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# OCCUPATIONAL RISKS OF FIREFIGHTERS: COMPARATIVE ANALYSIS OF WORKING CONDITIONS DURING URBAN AND FOREST FIREFIGHTING

*Abstract*

The relevance of the study is determined by the increase in the intensity and complexity of various types of fires, accompanied by an increase in occupational risks for firefighters and requiring a differentiated scientific analysis of the conditions of their activities. The purpose of the article was to conduct a comparative analysis of the occupational risks of firefighters, taking into account the specifics of working conditions during the elimination of urban and forest fires and identifying threats to their physical and mental health. The methodological basis of the study was comparative and systematic analysis, analysis and synthesis of scientific publications, generalization of empirical data from medical, physiological, and psychological studies of firefighters, as well as analytical comparison of professional activity conditions depending on the type of fire. The study found that the occupational risks of firefighters are multi-component and cumulative in nature and are influenced by physical, chemical, psychophysiological, and organizational and technical factors. It was found that urban fires are characterized by peak thermal and psycho-emotional stress, increased toxicological complexity of combustion products, and a high level of responsibility for the safety of the civilian population. In contrast, forest fires involve prolonged physical stress, severe heat stress, autonomy of action, and chronic lack of recovery. Empirical data confirm differences in the profiles of

health risks for firefighters, particularly with regard to the development of heat disorders, respiratory disorders, and stress-induced mental states. It is justified that the recurrence and duration of exposure to harmful factors cause long-term negative consequences for the occupational health of personnel. The practical significance of the results lies in the possibility of using them to develop differentiated approaches to occupational risk management, improve the occupational safety system, work and recovery regimes, as well as medical and psychological support programs for firefighters depending on the type of fire.

*Keywords*

Physical exertion, severe heat stress, autonomy of activity, lack of recovery, medical and psychological support programs.

*Introduction*

The current conditions for the functioning of civil protection services are characterized by an increase in the number and complexity of fire emergencies, which is caused by intensive urbanization, climate change, increased technogenic load, and degradation of natural ecosystems [1]. In these conditions, the professional activities of firefighters are characterized by a high level of risk to life and health, which necessitates an in-depth scientific analysis of the factors of danger and working conditions during the elimination of various types of fires [2]. Of particular relevance is the study of the specifics of occupational risks in the context of urban and forest fires, which differ significantly in terms of their nature of development, dynamics, spatial organization, and the combination of influential harmful factors.

Urban fires are usually accompanied by the threat of structural collapse, explosions, the influence of toxic combustion products, and difficult conditions for evacuating the population, while forest fires are characterized by their scale, prolonged physical stress, limited access to resources, the impact of high

temperatures in open areas, and the unpredictability of the direction of the fire [3]. Despite the obvious differences between these environments, scientific research often lacks a systematic comparative approach to analyzing firefighters' working conditions, which complicates the development of effective models for managing occupational risks and measures to prevent negative consequences for personnel [4].

*Literature Review*

In the scientific database dedicated to the safety and health of firefighters, there is a clear trend toward detailing individual components of occupational risk – from organizational factors of unit operations to physiological reactions to heat stress and toxicological exposure. Thus, in a study by L. Moore-Merrell et al. [1] convincingly showed that the number of guards is not only a management parameter, but also a factor directly related to the level of safety in performing tasks and the likelihood of adverse health effects. The authors emphasize that insufficient staffing of a unit can increase the individual workload on firefighters, reduce tactical flexibility, and complicate the simultaneous execution of critical operations at a fire. As a result, the study draws an important conclusion: organizational decisions regarding the composition of the unit are indirectly converted into physiological and operational stress, and therefore into risks of injury and overload for personnel.

The issue of functional performance after exposure to extreme conditions is specified in the work of K. E. Games et al. [2], which focuses on how the combination of physical load and unfavorable environmental parameters affects the performance of motor and applied tasks. The results demonstrate that after exposure to “fire” loads, firefighters' functional performance declines, which has a direct impact on safety in dynamic situations. It is important to note that this is not just about subjective fatigue, but about changes that can impair the efficiency and

accuracy of work at a time when the risk of errors depends on motor control and reaction speed.

The issue of recovery after firefighting as a critical link in maintaining occupational health is explored in depth in a study by G. P. Horn et al. [3]. The authors show that physiological recovery does not automatically end after the active phase of work has ceased: even during the rehabilitation period, elevated stress indicators and signs of incomplete return to the initial state may persist. This is fundamental for risk assessment, because in the context of repeated deployments, “non-recovery” becomes a cumulative mechanism – it can increase the body's vulnerability to heat stress, dehydration, and cardiovascular complications during subsequent operations. Thus, the study substantiates that the risks to firefighters are determined not only by the peak of exposure, but also by the quality and adequacy of recovery between work episodes.

The specifics of energy expenditure and heat load in natural fires are detailed by J. S. Cuddy et al. [4], who demonstrate that it is the work patterns (mode, pace, distribution of effort over time) that determine the level of energy requirements and thermal stress in forest firefighters. The conclusions of this work emphasize that natural fires are characterized not so much by short-term intensity as by the long-term “cost” of work, which accumulates and is exacerbated by limited opportunities for rest and rehydration. The results obtained actually explain why, in the context of forest fires, health risks often manifest themselves through exhaustion and heat disorders: prolonged operations create a consistently high level of physiological stress that is difficult to compensate for with standard short breaks.

The toxicological assessment of occupational risks for firefighters has been thoroughly examined by K. W. Fent et al. [5], who empirically prove the significance of dermal exposure to polycyclic aromatic hydrocarbons (PAHs) during firefighting. Their results emphasize that contact with combustion products

is not limited to inhalation, and that contamination of the skin and equipment can be an additional channel for harmful substances to enter the body. This shifts the focus of risk management: along with protecting the respiratory system, decontamination procedures, equipment handling, and control of secondary transfer of contaminants, which is directly related to long-term health risks.

A separate area of risk in wildfires is reflected in the work of K. M. Navarro et al. [6], which emphasizes that intense smoke exposure in forest firefighters poses an additional danger in the context of respiratory threats, particularly during pandemic challenges. The authors demonstrate that the risk profile of forest firefighters can be complicated by the "overlap" of factors: prolonged smoke inhalation creates vulnerability in the respiratory system, which under certain conditions exacerbates the potential negative effects of infectious agents and respiratory complications. As a result, the study broadens the understanding of the risks of forest fires not only as thermal and physiological, but as complex medical and environmental threats that are relevant in modern conditions.

Despite substantial evidence regarding certain aspects of occupational risk, there are still a number of gaps in the scientific literature that complicate the development of comprehensive and differentiated approaches to occupational safety for firefighters [1-6]. Empirical data on physiological recovery, functional working capacity, and heat stress are presented without a systematic comparison of urban and forest contexts, although it is the type of fire that determines the duration of the operation, the availability of resources, and the nature of the hazards.

*The purpose of the article* was to conduct a comparative analysis of the occupational risks of firefighters, taking into account the specific conditions of their work during the elimination of urban and forest fires.

*Research Results*

The professional activities of firefighters are classified as high-risk work due to the specific nature of their tasks in emergency situations involving fire, high temperatures, and combustion products. The impact of hazardous and harmful factors during firefighting is complex, cumulative, and mutually reinforcing, as firefighters are simultaneously exposed to several risk factors of different nature [7] (Table 1). These factors arise from a combination of physical, chemical, biological, psychophysiological, and organizational and technical conditions of professional activity, which significantly complicates the process of ensuring occupational safety and preserving the health of personnel. Awareness of the multifactorial nature of risks is a necessary prerequisite for their further scientific analysis and justification of effective preventive measures.

Physical hazards are among the key factors in the occupational risks faced by firefighters, as they are directly formed by the physical environment of a fire and have an intense impact on the functional state of the body [10]. The effects of high temperatures and heat radiation lead to significant disruption of thermoregulation processes, increased heat load, and rapid depletion of the body's physical resources. Prolonged exposure to heat combined with limited heat dissipation due to the use of personal protective equipment increases the risk of overheating, heat stroke, and burns, which negatively affects the endurance, reaction speed, and accuracy of a firefighter's movements [11]. An additional complicating factor is smoke and limited visibility, which disrupt spatial orientation, increase the likelihood of injury, and complicate the coordination of actions within the unit [3]. Increased noise levels from equipment, explosions, or structural collapse create additional sensory overload and reduce the effectiveness of command perception. The danger of building elements collapsing in urban fires or trees and branches falling during forest fires creates a constant threat of sudden injury, forcing firefighters to work in conditions of increased stress and limited mobility [4].

Table 1

Main hazardous and harmful factors in the professional activities of firefighters and their impact on the functional state of the body

| Group of factors | Characteristics of impact | Main manifestations and risks for firefighters |
|---|---|---|
| Physical factors | Formed by the immediate physical environment of the fire and act intensively throughout the entire period of liquidation | Disruption of thermoregulation due to high temperatures and heat radiation; risk of burns, overheating, and heat stroke; decreased endurance and accuracy of movements; impaired spatial orientation due to smoke and limited visibility; increased risk of injury due to collapsing structures or falling trees |
| Chemical factors | Caused by inhalation of combustion products and toxic substances of various origins | Acute hypoxic conditions, respiratory dysfunction, decreased performance; cumulative toxic effect with repeated participation in firefighting; increased risk of chronic diseases of the respiratory and cardiovascular systems; different chemical structure of harmful substances depending on the type of fire |
| Psychophysiological factors | Arise from a combination of physical exertion, stress, and high responsibility | Increased psycho-emotional tension; the need to make decisions in conditions of time and information deficit; the development of chronic stress and professional burnout; sleep disturbances, decreased concentration and cognitive functions; increased likelihood of errors in actions |
| Organizational, technical, and ergonomic factors | Determined by the conditions of the service organization, technical support, and the nature of interaction within the unit | Uneven workload and long shifts; fatigue buildup due to insufficient recovery time; limited maneuverability in difficult terrain; communication risks within the team; equipment that does not match the anthropometric and functional capabilities of firefighters |

Source: compiled by the author based on [8; 9]

A significant component of occupational risk is chemical hazards associated with inhalation of combustion products and toxic substances. When extinguishing fires, firefighters are exposed to carbon monoxide, fine particles, volatile organic compounds, and carcinogenic substances, which, even when using respiratory protection equipment, can partially penetrate the body [7]. Acute exposure to such substances causes respiratory dysfunction, hypoxic conditions, headaches, and reduced performance, while repeated or prolonged exposure has a cumulative effect and increases the risk of developing chronic diseases of the respiratory and cardiovascular systems. The diversity of combustion products depending on the fire environment poses a particular danger: in urban areas, this is due to the combustion of synthetic materials and chemical compounds, while in forest fires, smoke from organic biomass dominates, which also has a harmful effect, but with a different chemical structure [6]. Thus, chemical factors pose not only an immediate health threat, but also long-term negative consequences that are often underestimated.

No less significant are the psychophysiological factors that determine the psychological stability and cognitive efficiency of firefighters in the process of performing their professional tasks [12]. Firefighting takes place in conditions of high psycho-emotional stress associated with real risk to life, responsibility for the safety of the civilian population and team members, as well as the need to make quick decisions when time and information are scarce. Chronic exposure to stressors contributes to the development of psycho-emotional exhaustion, professional burnout, and a decrease in the ability to concentrate [13]. Sleep disturbances, irregular work shifts, and prolonged physical exertion further impair cognitive functions, which can lead to errors in actions and an increased risk of injury. The combination of intense physical exertion and constant psychological stress pushes the body to its limits, where even minor external influences can have critical consequences for the safety of task performance [14].

Organizational, technical, and ergonomic factors also play a significant role in shaping the occupational risks of firefighters, as they determine the conditions and effectiveness of their activities. Uneven workloads, long shifts, and insufficient time for recovery lead to fatigue and reduced functional readiness [15]. Difficult access to the scene of a fire and limited maneuverability in dense urban areas or rough terrain complicate the execution of tactical tasks and increase physical exertion. An important aspect is the quality of teamwork and effective communication, as any failures in the transmission of information in conditions of increased noise and stress can have critical consequences [8]. In addition, the incompatibility of equipment with the anthropometric and functional capabilities of firefighters negatively affects mobility, accuracy of actions, and speed of response, which together exacerbates the impact of other dangerous and harmful factors.

The conditions of firefighters' professional activities are determined not only by the type of fire, but also by a combination of spatial, infrastructural, and organizational characteristics of the environment in which the emergency is being responded to [16]. It is the environment in which the tasks are performed that determines the specifics of tactical actions, the level of technical support, the intensity of physical and psycho-emotional stress, and the degree of risk to the life and health of personnel. Urban and forest environments differ significantly in terms of the density of objects, resource availability, operational management capabilities, and the nature of fire development, which determines the formation of fundamentally different models of professional activity for firefighters [10]. In these conditions, effective performance of tasks requires firefighters to have different levels of mobility, autonomy, and tactical adaptation, as well as the ability to quickly change their strategy according to the dynamics of the fire situation.

The conditions of professional activity of firefighters in urban environments and when extinguishing forest fires differ significantly in terms of spatial, infrastructure, and organizational parameters, which determines the different nature of the performance of official duties and the level of professional workload [4]. The urban environment is characterized by high building density, the presence of multi-story and underground structures, complex engineering infrastructure, and a significant concentration of population, which necessitates the simultaneous solution of tasks such as firefighting, evacuation of people, and interaction with other emergency services. In such conditions, firefighters are forced to operate in a confined space, under conditions of rapidly changing circumstances and an increased risk of sudden structural collapses, explosions, or damage to communications, which requires a high level of tactical coordination and precision of actions [6].

In contrast, when fighting forest fires, firefighters work in an open natural environment, which is characterized by significant areas of fire spread, unpredictable fire direction, and strong dependence on meteorological and landscape conditions [7]. In such circumstances, the mobility and autonomy of units, as well as their ability to work for long periods of time with limited access to water, equipment, and means of communication, become key factors. Long marches across rough terrain, high temperatures in open spaces, and the need for continuous monitoring of wind direction changes significantly increase the physical load and level of exhaustion of firefighters [8].

A comparative analysis shows that infrastructure and technogenic factors play a leading role in urban environments, while natural and climatic conditions dominate in forest firefighting [6] (Table 2). In cities, risks are often local but highly concentrated and related to limited space and the presence of civilians, while forest fires require operations that are extended in time and space, requiring prolonged physical endurance and autonomous decision-making.

Table 2

Comparative characteristics of the conditions of professional activity of firefighters in urban environments and when extinguishing forest fires

| Comparison criterion | Urban environment | Forest fires |
|---|---|---|
| Spatial organization of work | Limited space, dense buildings, multi-storey and underground structures | Open spaces, large areas of ignition, rugged terrain |
| Nature of fire development | Rapid local escalation, complex internal dynamics | Spread over long distances, dependence on wind and terrain |
| Infrastructure conditions | Presence of engineering networks, transport infrastructure, man-made objects | Limited or no infrastructure, complex logistics |
| Access to resources | Relatively quick access to water, equipment, and reinforcements | Limited access to water, equipment, and material resources |
| Level of autonomy of subdivisions | Low or medium, high centralization of management | High level of autonomy, long-lasting independent operation |
| Physical exertion | Intense, but often short-term | Long, exhausting, with high demands on endurance |
| Psycho-emotional load | High due to the presence of civilians and the risk of mass casualties | High due to the duration of operations and uncertainty of fire development |
| Coordination | Close coordination with other emergency and municipal services | Interregional or interagency coordination, decentralization of forces |
| Main occupational risks | Collapse of structures, explosions, toxic combustion products | Overheating, physical exhaustion, sudden changes in the direction of fire |
| Tactical requirements | High precision of actions, quick adaptation in confined spaces | High mobility, flexibility, and autonomous decision-making |

Source: compiled by the author based on [12; 14]

At the same time, both types of environments are united by the highly dynamic nature of the fire situation, which forces firefighters to constantly adapt their tactics and work in conditions of increased professional risk [4].

The specific characteristics of the stresses and threats to the health of firefighters vary significantly depending on the type of fire, as urban and forest fires create different profiles of physiological, toxicological, and psycho-emotional effects [4]. In an urban environment, work is often characterized by shorter duration but peak in intensity episodes of physical exertion, combined with severe heat stress in personal protective equipment and the need to perform complex maneuvers in confined spaces. Empirical data from studies of repeated firefighting cycles show that during several hours of operation, the body temperature of firefighters can increase by an average of almost 2 °C and continue to rise even between work cycles, despite relatively long breaks, indicating incomplete recovery of thermoregulatory mechanisms and accumulation of heat load [7]. In practical terms, this means an increased risk of heat exhaustion, impaired movement accuracy and reaction speed, as well as an increased likelihood of errors in tactical actions at critical moments.

For forest fires, a more typical scenario is prolonged submaximal exertion with high demands on endurance, autonomy, and the ability to maintain performance over a long period of time [8]. Field observations of work during the extinguishing of natural fires show that the average heart rate can reach approximately 150 beats per minute, and body temperature can reach approximately 38°C when working with hand tools in hot weather, which reflects the significant physiological cost of such operations [12]. Against this background, the key risk mechanism is the combination of heat stress with dehydration and limited access to restorative resources, which increases the risk of cardiovascular complications, heat disorders, and overall functional instability of units in the final phases of prolonged operations.

The toxicological profile of hazards also has fundamental differences. In urban fires, the burning of synthetic materials and complex composites plays a significant role, accompanied by the formation of toxic and potentially carcinogenic compounds, as well as fine particles [13]. Empirical studies of firefighters' exposure during controlled structural fires record a statistically significant increase in benzene exposure after work, as well as an increase in polycyclic aromatic hydrocarbon contamination on skin areas (particularly in the neck area) and links between external pollutant concentrations and internal dose biomarkers [15]. This is important for substantiating that the health risk is formed not only through inhalation, but also through dermal contamination and the subsequent cumulative effect of repeated trips, which increases the long-term threats to respiratory health and potential oncological risks. Similarly, empirical data from field measurements in firefighters confirm the presence of skin, equipment, and work environment with carcinogenic polycyclic aromatic hydrocarbons (PAHs), which highlights the importance of decontamination procedures and reducing contact with combustion products as risk management elements [17].

For forest fires, despite the different chemical profile of smoke (dominated by biomass combustion products), the critical factor is the duration of inhalation exposure and the repetition of exposure over many hours or days [12]. In such conditions, health risks are more likely to manifest themselves through the accumulation of irritating and inflammatory effects on the respiratory tract, which requires an emphasis on long-term medical observation, prevention, and recovery standards, rather than just controlling acute symptoms [10].

A separate layer of threats is formed by psychophysiological stress, which depends on the context of the fire and the structure of operations. In an urban environment, psycho-emotional pressure is exacerbated by the need for evacuation, the high probability of contact with traumatic events, and

responsibility for the lives of civilians and colleagues in a situation of rapidly escalating risks [5]. In forest fires, on the other hand, a chronic stress profile is more common, associated with the duration of operations, sleep deprivation, uncertainty about the development of the fire, and prolonged tension against a backdrop of physical exhaustion. Empirical studies in the field of mental health of rescuers confirm that post-traumatic symptoms are a common problem among firefighters, and meta-analyses indicate a significant proportion of individuals with probable post-traumatic stress disorder (PTSD) in this occupational group; In particular, global samples report estimates of around 12% for firefighters in the context of routine occupational exposure, which highlights the systemic nature of the problem [3]. Importantly, psychophysiological risks have a direct operational dimension: experimental data on modeling the extinguishing of natural fires in very hot conditions show a deterioration in cognitive functions after working in the heat compared to a moderate environment, i.e., heat stress and fatigue can reduce the quality of decision-making precisely when it is critically needed [5]. In addition, survey data from a large sample of firefighters involved in extinguishing wildfires demonstrate that the vast majority of respondents identify heat stress as one of the main threats during such operations, confirming the practical significance of the problem and its perception by personnel as systemic.

In summary, it can be argued that urban fires form a more peaky load profile with pronounced technogenic uncertainty, high toxicological complexity, and acute psychoemotional triggers, while forest fires more often create a prolonged risk profile dominated by physical exhaustion, heat stress, repeated inhalation exposure, and chronic recovery deficit [7]. Accordingly, empirical data support the conclusion that a unified model of occupational safety and medical and psychological support is not appropriate: different types of fires require differentiated approaches to work and recovery regimes, decontamination

procedures, thermal load control, as well as psychological support programs and prevention of stress-induced disorders [8].

*Conclusions*

The analysis showed that firefighters' professional activities are carried out in conditions of increased and multi-component risk, the structure and intensity of which significantly depend on the type of fire and the environment in which it is extinguished. It has been established that hazardous and harmful factors are complex and cumulative in nature, resulting from the interaction of physical, chemical, psychophysiological, and organizational and technical working conditions, which directly affect the functional state and health of firefighters.

It has been established that the conditions of professional activity in an urban environment and when extinguishing forest fires form fundamentally different models of stress. Urban fires are characterized by high intensity of short-term physiological and psycho-emotional influences, increased toxicological complexity of combustion products, and significant responsibility for the safety of the civilian population, while forest fires are characterized by prolonged physical exertion, heat stress, autonomy of actions, and limited opportunities for rapid recovery.

Empirical data used in the study confirm that these differences result in different health risk profiles for firefighters. In urban environments, acute thermal and toxicological risks dominate, as well as stress-induced disorders associated with extreme events, while in forest firefighting, the risks of chronic fatigue, dehydration, respiratory disorders, and cumulative psycho-emotional exhaustion are more pronounced. This indicates the systemic nature of the impact of occupational stress and its long-term consequences for the physical and mental health of personnel.

Prospects for further research are related to an in-depth quantitative analysis of the impact of individual risk factors, the development of integrated models for

assessing occupational stress, and empirical testing of the effectiveness of specialized programs for the prevention and preservation of firefighters' health in various professional settings.

*References*

1. Alexandrov, Y. V. (2020). Features of professional activity of fire-fighters-rescuers of the State Emergency Service of Ukraine and their psychological analysis. Personality, Society, Law, 175–178. https://dspace.univd.edu.ua/server/api/core/bitstreams/45a74527-22b5-4685-9208-5c37b96998b3/content

2. Babenko, M. (2024). Socio-psychological factors of professional self-realization development of future fire safety specialists. In Problems of psychology of activity in special conditions: Proceedings of the II All-Ukrainian Scientific and Practical Conference (pp. 1–350). Kyiv: 7BC. https://files.znu.edu.ua/files/Bibliobooks/Inshi79/0059548.pdf

3. Cuddy, J. S., Sol, J. A., Hailes, W. S., Ruby, B. C., & Hargens, A. R. (2015). Work patterns dictate energy demands and thermal strain during wildland firefighting. Journal of Occupational and Environmental Hygiene, 12(9), 632–640. https://doi.org/10.1080/15459624.2015.1043058

4. Fent, K. W., Eisenberg, J., Evans, D., Sammons, D., Robertson, S., Striley, C., & Kerber, S. (2014). Evaluation of dermal exposure to polycyclic aromatic hydrocarbons in firefighters. Journal of Occupational and Environmental Hygiene, 11(10), 699–711. https://doi.org/10.1080/15459624.2014.935269

5. Fent, K. W., Evans, D. E., Booher, D., Pleil, J. D., Stiegel, M. A., Horn, G. P., & Dalton, J. (2015). Volatile organic compounds off-gassing from firefighters' personal protective equipment ensembles after use. Journal of Occupational and Environmental Hygiene, 12(6), 404–414. https://doi.org/10.1080/15459624.2015.1025135

6. Games, K. E., Winkelmann, Z. K., McGinnis, K. D., McAdam, J. S., Pascoe, D. D., & Sefton, J. M. (2020). Functional performance of firefighters after exposure to environmental conditions and exercise. Journal of Athletic Training, 55(1), 71–79. https://doi.org/10.4085/1062-6050-75-18

7. Groot, E., Cuddy, J. S., & Ruby, B. C. (2022). Perceived heat strain and hydration status among wildland firefighters. International Journal of Environmental Research and Public Health, 19(19), 12288. https://doi.org/10.3390/ijerph191912288

8. Horn, G. P., Gutzmer, S., Fahs, C. A., Petruzzello, S. J., Goldstein, E., Fahey, G. C., & Smith, D. L. (2013). Physiological recovery from firefighting activities in rehabilitation and beyond. Prehospital Emergency Care, 17(2), 209-225. https://doi.org/10.3109/10903127.2012.729210

9. Kolesnichenko, O. S. (2011). Psychological readiness of employees of the Ministry of Emergency Situations of Ukraine for professional activity in extreme conditions (Abstract of PhD dissertation). National University of Civil Protection of Ukraine, Kharkiv. https://books.ndcnangu.co.ua/knigi/KOLESNIChENKO_P_G_avtoreferat.pdf

10. Koval, M. S., & Koval, I. S. (2018). General didactic principles of forming professional readiness of future rescuers for activity in extreme conditions. Young Scientist, (12), 95–99. https://doi.org/10.32839/2304-5809/2018-12-64-25

11. Moore-Merrell, L., Kerber, S., Horn, G. P., & Smith, D. L. (2021). Effects of crew size on firefighter health and safety. International Fire Service Journal of Leadership and Management, 15, 7–25. https://d1gi3fvbl0xj2a.cloudfront.net/2021-12/IFSJLM%20Vol15_Horn.pdf

12. Navarro, K. M., Cisneros, R., O'Neill, S. M., Schweizer, D., Larkin, N. K., & Balmes, J. R. (2021). Wildland firefighter exposure to smoke and

COVID-19: A new risk on the fire line. Science of the Total Environment, 760, 144296. https://doi.org/10.1016/j.scitotenv.2020.144296

13. Pokanovych, O. A. (2019). Aspects of forming psychological readiness of firefighter-rescuers for extreme professional activity. Psychological Journal, 5(7), 50–63. https://doi.org/10.31108/1.2019.5.7

14. Salman, A., Sattler, M. C., Jovanović, M., & Marković, S. (2023). Prevalence of post-traumatic stress disorder among firefighters: A systematic review and meta-analysis. Clinical Psychology Review, 101, 102233. https://doi.org/10.1016/j.cpr.2022.102233

15. Skliarova, H., & Surnina, Y. (2025). Risk readiness as a factor of professional realization of workers in high-risk occupations. Scientific Notes of "KROK" University, (2), 512–519. https://doi.org/10.31732/2663-2209-2025-78-512-519

16. Taylor, N. A. S., Dodd, M. J., Taylor, E. A., & Donohoe, A. M. (2017). A retrospective evaluation of heat stress in firefighters. Frontiers in Physiology, 8, Article 815. https://doi.org/10.3389/fphys.2017.00815