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Improvement of the integrated safety of the labor process of employees

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Introduction. The article proposes a model for assessing the integrated safety of the labor process of workers with the risk of the spread of infectious respiratory diseases, for the development of which multifactorial dependences of occupational risk on working conditions at the workplace were used, taking into account the likelihood of contracting coronavirus infection.
Problem Statement. The objective of this study is to formulate methodological aspects of ensuring the safety of the workplace and the working environment, reflecting the need for constant epidemiological monitoring of objects of control (employees and the ways of virus transmission) with an assessment of the controlled parameters.
Theoretical Part. Official data provided by the Federal State Statistics Service was used as basic information.
Conclusion. The results of the analysis indicate the need for a rapid assessment of occupational risk, taking into account the epidemiological circumstances.

Keywords: labor protection, risk of infection, coronavirus infection, occupational risk, protective equipment.

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Introduction. With the growth of the total population and global urbanization, there is an increase in the level of risk and the rate of spread of infectious diseases, which is due to the high population density and the frequency of human contact. These processes naturally lead to the emergence of new viruses, mutations of the existing ones. So, at the beginning of 2020, the SARS-CoV-2 virus (the causative agent of the COVID-19 disease) received a worldwide epidemic spread and turned into a pandemic. At the time of the spread of the infection, there were no vaccines, specific medications, and there was no single clinical methodology for the therapeutic treatment and prevention of coronavirus [1, 2]. Faced with the severe consequences of contracting coronavirus infection in the form of complications and deaths, the governments of most countries have introduced restrictive measures that have caused serious changes in people's lives. Human security in the conditions of the spread of infectious diseases can be represented in the form of a pyramidal division into several interrelated levels: a safe household environment, a safe working environment and the safety of the population as a whole (Fig. 1).

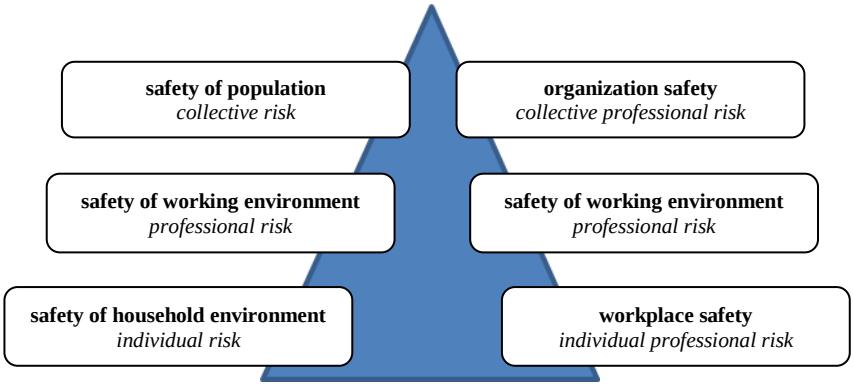

Fig. 1. Pyramidal division of the level of human safety in the conditions of the spread of infectious diseases

The central place is occupied by the area of ensuring a safe labor process, for the maintenance of which the resources of health care, sanitary and epidemiological well-being, protection in emergency situations are used. Workplaces are an environment that can accelerate the spread of COVID-19. The control of the level of exposure to SARS-CoV-2 infection in the workplace is carried out through labor protection services in order to reduce the viral load at the enterprise as a whole [3, 4].

Predicting the expansion of coronavirus infection allows us to predict that the end of the pandemic will occur within a few years, so the restrictions and requirements imposed are fixed at the legislative level. The Russian Federation has already adopted regulatory documents regulating the requirements for the prevention of coronavirus: SP 3.1.3597-20 "Prevention of a new coronavirus infection (COVID-19)", SP 3.1/2.4.3598-20 "Sanitary and epidemiological requirements for the design, maintenance and organization of the work of educational organizations and other social infrastructure facilities for children and youth in the conditions of the spread of a new coronavirus infection (COVID-19)", etc.

In addition, the Ministry of Health of the Russian Federation, Rospotrebnadzor constantly update recommendations for employees and employers in a negative epidemiological situation. The employer has the right to independently determine the structure and scope of the system of anti-epidemic measures, taking into account the specifics of the organization, the parameters of the labor process and other characteristics of the enterprise, based on the recommendations of authorized bodies and current legal requirements [5, 6]. In the context of a pandemic, the role of occupational safety specialists in ensuring safe working conditions is increasing through timely identification of infectious and non-infectious hazards, as well as risk assessment and management. The adoption of urgent organizational and administrative measures to monitor, control, prevent, counteract and contain the spread of infection will minimize infection and restore the normal operation of the enterprise [7].

Problem Statement. The objective of this study is to form methodological aspects of ensuring the safety of the workplace and the working environment, reflecting the need for constant epidemiological monitoring of control objects (workers and ways of virus transmission) with an assessment of the controlled parameters. The aim of the work is to modernize the occupational health and safety management system of enterprises, taking into account the analysis of the main changes in the legislative sphere aimed at limiting the coronavirus infection spread and ensuring the population safety. The relevance of the studied issues is also evidenced by the statistical data of state supervisory agencies on the detected violations in the field of anti-epidemic protection at the workplace.

Theoretical Part. The analysis of the circumstances of infection of workers with SARS-CoV-2 allows us to identify the following main ways of infection through contact with infected people or with infected surfaces and objects: during the performance of duties at the workplace, during business trips and official trips, while traveling to the place of work or from work on a vehicle. It should be taken into account that a person infected while performing work functions can infect people around him both at the enterprise and outside it [8, 9].

Methodological aspects of ensuring the safety of the workplace and the working environment, reflecting the need for constant epidemiological monitoring of control objects (workers and ways of transmitting the virus) with an assessment of the controlled parameters, are presented in Tables 1, 2.

Table 1

Organization of a safe workplace (reduction of individual occupational risk)

Object of control	Control methods	Controlled parameters
An employee (an organism susceptible to infection)	Protection of receptors (respiratory hygiene, gloves, special clothing), personal hygiene	Efficiency, frequency of replacement, degree of comfort, processing, disposal
	Distancing of physical interaction	Location and number of workplaces
	Thermometric control of employees	Accuracy and frequency of measurement
	Monitoring the well-being of employees (detection of signs of an infectious disease, testing for infection) and compliance with the self-isolation regime	Efficiency and frequency
Working area (path of transmission of pathogenic agents)	Disinfection of the workplace	Effectiveness of disinfectants, frequency of treatment
	Installation of protective barriers	Location and height, efficiency

Table 2

Organization of a safe working environment (reduction of collective occupational risk)

Object of control	Control methods	Controlled parameters, calculation of the risk of disease	Necessity to calculate the risk of the disease
An employee (an organism susceptible to infection)	Training to prevent the risk of infection	Knowledge assessment	+
	Informing employees about the current situation in the organization, in the region or the country as a whole, about ways to protect against infection	Knowledge assessment	–
	Improving the health of employees	Efficiency, reducing the risk of disease	+
	Social protection of employees	The amount of payments, social discrimination, stigmatization	–
	Changing the production culture	Behavior at work	–
Working area (path of transmission of pathogenic agents)	Time management	Flexibility of the working schedule, transfer to remote work	+
	Optimization of microclimatic parameters and disinfection of the air environment (ventilation, air conditioning, heating, bactericidal protection)	Efficiency, frequency, registration in the journal	+
	Cleaning and disinfection of public surfaces	Efficiency, frequency, registration in the journal	+

The epidemiological situation in the workplace not only affects the health and safety of employees, but also affects the level of stability of their employment.

An important element in the occupational health and safety management system, the presence of which is checked by state inspectors for employers, is the management of occupational risks. The need to make changes to the procedure for assessing occupational risks is caused by the coronavirus pandemic and requires an assessment of the

probability of infection of employees. Employers are faced with the problem of effective assessment and management of occupational risks in the workplace [10, 11].

To prepare workplaces for an increase in the risk of infection of employees, it is necessary to conduct an early and further operational assessment of the occupational risk of infection, taking into account the following indicato

$$R = (a_1 \cdot ИОУТ + a_2 \cdot K_{T1} + a_3 \cdot K_{T2} + a_4 \cdot K_{T3}) \times L \times D \times 3 \times R_t, \quad (1)$$

where a — the coefficient that takes into account the significance of the parameter;

$ИОУТ$ — integrated assessment of working conditions at the workplace;

K_T — the indicator of individual susceptibility and severity of the consequences of infection (K_{T1} — takes into account the state of health (the presence of diseases), K_{T2} — takes into account age, K_{T3} — takes into account work experience);

L — the indicator of the probability of contact with potentially infected people;

D — the indicator of the probability of an employee's contact with a source of infection (potentially infected people or infected surfaces/materials when performing work functions;

3 — the indicator that takes into account the number of infected employees in the organization;

R_t — the coronavirus spread coefficient is an indicator that determines the average number of people infected by one patient before his isolation according to the methodological recommendations of Rospotrebnadzor of 8.05.2020:

$$R_t = (X_8 + X_7 + X_6 + X_5) / (X_1 + X_2 + X_3 + X_4), \quad (2)$$

where R_t — the coronavirus spread coefficient, official data on its magnitude (by region and in the Russian Federation as a whole) are published on the Rospotrebnadzor website (Fig. 2);;

$X_1 \ldots X_8$ — the number of registered infected by COVID-19 people in the region for the corresponding day.

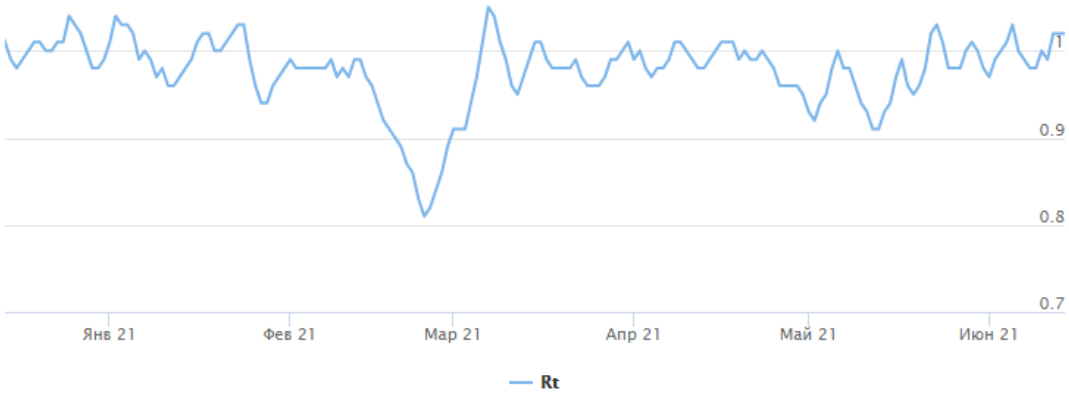

Fig. 2. Data on the spread rate of coronavirus in the Belgorod region

The level of professional risk in the organization is determined taking into account the individual professional risk:

$$У = R/N, \quad (3)$$

where N — the number of employees in the organization, people.

To determine the epidemiological situation in the Belgorod region, the values of the risk of infection with coronavirus infection and the risk of mortality of the population (the number of 1,541,259 people) were determined (Table 3). The results obtained indicate that the level of acceptable risk is exceeded (10-6), which necessitates the introduction of measures aimed at contain the spread of the coronavirus infection.

Table 3

Indicators of the epidemiological situation in the Belgorod region as of June 2021

Month	Number of infections	Risk of infection	Infection frequency coefficient	Number of deaths	Risk of mortality
June	44997	0.0292	$1.44192 \cdot 10^{-8}$	55	0.001222
May	57481	0.0373	$1.12876 \cdot 10^{-8}$	59	0.001026
April	44803	0.0291	$1.44816 \cdot 10^{-8}$	68	0.001518
March	59618	0.0387	$1.0883 \cdot 10^{-8}$	78	0.001308
February	65845	0.0427	$9.85375 \cdot 10^{-9}$	112	0.001701
January	65903	0.0428	$9.84508 \cdot 10^{-9}$	113	0.001715

When assessing professional risk, it is necessary to take into account the differentiation of the level of risk within one organization [12]. Adjustment of the risk level should be made taking into account changes in the epidemiological picture of morbidity in the country, region, at the enterprise as a whole and in specific structural divisions. Risk ranking can be carried out in two directions — the probability and severity of the impact.

In order to take effective measures to contain the spread of the COVID-19 virus (the causative agent of SARS-CoV-2), it is also necessary to take into account the categorization of workplaces by the level of exposure to infection (very high, high, medium and low), developed by the US Occupational Safety and Health Administration (OSHA) [13, 14]. According to the official data of the Federal State Statistics Service, the employed population of the Russian Federation aged 15-72 years in 2020 was: total — 70,601 thousand people (100%), men — 36,208 thousand people (51.3%), women — 34,393 thousand people (48.7%) [15]. Taking into account the information received, the authors conducted a categorization in accordance with the All-Russian Classifier of Occupations OK 010-2014 (division into groups of professions at the main job) according to the level of risk of infection with coronavirus infection (Table 4).

Table 4

Employed population aged 15-72 years in 2020

Groups of professions at the main job in 2020 (in accordance with All-Russian Classifier of Occupations OK 010-2014)	Total	Percentage ratio		Risk category
		men	women	
Total	100	51.3	48.7	
Managers	5.81	3.15	2.66	1
Specialists of the highest qualification level:	26.34	9.80	16.54	2
– scientific and technical activities	4.58	3.12	1.46	1
– activities in the field of healthcare	2.24	0.74	1.50	4
– activities in the field of education	6.05	0.98	5.07	3
– business and administration	7.59	2.26	5.33	1
– information and communication technologies	1.55	1.27	0.28	1
– law, humanities and culture	4.32	1.42	2.90	1
Specialists of the average qualification level:	13.74	5.63	8.11	
– specialists-technicians (scientific and technical activities)	4.38	3.82	0.56	1
– secondary medical personnel in the field of healthcare	3.55	0.29	3.26	3
– MSS in the field of economic and administrative activities	4.48	1.07	3.40	1
– MSS in the field of legal, social work, culture, education, sports and related activities	1.14	0.28	0.86	1
– technology in the field of ICT	0.21	0.18	0.03	1

Groups of professions at the main job in 2020 (in accordance with All-Russian Classifier of Occupations OK 010-2014)	Total	Percentage ratio		Risk category
		men	women	
Employees engaged in the preparation and execution of documentation, accounting and maintenance:	2.76	0.49	2.26	1
– general profile and maintenance of office equipment	0.75	0.09	0.67	1
– public service	0.79	0.14	0.65	1
– processing of numerical information and accounting of material values	0.73	0.20	0.53	1
– other office employees	0.48	0.07	0.41	1
Employees of the service and trade sector, protection of citizens and property:	15.19	4.61	10.59	2
– individual services	3.59	0.52	3.07	2
–trade (sellers, consultants)	7.31	1.21	6.10	3
– individual care	1.18	0.06	1.11	2
– protection of citizens and property	3.11	2.81	0.30	2
Qualified workers of agriculture and forestry, fish farming and fishing	2.49	1.29	1.20	1
Skilled workers of industry, construction, transport and workers of related occupations:	13.07	10.76	2.31	2
– construction and workers of related occupations (except electricians)	3.08	2.81	0.27	1
– metalworking and machine-building production, mechanics and repair	5.42	5.19	0.23	1
– manufacture of precision tools and devices, workers of artistic crafts and printing production	0.36	0.19	0.16	1
– electrical engineering and electronics	1.54	1.35	0.19	2
– food, woodworking, textile and clothing industries and workers of related occupations	2.68	1.23	1.46	2
Operators of industrial installations and machines, assemblers and drivers:	13.03	11.52	1.51	1
– maintenance of industrial installations and stationary equipment	3.19	2.01	1.18	1
– assemblers	0.26	0.18	0.08	1
– drivers and operators of mobile equipment	9.58	9.33	0.25	1
Unskilled workers:	7.57	4.03	3.54	1
– servants and cleaners	1.64	0.07	1.57	1
– agriculture and forestry, fish farming and fishing	0.55	0.39	0.16	1
– mining, construction, manufacturing and transportation	2.01	1.31	0.70	1
– food preparation assistants	0.19	0.02	0.17	1
– street vendors and other types of street services	0.01	0.002	0.01	1
– garbage collection and other unskilled workers	3.17	2.24	0.93	1

As part of the digitalization of labor protection, a promising direction is the development of software for system analysis and assessment of occupational risks, taking into account the probability of infection with COVID-19 [16]. The modern domestic market in this area is represented by the following development companies: RiskProf

service (information and analytical portal "Labor Protection"), the program "Professional Risk Assessment System" (ARM SERVICE group of companies, Samara), the software product "Professional Risk Management System" (Inform Center LLC, Perm Krai), the HSE RMS cloud service for working with professional risks (HSE Lab, Moscow), the Professional Risk Assessment program (Institute of Occupational Safety, Moscow), the Professional Risk Management System program (System Soft LLC, Moscow), the SoftExpert company (SoftExpert ERM software "Enterprise Risk Management"). The largest foreign companies that develop software for assessing professional risks are Vigilant Software (vsRisk), PTA Technologies (PTA), Archer (RSA Archer), Modulo (Modulo Risk Manager), RM Studio, Digital Security.

The main elements of the assessment of the risk of infection of employees with COVID-19 (relative to the structure of the general assessment of occupational risks) are:

1. Objects of assessment (workplace, work activity, emergency situation).

2. Characteristics of hazards (according to paragraph 35 of Order of the Ministry of Labor of 19.08.2016 No. 438n "On approval of the Standard Regulation on the Occupational Health and Safety Management System").

3. Assessment of the probability of occurrence and severity of consequences (potential triggers are taken into account, the correlation of risks by the source of danger).

4. Risk ranking.

5. Development of measures to reduce the level of risk + personal response strategies (with an indication of deadlines and responsible persons).

The regulatory and legal regulation of labor protection for the period of an unfavorable epidemiological situation is at the stage of active development, some draft laws have already been adopted. The prospects for further developments on the issue under consideration are the introduction of an effective occupational health and safety management system in organizations, taking into account the effectiveness of their practical application.

The authors propose the following scheme for improving the occupational health and safety management system, taking into account the risk-oriented approach:

1. Development of an effective risk management structure: development of the organization's anti-epidemic policy and local documents (orders, regulations, programs, instructions), appointment of responsible persons for the implementation of preventive measures based on the management structure, the amount of resources and the official powers of employees.

2. Digitalization and introduction of end-to-end technologies in labor protection:

2.1. Automation of control systems for the issuance and operation of personal protective equipment (vending machines for PPE, monitoring scanning of violations during the operation of PPE by employees).

2.2. Introduction of augmented and virtual reality technologies in occupational safety training.

2.3. Introduction of machine learning and artificial intelligence technologies.

3. Development of a flexible labor organization system (optimization of the labor process schedule):

3.1. Introduction of remote work mode for employees who are at high risk.

3.2. Implementation of a time management system, taking into account the effective distribution of work shifts to achieve minimal employee contact.

3.3. Development of an emergency program for switching to remote operation.

4. Optimization of social protection of employees (development of a system of remuneration during the spread of infections, protection from social discrimination and stigmatization).

5. Development of employee wellness programs:

5.1. Organization of detoxification nutrition.

5.2. Implementation of projects for the development of healthy lifestyle, physical culture and sports for employees.

5.3. Protection of psychological health (trainings).

6. Improvement of the system of medical supervision of employees in order to identify physical or psychological pathology affecting the performance of professional duties: thermometric control, testing for the presence of infection and organization of vaccination at the enterprise.

7. Organization of collective antiviral protection of the air environment (antibacterial ventilation/air conditioning and air disinfection).

8. Correlation of occupational risk assessment taking into account the risk of infection of employees (introduction of an electronic system for recording cases with risk calculation).

9. Inclusion of the emergency preparedness procedure in the emergency management system. Development of a personal response strategy.

Conclusion:

1. The employer's obligation to ensure and maintain safe working conditions at the legislative level is fixed in Article 212 of the Labor Code of the Russian Federation. Currently, the risk of coronavirus infection and the risk of death exceed an acceptable level (10-6), which causes the mandatory introduction of deterrent measures. Due to the spread of coronavirus infection, the nomenclature of principles for creating safe working conditions includes the prevention of potential infection of employees with COVID-19, the implementation of which is checked by Rostechnadzor and the State Labor Inspectorate in accordance with current regulatory requirements.

2. During the pandemic, employers have faced the problem of effective assessment and management of occupational risks in the workplace. To ensure the safe functioning of the organization, it is necessary to conduct an early and further operational assessment of occupational risk, taking into account epidemiological circumstances.

3. The level of risk of COVID-19 infection may vary within one organization, so a risk assessment should be made for each workplace, taking into account specific working conditions and the presence of actual and potential hazards. In addition, when conducting an individual risk assessment, it is necessary to take into account the probability of a severe disease due to age and the existing diseases.

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