.8-16.7	91.5	1.9 1.7-2.1	47.4
Diseases of the ear and mastoid process (N60-N95)	-	-	-	-	2.6 2.4-2.8	61.5

By comparing the productions against each other, we can see that the emergence of risk of disorders of phren and behavior in underground mining of iron ore 22.0 times higher than in the open mining of iron ore and 11.8 times higher than in metallurgical production with EF 95.5 and 91.5 %, diseases of the nervous system 6.8 times higher than in underground mining of iron ore and 4.2 times than in metallurgical production with EF 85.3 and 76.2 %, which indicates a very high dependence on working conditions. In metallurgical production risk of neoplasms 4.2 times higher than in open mining of iron ore, diseases of the blood and hematopoietic gland 2.7 times, 2.5 times higher for endocrine diseases and 2.6 times higher for diseases of the ear and mastoid process. EF of occupational factors 76.2, 63.0, 60.0, 61.5 %, which indicates the high and very high connection with working conditions.

The risk of developing a disease with temporary disability is influenced by a set of factors, among which working conditions, economic conditions, lifestyle and quality of life are leading and determine the level of population health and work potential, which is confirmed not only by our studies, which found that the risk of occurrence of mental and behavioral disorders in underground mining of iron ore is 22.0 times higher than in open and 11.8 times higher than in metallurgy, diseases of the nervous system 6.8 times higher than in underground and 4.2 times than in metallurgy, in metallurgical production the risk of neoplasms is 4.2 times higher than in open production, blood and hematopoietic diseases 2.7 times, 2.5 times higher for endocrine diseases and 2.6 times higher for diseases of the ear and mastoid process, but also studies by many authors worldwide [1, 2, 10, 11].

According to various researchers Shastin A. S. [4], Andrushchenko T. A., Basanets' A. V. [5], Shlyapnikov D. M. [6], Preobrazhenskaya Ye. A., Sukhova A. V., Zor'kina L. A. [12], Chernyuk V. I., Solovyov O. I., Honcharov O. E. [13] working conditions in workers engaged in the mining and processing of minerals cause rather high levels of diseases of the cardiovascular, respiratory, and bone-muscular systems, the development of myocardial infarction, stroke, which correlates with the results of our studies, which found that the highest number of sick workers occurs in metallurgical production (11.3), and the average length of periods between diseases in metallurgical production and in open-pit mining iron ore is approximately at the same level (61.0 and 59.1).

Assessment of working conditions and the assessment of individual and group occupational risk and hazards of production in specific occupations and specific industries are considered by many of the world's leading scientists [3, 7, 8, 9, 11, 14] as necessary to establish the relationship between working conditions, seniority and age and development of diseases in the employees of industrial enterprises from the point of view of evidential medicine. Thus, according to our research, working conditions for underground and open-pit mining of iron ore correspond to Grade 2 grade 2, and for metallurgical production – grade 3 grade 1 or permissible.

The prospect of further research is the development of an individual occupational risk management card, one of the components of which is the assessment and analysis of the risk of developing disease with temporary disability, which is the key to developing effective integrated models to reduce the risk of not only common but also occupational diseases.

Conclusions

1. In-depth analysis of morbidity with temporary disability is conducted for establishment reliably proven cause-and-effect relationship between worker's health and industrial and professional environment with a view to developing, implement and monitor the effectiveness of preventive measures which are aimed at reducing of morbidity and management of professional risk. Reduction in the level of disease has not only social but also economic importance because it contributes to the preservation of a significant number of workers in the sphere of production.

2. The risk of developing of common diseases in the workers of mining and metallurgical industry is lower, than in the control group and is 0,127 for underground mining of iron ore, 0,173 for open mining of iron ore and 0,161 for metallurgical production, and the ratio of the chances to get sick of occupational disease (OR) is 0,0516, 0,041 and 0,0061 respectively, which correlated with working conditions. When calculating the indicators of diseases with temporary disability it has been established that that working conditions for underground and open mining of iron ore corresponds to 3 Class 2 degree of harmfulness, and for metallurgical production – 3 Class 1 degree of harmfulness or admissible.

3. In-depth analysis of morbidity and establish the causes which lead to its increase will case follow-up dynamic supervision, monitoring the health of each individual employee in order to timely detect early manifestations of occupational disease and mandatory medical rehabilitation in order preservation of working ability of the workers in his profession, calculation of individual safe working term and open perspectives for future research aimed to the development and implementation of effective system of management of professional risk.

Prospects for further research are that the results obtained during the analysis of the morbidity with temporary disability for workers of the above-mentioned occupations can be considered as initial data and will allow the establishment of dynamic monitoring, monitoring of the health status of each individual worker in order to timely identify the initial manifestations of occupational disease and the mandatory conduct of a recovery treatment in order to maintain the worker's ability to work in his profession. The obtained results will be the basis for determining both group and individual safe working terms, criteria for early diagnosis of initial manifestations of diseases, which are caused by the influence of working conditions, criteria of professional selection.

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Реферати

**РИЗИК РОЗВИТКУ ЗАХВОРЮВАНЬ
З ТИМЧАСОВОЮ ВТРАТОЮ ПРАЦЕЗДАТНОСТІ
У ПРАЦІВНИКІВ ГІРНИЧО-МЕТАЛУРГІЙНОЇ
ГАЛУЗІ УКРАЇНИ**

Ковальчук Т.А., Орехова О.В., Павленко О.І.

Метою даного дослідження була оцінка ризику розвитку захворюваності з тимчасовою втратою працевздатності серед працівників, що зайняті видобуванням та переробкою залізної руди в гірничо-металургійній галузі України. Ризик розвитку загальних захворювань у працівників гірничо-металургійної галузі є нижче, ніж у контрольній групі та становить 0,127 для підземного видобутку залізної руди, 0,173 для відкритого видобутку залізної руди та 0,161 для металургійного виробництва, а відношення шансів захворіти на професійне захворювання (OR) становить 0,0516, 0,041 та 0,0061 відповідно, що корелює з умовами праці. Проведенні дослідження доводять необхідність розрахунку індивідуального безпечного терміну роботи та відкривають перспективи для подальших наукових досліджень, спрямованих на розроблення та впровадження ефективної системи керування професійним ризиком.

Ключові слова: умови праці, захворюваність, професійний ризик, гірничо-металургійна галузь.

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**РИСК РАЗВИТИЯ ЗАБОЛЕВАНИЙ
С ВРЕМЕННОЙ УТРАТОЙ ТРУДОСПОСОБНОСТИ
У РАБОТАЮЩИХ ГОРНО-МЕТАЛЛУРГИЧЕСКОЙ
ОТРАСЛИ УКРАИНЫ**

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Целью данного исследования была оценка риска развития заболеваемости с временной утратой трудоспособности среди рабочих, занятых добычей и переработкой железной руды в горно-металлургической отрасли Украины. Риск развития общих заболеваний у работников горно-металлургической отрасли ниже, чем в контрольной группе и составляет 0,127 для подземной добычи железной руды, 0,173 для открытой добычи железной руды и 0,161 для металлургического производства, а отношение шансов заболеть профессиональное заболевание (OR) составляет 0,0516, 0,041 и 0,0061 соответственно, что коррелирует с условиями труда. Проведенные исследования доказывают необходимость расчета индивидуального безопасного срока работы и открывают перспективы для дальнейших научных исследований, направленных на разработку и внедрение эффективной системы управления профессиональным риском.

Ключевые слова: условия труда, заболеваемость, профессиональный риск, горно-металлургическая отрасль.

Рецензент Голованова І.А.