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HYGIENE, SANITATION, EPIDEMIOLOGY PAND MEDICAL ECOLOGY

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ASSESSMENT OF THE ROLE OF VARIOUS FACTORS IN THE FORMATION OF ARTERIAL HYPERTENSION IN CHEMICAL WORKERS BY A MACHINE TRAINING METHOD

The article discusses key cardiovascular risk factors hypertension in workers of chemical industries. The study aims to identify the contributing factors using machine learning methods.

Materials and methods. The study involved 643 male workers, including 551 operators from two chemical production facilities (Ethylene-Propylene and Ethylbenzene-Styrene plants) and 92 automation center workers. The evaluation of production and non-production risk factors was conducted through periodic medical exams, consultations with cardiologists, and assessments of stress and depression levels. A gradient boosting method in the CatBoost library was used to analyze the data, considering both work-related and personal factors like age, smoking, anxiety, depression, and lipid profiles.

Results. The analysis showed that age, smoking, high LDL levels, BMI, and years of work in harmful conditions were the most significant factors in predicting the development of AH. For the Ethylbenzene-Styrene (EBS) operators, the major factors influencing AH risk were work experience (23.78%), age (18.06%), and smoking (14.53%). For the Ethylene-Propylene (EP) operators, the key factors were work experience (20.59%), smoking (20.22%), and LDL levels (18.07%). Statistically significant differences in anxiety and stress levels were found between the EP and EBS groups ($p<0.05$).

Conclusion. The study concludes that both production-related and non-production factors contribute significantly to the risk of developing AH among workers in chemical industries. Key factors like smoking, BMI, and LDL levels, along with harmful occupational exposures and high emotional stress, should be addressed in preventive measures to reduce hypertension risks in this workforce.

Keywords: chemical industry, risk factors, machine learning, occupational stress.

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Introduction. Research conducted in recent decades has allowed for the identification of key risk factors for the development of cardiovascular diseases (CVD), the study of their interrelationship, and the formulation of the concept of overall cardiovascular risk [1].

It has been established that the main risk factors include hypertension (HT), dyslipidemia, excess body weight (BMI), obesity, diabetes, hyperuricemia, thrombogenic factors, and inflammatory factors [4]. It is important to note that ecology, the social environment, and lifestyle also have a significant impact on the development of CVD. The interaction of these factors with genetic and gender characteristics can contribute to the progression of cardiovascular diseases [15].

Low educational levels, lack of social support, psychosocial stress, as well as anxiety and depressive disorders in the working-age population also play an important role in the development of CVD, as confirmed by the results of numerous epidemiological studies [11,14,5]. Smoking is one of the most significant clinical risk factors for CVD [3,8].

Lack of physical activity and obesity also lead to a decrease in the adaptive capacity of the cardiovascular system, worsening tolerance to physical exertion, and increasing the risk of developing CVD [9,12]. Disruption of lipid metabolism is recognized as one of the main risk factors for the development of atherosclerosis and coronary artery disease (CAD) [16].

Numerous studies confirm the adverse effects of harmful occupational factors and chronic workplace stress on the onset and progression of CVD [6,2,7,10].

The above justifies the need for special studies among workers in various industries to establish the causal relationship between the prevalence of CVD and cardiovascular risk factors.

Materials and Methods. The study involved 643 male workers, of which 551 were chemical production operators (295 workers in the EBPS and 256 in the EP) and 92 workers from the automation center (AC).

The study evaluated both occupational and non-occupational factors influencing the risk of developing hypertension. The evaluation of occupational risk factors was conducted based on materials from a special assessment of working conditions, industrial control, and self-inspection of workplaces.

The main non-occupational risk factors were studied through periodic medical examinations (PME) (Order of the Ministry of Health of the Russian Federation No. 29n, dated January 28, 2021). Additional studies included cardiologist consultations, lipid profile determination, and the assessment of anxiety and depression levels using the HADS scale, Reader.

To assess the contribution of occupational and non-occupational risk factors to the development of hypertension in workers, the gradient boosting method on decision trees was used, implemented in the CatBoost library.

The model training was conducted on a sample that included both occupational (working years in harmful conditions, factors of the working environment and labor process) and non-occupational (age, levels of anxiety, depression, and stress, body mass index, lipid profile indicators) risk factors. Hypertension presence was considered as the target variable (binary classification). To interpret the results, we used the built-in CatBoost method for assessing factor importance, which allowed for determining the contribution of each factor to the development of hypertension. The visualization of the distribution of factors and their contribution to the probability of the disease is presented in the form of density diagrams (violin plots), showing the direction and strength of their impact. The significance metrics used for the factors were the mean absolute SHAP value (mean abs shap) and the percentage impact of each feature.

Results. The research was conducted at two chemical production facilities: ethylene-propylene production, which is partially automated, and the highly automated ethylbenzene-styrene production. The majority of the staff consisted of operators who remotely controlled technological processes from control rooms. The continuous technological process schemes, automation, and the use of mainly sealed equipment at both facilities do not eliminate the possibility of operators being exposed to a complex of harmful occupational factors.

The final assessment of working conditions for operators at the ethylbenzene-styrene production corresponds to the third class of the first degree of harm (class 3.1), while at the ethylene-propylene production, it corresponds to the third class of the second degree of harm (class 3.2).

The differences in the final assessment of working conditions for the operators at these productions depended on the level of automation and computerization of the production processes, which determined the time the worker spent directly at the equipment, as well as the spectrum and levels of harmful occupational factors (Table).

Self-assessment of psychosocial stress levels using the Reeder scale

Main characteristics of the studied groups

Indicator	EBS Operators (n=295)	EP Operators (n=256)	AC Workers (n=92)	*p*		
				EBSvs.EP	EBSvs.CA	EPvs.CA
Working Conditions						
Harmful Substances	2	3.1	2	-	-	-
Noise	2	3.1	2	-	-	-
Lighting Environment	3.1	2	2	-	-	-
Severity	2	3.1	2	-	-	-
Intensity	3.1	3.1	2	-	-	-
Final Assessment	3.1	3.2	2	-	-	-
Male gender (%)	100	100	100	-	-	-
Age (years)	47.2±7.1	48.3±7.6	49.9±9.7	0.86	0.40	0.73
Years of employment	24.1±8.2	23.9 ± 8.0	26.7±9.5	0.88	0.29	0.11
Smoking (%)	32.9	40.6	34.8	0.07	0.83	0.39
BMI ≥30 (%)	36.9	37.1	39.1	0.96	0.80	0.93
LDL >3.0 mmol/L (%)	50.7	46.1	50.0	0.32	0.99	0.60
TC >5.0 mmol/L (%)	56.9	52.0	50.0	0.28	0.29	0.84
Stress level and psychoemotional state						
HADS-Anxiety. > 7 points (%)	24.7	37.9	21.7	**0.001***	0.65	**0.007***
HADS-Depression. > 7 points (%)	14.9	19.8	15.2	0.162	0.92	0.44
Psychosocial Stress (Reeder). > 1 point (%)	39.0	49.2	34.8	**0.016***	0.20	**0.024***

Notes: * - statistically significant differences (χ2 test. p<0.05) and psychoemotional state using the HADS scale revealed that the highest prevalence of high levels of anxiety and stress was recorded among operators in the EP production (37.9% and 49.2%, respectively). A statistically significant difference was found in anxiety levels between operators at the EP production and those at the EBS production ($\chi2$ = 10.49; p = 0.001), workers in the AC ($\chi2$ = 7.20; p = 0.007), as well as in stress levels between operators at the EP production and those at the EBS production ($\chi2$ = 5.86; p = 0.016), and workers in the AC ($\chi2$ = 5.12; p = 0.024). To develop a model assessing the contribution of various risk factors to the onset of hypertension, the following risk factors were used: data on working conditions, clinical and laboratory tests, and assessments of anxiety and depression levels for 551 operators (Figure 1).

As a result of machine learning using artificial intelligence, factors that have the greatest impact on the prediction of hypertension development in operators were identified: age, smoking, low-density lipoprotein (LDL) levels, excess body weight, and years of work in harmful working conditions.

In the next stage, models were developed to assess the risk of hypertension development separately for operators at the EBS and EP production facilities. In the presented model, factors related to the working environment and labor process were not taken into account, as they were the same for operators in both groups.

Based on the results of the evaluation of the influence of individual risk factors on the development of hypertension in operators at the EBS production, the leading factors were: years of work (impact 23.78%), age (impact 18.06%), smoking (impact 14.53%), LDL levels (impact 13.61%), BMI (impact 7.82%), stress level (impact 7.07%), and total cholesterol level (impact 6.10%) (Figure 2, a).

It was found that in the EP operators group, the factors that had the greatest impact on the accuracy of hypertension development predictions were work experience, smoking (impact 20.59%), age (impact 20.22%), LDL levels (impact 18.07%), body mass index (impact 10.90%), years of work in harmful conditions (impact 9.67%), total cholesterol (impact 6.83%), and psychoemotional factors: anxiety and stress levels (impact 6.34% and 4.93%, respectively) (Figure 2, b).

Furthermore, the results of the statistical analysis revealed the average values of risk factors for hypertension development in operators at the EBS and EP productions (Figure 4).

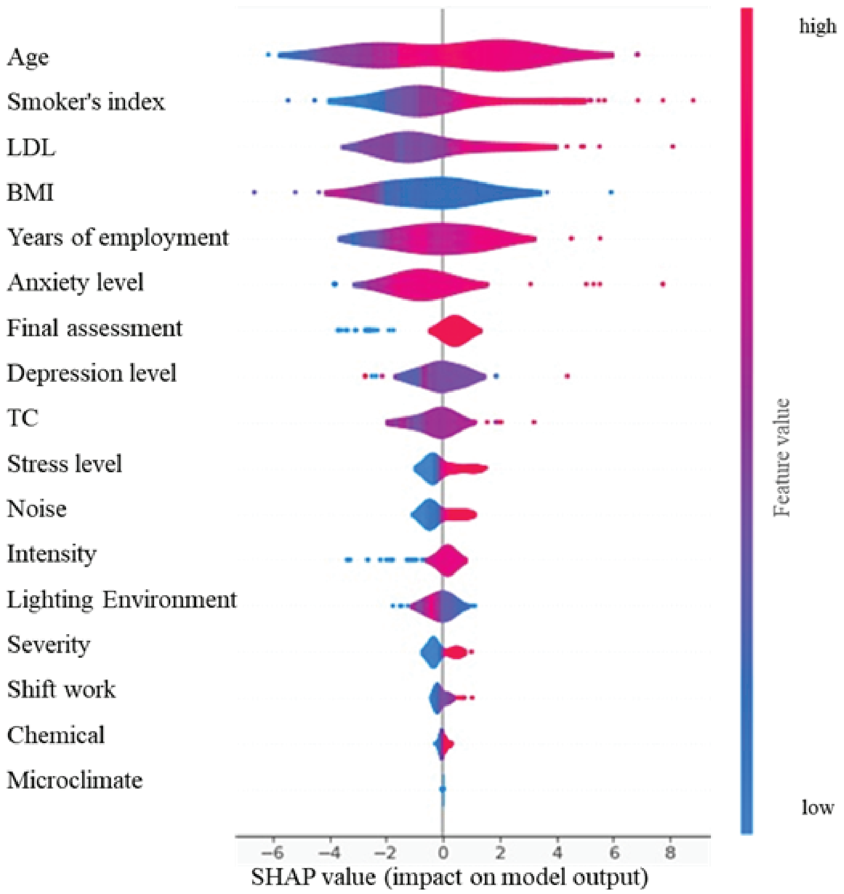

Fig. 1. Contribution of Each Predictor to the Predictive Ability of the Overall Model

Discussion. Despite the increasing number of studies examining the impact of harmful occupational and non-occupational risk factors on the cardiovascular health of workers in various industries, the number of studies dedicated to this issue in the chemical industry is limited [6,13]. In line with the stated objective, this study examined the influence of occupational and non-occupational factors on the risk of developing hypertension in workers at specific chemical productions and scientifically justified a set of preventive measures for cardiovascular risk based on the identified priority risk factors.

Based on the constructed mathematical model, it was determined that the risk of developing hypertension in operators of chemical productions is influenced by several factors, the key ones being age, years of work, smoking, increased body mass index, and low-density lipoprotein levels. These factors, in combination with chronic exposure to workplace environmental factors and high emotional stress, contribute to an increased cardiovascular risk due to their cumulative effect on the cardiovascular system.

The complex of harmful occupational factors also contributes to the increase in blood pressure. It should be noted that industrial noise exceeding hygienic standards activates stress reactions in the body, while exposure to chemicals disrupts the functioning of the vessel walls.

Conclusion. Thus, the presented materials clearly demonstrate that the combination of occupational and non-occupational factors contributes to an increased risk of developing hypertension among workers in the chemical industry. Statistically significant differences in the prevalence of hypertension among operators at the EP production are primarily due to the high prevalence of smoking as a risk factor, as well as exposure to a number of harmful occupational factors exceeding standard values.

Operators at the EP production facility have the highest prevalence of high anxiety and stress levels compared to operators at the EBS production and workers in the AC.

Based on the results of the study, a cardiovascular risk prevention program

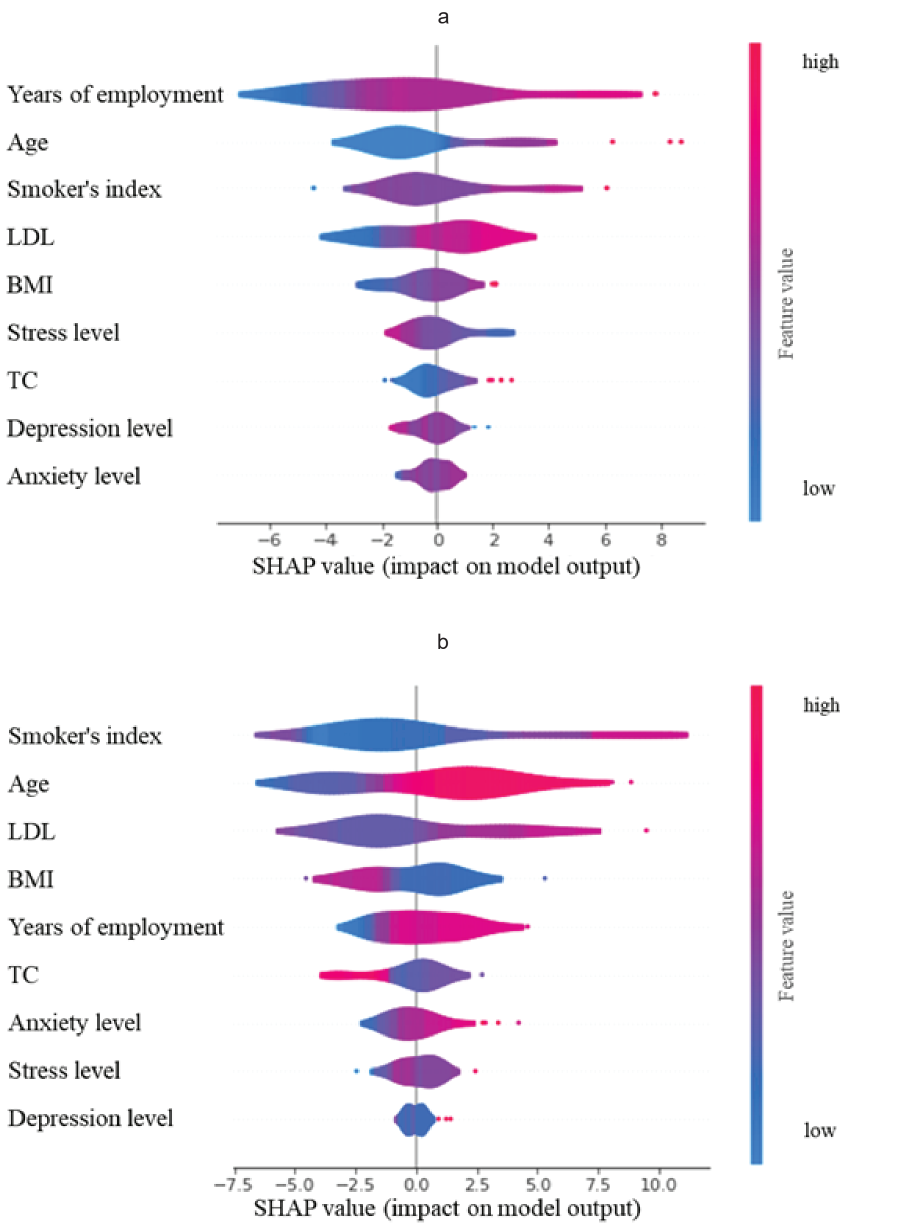

Fig. 2. Model of the influence of risk factors on the development of hypertension in production operators: a-EBS, b-EP

has been developed, aimed at minimizing the negative effects of stress factors, as well as occupational and non-occupational risk factors. Therapeutic and preventive measures include the formation of groups for dispensary observation depending on cardiovascular risk levels, and conducting the necessary volume of therapeutic and health improvement activities in various medical and health institutions.

The authors declare no conflict of interest in the submitted article.

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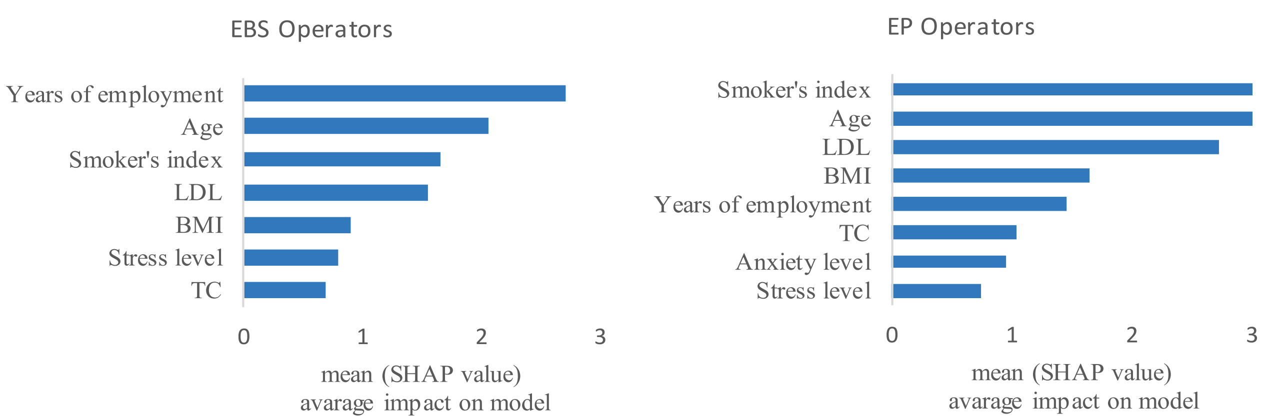

Fig. 3. Average values of risk factors affecting the development of AH in operators

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TOPICAL ISSUE

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PREVENTABLE CAUSES IN THE MORTALITY STRUCTURE OF THE POPULATION OF THE SAKHA REPUBLIC (YAKUTIA) AND ITS ARCTIC ZONE

When studying a population mortality, a survey of the factors by influencing which it is possible to minimize losses are of great practical and scientific interest. The aim of the survey was to assess the population mortality from preventable causes in the Sakha Republic (Yakutia) using the Russian classification.

Materials and Methods. Using the methods of comparative and mathematical analyses, the data on the population mortality in the Sakha Republic (Yakutia) and its Arctic zone in 2020-2023 were studied, with grouping of the causes of deaths which could have been avoided either by preventing the risks of developing diseases, by timely diagnosis of a disease, or by adequate treatment.

Results and Discussion. It was found that 37.2% of the total number of deaths in the republic in 2020-2023 could have been avoided, including 71.8% of the cases by primary prevention measures (Group 1 of the causes); 3.2% – by early diagnosis of diseases (Group 2 of the causes); and 25.0% – by adequate treatment (Group 3 of the causes). In the mortality structure in the Arctic zone of the republic, these causes accounted for 75.1%, 2.6%, and 22.3%, respectively. The greatest contribution to preventable mortality of the population in Yakutia is made by lifestyle-related diseases. Losses due to injuries and poisoning account for 35.7% in the preventable mortality in the republic as a whole and for 45.0% in the Arctic zone of the region. 24.9% of fatal cases in the Arctic zone (10.5% in the republic) directly depended on the quality of medical care. To minimize these losses, it remains important to identify diseases at early stages; to address them with adequate treatment; and, for district hospitals, to refer patients to level 3 medical institutions in a timely manner.

Keywords: mortality, preventable causes, Sakha Republic (Yakutia), Arctic zone.

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Introduction. The introduction of the Rutstein concept of preventable mortality in foreign countries in the second half of the 20th century made it possible to adequately assess the performance of healthcare as a social institution and significantly increase the efficiency of investments in maintaining public health. The concept is based on the differentiation of nosological forms of diseases, death from which can be avoided through medical intervention [4,5,6,7]. There are two lists of preventable mortality causes, where the grouping is determined by levels of prevention: "old" ("Avoidable mortality") and new ("Amenable mortality"). The first list includes the efforts of the entire public health system, the second – only healthcare institutions. The index of causes in the lists may change as medical science and practice develop, and diagnostic and therapeutic capabilities expand. The difficulty with applying this methodology as it is in the