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ПРОБЛЕМНЫЕ ВОПРОСЫ МЕДИЦИНСКОЙ СОРТИРОВКИ ПОРАЖЕННЫХ  
ПРИ ТЕРРОРИСТИЧЕСКИХ АКТАХ\*

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**Резюме.** Цель исследования – разработать предложения по совершенствованию методических подходов к организации и выполнению медицинской сортировки пораженных в зоне террористического акта, совершенного с применением обычных средств поражения.

**Материалы и методы исследования.** Материал исследования: нормативные и методические документы, регламентирующие порядок организации и проведения медицинской сортировки пораженных в чрезвычайных ситуациях (ЧС), в том числе при террористических актах; данные карт экспертной оценки по теме исследования; научные работы и публикации, посвященные вопросам медицинской сортировки пораженных в чрезвычайных ситуациях.

При выполнении исследования применялись следующие научные методы: методы контент-анализа и экспертной оценки, статистический метод, метод логического и информационного моделирования, аналитический метод.

**Результаты исследования и их анализ.** Представлены результаты исследования, характеризующие состояние проблемных вопросов организации и проведения медицинской сортировки пораженных при террористических актах.

Внесены обоснованные предложения по совершенствованию методических подходов к порядку организации и выполнения медицинской сортировки и выделения сортировочных групп пораженных в зоне террористического акта.

**Ключевые слова:** зона террористического акта, лечебные медицинские организации, лечебно-эвакуационное обеспечение, медицина катастроф, медицинская сортировка, медицинская эвакуация, методические подходы, обычные средства поражения, пораженные, скорая медицинская помощь, скорая специализированная медицинская помощь, Служба медицины катастроф, террористические акты, чрезвычайные ситуации

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ISSUES OF MEDICAL TRIAGE OF THE WOUNDED IN ACTS OF TERRORISM\*

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**Summary.** The aim of the study is to develop proposals to improve methodological approaches to the organization and performance of medical triage of the injured in terrorists attack committed with conventional means of destruction.

**Materials and research methods.** Normative and methodical documents regulating the order of organizing and carrying out medical triage of the wounded in emergencies, including acts of terrorism; data of expert examination maps; scientific works and publications devoted to the issues of medical triage of the wounded in extreme situations.

The following scientific methods were used while performing the research: content-analysis and expert assessment methods, statistical method, method of logical and informational modeling, analytical method.

**Results of the study and their analysis.** The results of the study, characterizing the state of problematic issues of medical triage of the victims of acts of terrorism, are presented.

\* In this article the issues of medical triage are considered in relation to terrorist acts committed with the use of conventional means of destruction. Conventional means of destruction are weapons that are based on the use of explosives and incendiary mixtures (artillery, missile and aviation ammunition, small arms, mines, incendiary ammunition and flammable mixtures), as well as cold steel weapons and non-standard (home-made) explosive devices

The substantiated proposals on improvement of methodical approaches to the order of organization and performance of medical triage and allocation of sorting groups of the defeated in the terrorist act zone have been made.

**Keywords:** conventional means of destruction, disaster medicine, Disaster Medicine Service, defeated, emergencies, emergency medical aid, emergency specialized medical aid, medical and evacuation support, medical evacuation, medical treatment organizations, medical triage, methodical approaches, terrorist acts, terrorist act zone

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Medical triage — a fundamental organizational measure, the implementation of which creates the conditions for the performance of adequate actions in the organization and provision of emergency, including emergency specialized, medical care in emergency situations (ES) and medical evacuation [1-5]. Its bases were developed by the outstanding Russian surgeon N.I. Pirogov. Medical triage is widely used in disaster medicine and work of the All-Russian Disaster Medicine Service in the liquidation of medical and sanitary consequences of emergencies, including terrorist acts (acts of terrorism) [3, 5-7].

It is mentioned in the majority of guiding and methodical documents, in scientific works, textbooks and manuals, that medical triage is of special importance when a considerable number of emergency victims arrive at the stages of medical evacuation at once. In such conditions only properly organized and properly conducted medical triage can ensure a more rational use of available forces and means, high efficiency of the specialists of medical formations and medical treatment organizations on timely provision of medical care to the injured, as well as the correct conduct of medical evacuation in compliance with the routing principles [1, 3-8].

Virtually no major work devoted to the elimination of medical and sanitary consequences of emergencies, not have considered aspects of the issues of medical triage [2, 3, 6, 7, 9]. Such a situation, on the one hand, emphasizes the great importance and priority of this element in the complex of medical and evacuation measures, but, on the other hand, it indicates that to date there is no complete clarity on this issue.

In view of this, a critical evaluation of accumulated factual material and results of theoretical research, presentation of refined provisions on organization and implementation of medical triage of wounded in the area of a terrorist attack, apparently, will be useful to ensure quality and accessibility of medical care rendered to the wounded.

The authors of this article, presenting it to specialists in disaster medicine, will be grateful to all who will participate in its discussion.

**The aim of the study** is to develop proposals to improve methodological approaches to the organization and implementation of medical triage of the injured, mainly in the area of a terrorist attack committed with the use of conventional means of destruction.

**Materials and methods of research.** Study materials: normative and methodical documents regulating the order

of organization of medical triage of casualties in emergency situations, including terrorist acts committed with the use of conventional means of destruction; data of expert examination maps on the subject of research; scientific works and publications devoted to the issues of medical triage of casualties in extreme situations.

The following scientific methods were applied: content-analysis, expert estimation, statistical method, method of logical and information modeling, analytical method.

**Results of the study and their analysis.**

The results of the study showed that medical triage is crucial not only for the injured who have arrived at the stage of medical evacuation, but also for the injured who are in the emergency zone at the site of a terrorist attack.

In addition, it was found that insufficient attention is paid to this option of medical triage and methodological approaches to its implementation in normative and methodological documents, scientific papers and training manuals. Thus, for example, in the Order of the organization and rendering of medical aid by the All-Russian Disaster Medicine Service 1, including medical evacuation; in the Order of the rendering of emergency, including specialized emergency medical aid 2, as well as in the existing methodological documents this variant of medical triage of the injured in an emergency is not mentioned at all [1, 2, 10].

In this regard, it is reasonable to ask: "What determines the need for medical triage of the injured in the area of a terrorist attack?"

While performing this research and studying the experience of medical specialists of the Emergency Medical Service and the Disaster Medicine Service of the Russian Ministry of Health in the emergency zones of terrorist acts, the main factors requiring organization and performance of medical triage at this stage of elimination of medical and sanitary consequences of an emergency were identified and specified.

These factors were, first of all:

- arrival of a significant number of casualties — usually at one time or within a short period of time;
- need for emergency medical assistance, many of them

<sup>1</sup> Procedure for the organization and provision by the All-Russian Disaster Medicine Service of medical aid in emergency situations, including medical evacuation: Order of the Ministry of Health of Russia from November 6, 2020 №1202n.

<sup>2</sup> Procedure for the provision of emergency, including specialized emergency, medical care: Order of the Ministry of Health of Russia of June 20, 2013 №388n

on life-saving indications, to be rendered immediately after an emergency;

- need for a large proportion of the wounded to receive medical care in a hospital of a medical treatment organization, while for many of the wounded such treatment must be provided as soon as possible after the injury;

- need for proper routing of the wounded, taking into account severity of their condition, nature of injury and prevailing medical and tactical situation;

- need, in order to ensure medical evacuation of the wounded, to provide them with prior medical care that minimizes negative impact of transportation on their condition and compensates for delay in the provision of medical care;
- insufficient quantity of sanitary transport.

The results of the study indicate that the medical specialists of the first-arriving medical emergency team should stick to the following procedure.

The first medical team to arrive is responsible for providing medical aid and has no right to leave the place of emergency until the arrival of other teams from the emergency medical service and relevant task force. If necessary, the doctor determines the place of gathering of the injured, which is agreed with the head of rescue works and which, if possible, should be on a level place or in a nearby building (room) — especially in winter or in bad weather.

Some sources on disaster medicine present similar opinions on the actions of the first-arriving ambulance or EMT team on the scene of a terrorist attack [5, 7].

An algorithm has also been established for the medical triage of casualties at the site of the attack or at the casualty collection point.

When there are a large number or a few casualties, the doctor should initially identify two groups of casualties: stretcher-bearers and walkers. Walking casualties should be separated from the stretcher-bearers, as they may be disruptive to the work of medical personnel with the stretcher-bearers.

Before the arrival of other ambulance or emergency medical services teams, the doctor works with the stretcher-bearers, sorting them selectively by quick examination (interview) in order to identify the patients in need of emergency medical aid; by urgent indications — those in need of cardiopulmonary resuscitation, stopping external bleeding, with signs of shock and blood loss, asphyxia, with visible defects and severed limbs, convulsive states, etc. In this case, priority is given to children and pregnant women.

After that, appropriate emergency medical appointments are determined and carried out, aimed at maintaining vital functions in the affected persons.

The medical staff then proceeds to the sequential examination of the casualties, seeking, if possible, to quickly assign them to five triage groups.

It should be understood that triage is not the provision of medical care or medical evacuation, but an organizational activity that contributes to the timely provision of medical care and rational medical evacuation of the casualties. Therefore, the medical triage should not delay either the provision of medical care or the medical evacuation [3, 5-7].

The first group are the casualties requiring emergency medical assistance at the site of the terrorist attack. These are, first of all, the wounded who are in an extremely grave condition with severe impairment of vital functions. Such persons need medical care, which should be provided immediately, immediately, and for many of the victims it is

necessary for vital indications. After emergency medical aid is provided to the victims of this triage group, they must first be medically evacuated by ambulance (helicopter, ambulance, mainly by reanimobile) to a designated medical treatment facility.

When an attack occurs outside a city (a major population center) or at a considerable distance from it, and medical evacuation of casualties is carried out by ambulances, the casualties in serious condition are taken, as a rule, to the nearest hospital.

The second group is those with severe injuries or moderate injuries that are not immediately life-threatening. If necessary, they are provided with emergency medical aid. These casualties are subject to primary evacuation by ambulance to a hospital facility.

The third group is those with injuries of moderate severity and not acutely expressed functional disorders or without them. These casualties are sent by ambulance transport to the medical organization in the second turn, as a rule, without medical care.

Attention should be paid to the fact that in this triage group there may be persons with relatively unsevere somatic pathology, most prone to psychopathic reactions with active hysterical and sometimes panic manifestations. Their early medical evacuation from the terrorist attack zone and hospitalization will contribute to the preservation of social stability in a public situation.

The fourth group is those with minor injuries (lightly wounded), who do not need emergency or urgent medical care. If necessary, they can perform individual medical aids — application of sterile or immobilization bandages, simple splints, administration of anesthetics, etc. Such patients are referred to outpatient treatment at the place of residence.

It should be borne in mind that, at the very beginning of work in the emergency zone, all measures must be taken to separate this group of casualties, together with the walkers, from those in need of hospital treatment, mainly stretcher-bearers.

The fifth group is those who died in the area of the terrorist attack. The bodies of the dead remain for a short time at the site of the terrorist attack until the necessary operational-investigative actions are performed. After that they are transported in the prescribed manner to the forensic (pathology and anatomy) laboratory (department).

It should be noted that during the elimination of medical and sanitary consequences of terrorist attacks, as well as in other emergencies, in the terrorist attack zone (outside the medical organization) the group of "non-transportable" is not distinguished among the affected. They are all subject to medical evacuation to the appropriate hospital in accordance with the principles of routing.

The study has shown that such a procedure for distributing the wounded according to their group affiliation, determining and performing the corresponding actions takes place especially often at the initial stage of elimination of medical and sanitary consequences of a terrorist attack, when due to the shortage of medical forces and evacuation means there are cases of forced delay in providing medical care and reducing its volume for those who have not been identified as having disorders of vital functions. To this circumstance authors of some scientific and educational-methodical works [5, 7] pay attention.

Taking into account the above, we can conclude that the medical triage of the wounded in the area of a terrorist at-

tack is performed mainly on the basis of two leading characteristics that allow the distribution of the wounded into sorting groups.

The first criterion is based on the need for medical aid, the place and the priority of its provision:

- those in need of emergency medical care at the site of the terrorist attack — first or second priority;
- those in need of medical care and treatment in the inpatient unit;
- those in need of outpatient treatment at their place of residence.

If, at the site of the terrorist attack, persons with injuries (wounds) incompatible with life are identified among the victims, as mentioned above, they are subject to medical evacuation to the nearest hospital. When carrying out medical evacuation of such wounded from the terrorist attack zone by helicopter, they can be delivered not only to the nearest medical organization, but also, subject to indications, mainly to higher level medical organizations located at a considerable distance from the terrorist attack site.

The second feature — based on the expediency of evacuation, type of transport, sequence and method of transportation:

- those subject to medical evacuation to medical organization (by which transport; in which turn — first or second; lying down or sitting down);
- not in need of medical evacuation and subject to referral for outpatient treatment at the place of residence.

The degree of statistical significance of the obtained results of the study concerning the technology of performing medical triage of the injured was determined by means of expert evaluations. The results showed that 95.3% of the experts agreed with the proposed organizational and methodological approaches to the medical triage of the victims of terrorist attacks performed in the pre-hospital period; 4.7% of the experts found it difficult to give a specific assessment of these proposals.

Consequently, the results of the expert evaluation of the proposed technology for organizing and conducting medical triage in the area of a terrorist attack indicate the advisability of introducing these proposals into the relevant regulatory and methodological documents in the form of additions.

When studying the experience of eliminating medical and sanitary consequences of terrorist attacks, it was found that the medical evacuation of the injured from the emergency zone can be carried out to one or more medical organizations. As an example, the organization of medical evacuation of the wounded to several medical organizations during the liquidation of the medical and sanitary consequences of the terrorist attack in Moscow (figure).

It turned out that such an organizational decision mainly depends on: number of wounded and its structure; their contingent; state of the medical organization infrastructure and their specialization; availability of "free" hospital beds of the corresponding profile, especially specialized ones; opportunities of medical assistance; location of medical treatment organizations in relation to the site of the attack (city, suburban area, at a considerable distance from a major population center).

If medical evacuation is carried out to a single hospital facility, the medical triage mainly identifies the casualties requiring emergency medical assistance at the scene (at the point of collection of the casualties, before their transport-

tion) taking into account the priority of its provision.

The next task of medical triage in the above case is the distribution of the wounded according to evacuation needs, i.e. in what turn and in what position the wounded should be in the ambulance during medical evacuation.

If the medical evacuation of the wounded from the terrorist attack zone was to be performed to several medical organizations, the study showed that one of the main and very difficult tasks of medical triage was to determine the prognostic evacuation assignment, depending on the nature and severity of the injury (wounding): in which medical organization; in which turn; by what mode of transport; in what position during transportation.

In addition, it was found that the effective implementation of the established evacuation purpose is possible only if certain conditions are met: presence of good communication, clear organization of the work (promptly, timely, uninterrupted) availability of dispatching service, as well as the clear and prompt work of the relevant health authorities to make decisions on the distribution of the affected people in medical treatment organizations, on sufficient (required) number of medical brigades and vehicles.

It should be recognized that it is not always possible to fully implement the triage conclusion and the decision on the distribution of the affected persons.

For example, E.M. Luk'yanchuk notes that during the liquidation of the medical and sanitary consequences of the explosion in a trolleybus in Moscow on Prospekt Mira, by order of the Department of Health of Moscow, all the injured (28 people) had to be sent to the Research Institute of Emergency Care named after N.N. Sklifosovskiy. But the reality proved to be different. Twenty-four persons were hospitalized in the Research Institute of Emergency Care named after N.N. Sklifosovskiy; two persons were hospitalized in municipal clinical hospitals <sup>1</sup>33 and 20, i.e. three medical treatment organizations were actually involved [11].

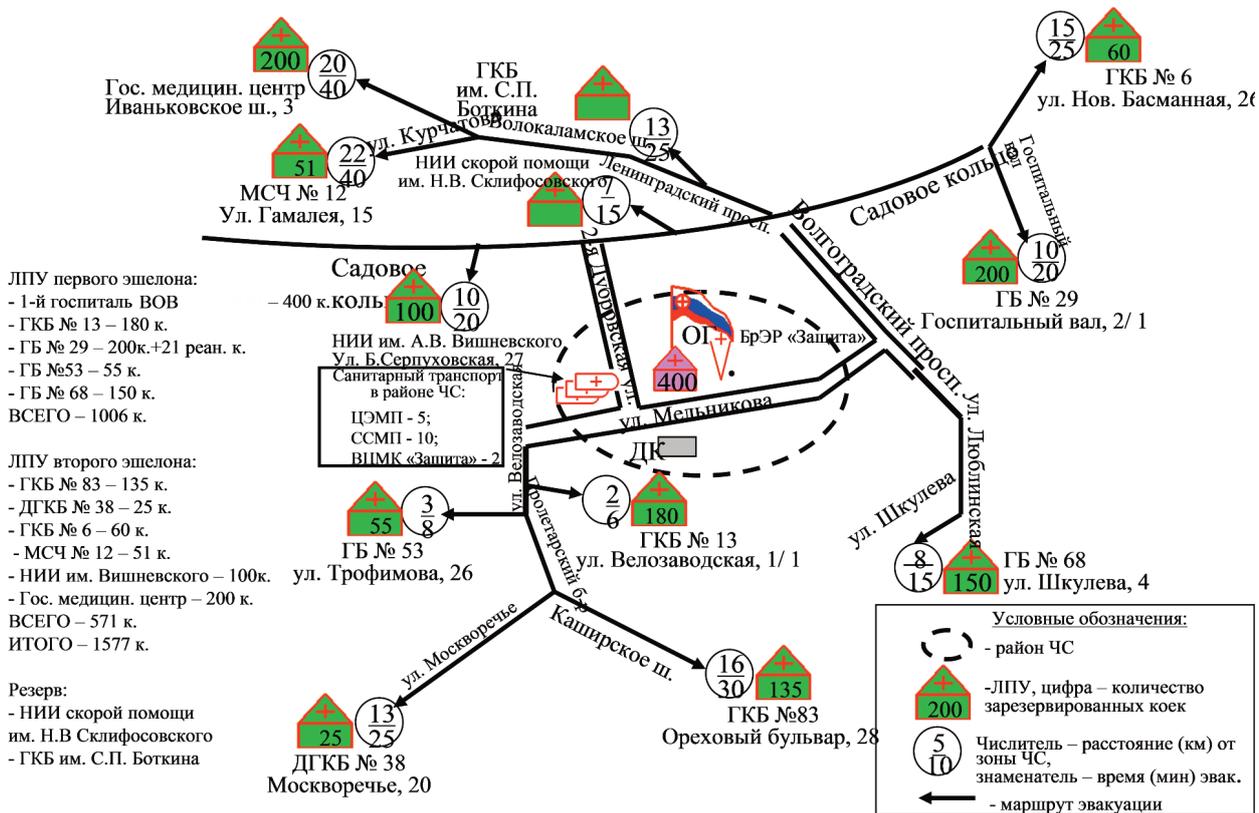
This variant of medical triage of the wounded during the liquidation of the medical and sanitary consequences of a terrorist attack differs from the similar work of the military medical service — the wounded and sick from the military personnel participating in combat operations, as a rule, receive an evacuation assignment only at the stage of primary medical and sanitary care.

This circumstance emphasizes once again that the medical triage of victims of a terrorist attack, carried out in the emergency zone, should be carried out by the most trained, primarily medical, ambulance crews and EMTs.

It should be noted that in both cases, the use of general purpose vehicles for the evacuation of casualties cannot be ruled out. In such cases, the medical triage of casualties must include the allocation of casualties that can be transported from the emergency area to the hospital in ordinary transport and in what position.

When analyzing the experience of work to eliminate medical and sanitary consequences of terrorist attacks, it was found that the victims with relatively minor injuries and wounds, without waiting for the arrival of the ambulance and emergency medical teams, sought medical assistance on their own in medical treatment organizations. For the most part, it was this category of people who, during medical triage carried out in hospital facilities, belonged to the fourth triage group.

In this case, such arrival of the injured in medical organizations is referred to as "self-sorting" [5, 12]. [5, 12]. This



**Рисунок.** Схема организации лечебно-эвакуационного обеспечения пострадавших при теракте в культурно-развлекательном центре шарикоподшипникового завода (Москва, октябрь 2002 г.)  
**Figure.** Scheme of organization of medical and evacuation support for those affected by the terrorist attack in the cultural and entertainment center of the ball-bearing plant (Moscow, October 2002)

phenomenon occurred in many terrorist attacks. For example, during the terrorist attack in Beslan (2004) about 7.5% of the wounded were transported to the medical organizations by motor vehicles [13]. When dealing with the medical and sanitary consequences of other emergencies (not terrorist attacks), the proportion of persons arriving at medical organizations "by gravity" is usually much higher. This situation can be explained by strict implementation of regime measures during liquidation of the consequences of terrorist acts, as well as by the presence of a developed health care infrastructure in the places where they occurred.

Some medical specialists consider this phenomenon as a positive fact when dealing with the aftermath of terrorist attacks. This is mainly due to the readiness of eyewitnesses to provide first aid, including transporting the victim to the medical organization within a short time after injury (wounding), as well as reducing the risk of repeated or secondary damage.

When the wounded arrive from the terrorist attack zone to the stage of medical evacuation (field hospital or mobile medical detachment, medical center, etc.), after unloading the wounded from vehicles, they, as a rule, in the reception department (inpatient department), carry out, in accordance with the adopted general methodological approaches and rules, medical triage.

Given the object of the study and a sufficiently detailed description of the order of organization and conduct of medical triage of the injured at the stages of medical evacuation, apparently, there is no need to dwell in more detail on the technology of its conduct [2, 3, 7, 9].

However, the results of studying the experience of eliminating medical and sanitary consequences of terrorist attacks show that in a number of cases medical triage, conducted at the stages of medical evacuation, was not performed in its classic version, which implies the formation (allocation) of typical conventional triage groups of the injured. For example, at the admission of children injured in the terrorist attack to the Field Pediatric Hospital of the All-Russian Center for Disaster Medicine "Zaschita" of the Russian Ministry of Health (Central Regional Hospital – Beslan), they were divided into 4 triage groups (Table). It can be seen from the table that the medical specialists sought to proceed as quickly as possible to provide specialized medical care to the injured in the medical organizations of the 2nd and 3rd levels, located in Vladikavkaz [13]. To achieve this goal, the medical triage and medical evacuation of the injured were organized accordingly.[Table]

Under conditions of liquidation of medical and sanitary consequences of terrorist attacks with a large number of victims, when repeatedly at short intervals in medical organizations may arrive numerous groups of victims, especially those whose condition is assessed as severe and extremely severe, when performing medical triage in the emergency department of medical organization the scope of diagnostic procedures should be limited to the identification of triage features necessary for a reasonable triage conclusion. Obviously, if a casualty has, for example, severe asphyxia or external bleeding phenomena, it is hardly necessary to examine "skin condition", "speech" or "motor" reactions, since these are of no importance for making a proper triage decision [3, 5, 9].

**Распределение детей, пораженных при теракте, на сортировочные группы при их поступлении в ЦРБ г.Беслана – Полевой педиатрический госпиталь ВЦМК «Защита» Минздрава России (2004)**  
 Distribution of children injured in the terrorist attack, in triage groups upon admission to Beslan's Central Clinical Hospital – All-Russian Center for Disaster Medicine "Zashchita" field pediatric hospital (2004)

Сортировочная группа Triage group	Число детей, чел. Number of children, people.	Сортировочное заключение* / Triage opinion
Первая First	199	Подлежащие незамедлительной эвакуации на следующий этап оказания медицинской помощи (ЛМО г.Владикавказ) после оказания доврачебной и первой врачебной медицинской помощи Victims subject to immediate evacuation to the next stage of medical care (Vladikavkaz medical organisations) after pre-hospital and first aid
Вторая Second	52	Нуждающиеся в экстренных медицинских мероприятиях по жизненным показаниям в объеме первой врачебной и квалифицированной медицинской помощи The injured, who need emergency medical measures for life indications in the volume of the first medical and qualified medical care
Третья Third	5	Не подлежащие эвакуации на следующий этап и нуждающиеся в проведении симптоматической терапии Affected persons not to be evacuated to the next stage and needing symptomatic therapy
Четвертая Fourth	55	Дети, не имеющие ранений и травм Children admitted with no wounds or injuries

\* Указанные в таблице виды медицинской помощи существовали до принятия Федерального закона «Об основах охраны здоровья граждан в Российской Федерации» от 21 ноября 2011 г. № 323-ФЗ

\* These types of medical care correspond to the provisions of the regulatory documents governing the activities of the Emergency Medicine Service of the Russian Ministry of Health, which were in effect at the time

As for determining the effectiveness of medical triage, it is necessary to proceed from the following provision — it is determined, on the one hand, by the timely and clear implementation of the adopted triage decisions, on the other — by the creation of conditions for the most optimal compliance and implementation of the principles of routing of the injured, by the full use of the possibilities for the provision of medical care by specialists of the emergency teams, medical treatment organization (at medical evacuation stage).

As an example, confirming the above, we can give a description of the rescue work during the liquidation of the consequences of the terrorist attack in New York (USA) in 2001. So, B.Eiseman points out that there were cases when the medical triage of the victims in the terrorist attack zone was not carried out and, therefore, there was no clear distribution of the victims among the medical treatment organizations that were ready enough to receive the victims and provide them with the necessary medical care. As a result, all the hospitals closest to the site of the tragedy were quickly filled with casualties, and it proved difficult, if not impossible, to reassign the wounded to other medical institutions within a short period of time [14].

#### Conclusion

The study of the experience of liquidating medical and sanitary consequences of terrorist acts, especially those ac-

companied by numerous sanitary losses, has shown that the medical triage of the wounded in the terrorist attack zone is an objective necessity and an important part of the medical and evacuation support, allowing conditions to increase the availability and quality of medical care and medical evacuation with optimal observance of the routing principles.

At the same time, the existing normative and methodological documents do not give a sufficiently clear and complete picture of the organization and conduct of the medical triage of the victims of a terrorist attack committed with conventional means of destruction, especially at the site of the attack.

On the basis of the analysis of the results of theoretical works, experience in the organization of medical evacuation during the liquidation of the consequences of terrorist acts committed with the use of conventional means of destruction, the improved methodical approaches to the organization and implementation of the medical triage of the wounded in the terrorist attack zone are proposed.

Thus, it can be stated that the results of the study have a pronounced practical significance for increasing the effectiveness of life-saving and health preservation of the injured during terrorist attacks, rational and effective use of medical forces and means involved in providing medical assistance and conducting medical evacuation.

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## ГИБРИДНАЯ ВОЙНА И МЕДИЦИНА: ОТ ЕДИНОГО ПОНИМАНИЯ СУТИ К МЕЖВЕДОМСТВЕННОМУ ВЗАИМОДЕЙСТВИЮ

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**Резюме.** Проанализировано понятие «гибридная война». Рассмотрены основные положения современной военно-медицинской доктрины и современной системы лечебно-эвакуационного обеспечения (ЛЭО) войск. Представлены основные задачи межведомственного взаимодействия в интересах медицинского обеспечения войск, здравоохранения и защиты здоровья граждан, а также главные направления его дальнейшего развития и др.

**Ключевые слова:** военная медицина, военно-медицинская доктрина, гибридные войны, здравоохранение, лечебно-эвакуационное обеспечение, межведомственное взаимодействие, чрезвычайные ситуации

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## HYBRID WARFARE AND MEDICINE: FROM COMMON UNDERSTANDING TO INTERAGENCY INTERACTION

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**Summary.** The concept of "hybrid warfare" is analyzed. Basic provisions of the modern military-medical doctrine and the modern system of medical and evacuation support of troops are considered. The main tasks of inter-departmental interaction in the interests of medical support of troops, health care and protection of citizens' health are presented. So are the main directions of its further development.

**Keywords:** emergencies, healthcare, hybrid wars, interdepartmental interaction, medical and evacuation support, military-medical doctrine, military medicine

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Modern understanding of war as a socio-political phenomenon assumes that its basis is a form of solving socio-political, economic, ideological, as well as national, religious, territorial and other contradictions between states, peoples, nations, classes and social groups by military violence.

At present it is impossible to imagine a system for countering threats to our country without the consolidation of the structures of the Ministry of Defense of the Russian Federation and other departmental structures of our state.

In one of his speeches, M.E. Mizintsev, head of the National Defense Control Center of the Russian Federation, noted that "today the system of inter-agency cooperation in the sphere of defense is comprised of 160 ministries, departments, corporations, and supreme executive bodies of all subjects of the Russian Federation.

In the last half century alone, not counting the human losses during the armed confrontations in Ukraine, there have been more than 450 wars in the world, covering more countries than during World War II, in which more than 40 million people died.

Modern wars are hybrid in nature — in addition to armed, they widely use other types of confrontation — political, diplomatic, economic, ideological, informational, etc.

The author of the term "hybrid war", which is understood as one of the varieties of war of the new type, is Gabriel Nodé (1600-1651), who revealed its essence as early as 1639 in his treatise "Political Considerations on High Politics and Mastery of Coups d'Etat".

The possibility of winning wars by "conducting them by other means" was pointed out by the famous military theorist of his time Karl von Clausewitz (1780-1831).

As early as in the 5th century B.C. the Chinese strategist and philosopher Sun Tzu in his treatise "The Art of War" asserted that "...the highest military art is to subdue the enemy without fighting".

The features of the new, previously unseen war were seen in the "shape" of the of the First World War, by the outstanding Russian military theorists A. E. Snesev (1865-1937) and A. A. Svechin (1878-1938).

M.N. Tukhachevsky drew attention to "...social resources for the coordinated achievement of war goals...".

Prominent Soviet military commander N.V. Ogarkov noted that the nature of the war was influenced by "the grim reality of our days."

Chief of the General Staff of the Armed Forces of the Russian Federation V. Gerasimov notes that geopolitical rivals of Russia do not hide the fact that they are going to achieve political goals not only during local conflicts. They are preparing to wage wars with a "high-tech enemy" using high-precision means of destruction used from the air, sea and space, with active conduct of information confrontation. "Under these conditions, our Armed Forces must be prepared to wage wars and armed conflicts of a new type using classical and asymmetric modes of action.

Hybrid wars have absorbed the features of traditional and irregular wars, and their participants are various combinations of state and non-state actors, they pursue combined goals and defeat the enemy on all fronts.

The most important feature of "hybrid wars" is a change in the methodology of conventional weapons and weapons of mass destruction, the use of weapons based on new physical principles and the use of robotic systems.

Any "hybrid" war has two stages.

The first stage is the implementation of indirect (nonforce) methods; the second stage is the implementation of direct (force) methods.

In this war there are no such generally accepted concepts as rear and lines of defense, its duration may vary from several days to several years, there is no cyclicality in the conduct of hostilities, it is characterized by unpredictability of sanitary and epidemiological situation, the emergence and nature of sanitary losses, etc.

An analysis of medical support in past and recent armed conflicts shows the high efficiency of domestic approaches to organizing medical and evacuation support for troops.

The scientific works of E.I. Smirnov, Academician of the USSR Academy of Medical Sciences, an outstanding organizer of military health care, became the basis for predicting the nature of modern wars. He argued that "new forms of armed struggle in World War III...will be the rule: weapons of mass destruction will be the main means of struggle", "combat losses will arise mainly among civilians, and losses in the armed forces on this background will be a drop in the ocean".

The Military Doctrine of the Russian Federation, approved by President Vladimir Putin, identifies the proliferation of weapons of mass destruction as a major external military threat.

According to the Stockholm International Peace Research Institute, Russia, the United States, Great Britain, France, China, India, Pakistan, Israel, and North Korea currently have over 150,000 nuclear weapons.

Despite the adoption of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction, the probability of using the products of the so-called "flexible" chemical industries as analogues of chemical weapons remains, prod-

ucts aimed at "military purposes not connected with the use of chemical weapons and not depending on the use of toxic properties of chemicals as means of warfare.

Despite broad participation of the states of the world in the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (Moscow — London — Washington, April 10, 1972), the risks of its spread remain, given that the effectiveness of its implementation is negatively influenced:

- increase in the number of questionable scientific research on so-called "protective" topics; low efficiency of existing export control regulations with respect to biotechnology;

- high availability of biological materials that can be obtained under laboratory conditions as a result of the implementation of modern biotechnologies;

- possibility of the use of "non-core" laboratory and technological equipment for the production of dangerous biological (microbial, viral) materials by individuals pursuing criminal goals.

All of these factors are "controllable" and can be used in hybrid warfare.

New forms of threats lead to the development of modern weapons with new lethal factors and, consequently, to new forms of combat injuries and new approaches to medical care.

In recent years, weapons based on new physical principles have been the most threatening in terms of the likelihood of their use in hybrid wars.

Such weapons include: laser, gas pedal (beam), infrasound, radiofrequency, geophysical, kinetic, annihilation and gene weapons.

In addition, there are new types of non-lethal weapons and means used in information wars.

Transformation of certain types of weapons based on new physical principles is quite dynamic. In particular, only in the last 10 years there has been a transformation of elements of information confrontation in the framework of information wars, the methodologies of their use have changed.

The main provisions of modern military-medical doctrine:

- unified understanding of combat pathology;

- scientifically substantiated principles of staged treatment of the wounded with evacuation by designation;

- strict regulation of therapeutic and evacuation actions and their continuity;

- technical support for consistency and continuity of medical care at the stages of medical evacuation;

- unified management of medical aid to the wounded.

The modern system of medical evacuation support includes 3 stages — tactical, operational and strategic provision (Fig. 1).

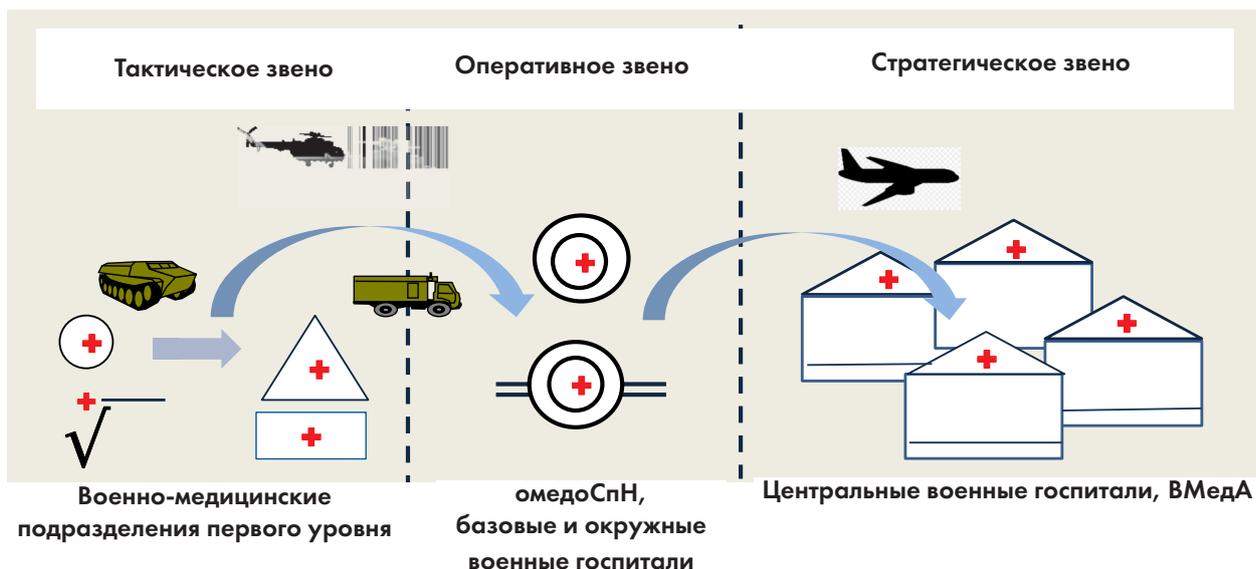
Features of modern military conflicts affecting the organization of medical care:

- ▶ possibility of expanding the scale of combat operations, danger of combat strikes, sabotage actions throughout the country;

- ▶ different duration of military actions (from several days to several years);

- ▶ cyclicality and intensity of military operations, different ratio of surgical and therapeutic casualties in separate periods of war;

- ▶ possibility of using, along with conventional weapons, weapons of mass destruction (chemical, including temporarily disabling weapons, nuclear weapons, bacterio-



**Рис. 1.** Схема трёхэтапной системы лечебно-эвакуационного обеспечения группировки войск (сил) в современном вооруженном конфликте  
**Fig. 1.** Scheme of the three-stage system of medical and evacuation support of a group of troops (forces) in a modern armed conflict

logical weapons and weapons based on new physical principles);

- ▶ probability of deterioration of the sanitary and epidemiological situation in the area of military conflict;

- ▶ possibility of destruction of chemical, nuclear and bio-hazardous facilities;

participation of troops in humanitarian actions (operations) involving, among other things, medical assistance to the affected civilian population.

Experience in areas of military conflicts and emergencies shows that during the application of nonforce methods in wars of a new type it is necessary to ensure the readiness of military-medical organizations, health care organizations and other structures.

The interdepartmental interaction in the organization of medical support of troops (forces), in the field of health care and protection of citizens' health is the process of joining resources of state authorities, local governments, medical organizations and institutions of different departmental affiliation, business structures for the implementation of measures to protect citizens' health and exercise of their rights.

We are talking about staff training, stockpiling, working on joint documents, making decisions on redistribution of hospital beds, mobilization of dual-use technologies and on scaling up production of radioprotectors, antidotes and vaccines.

The main objectives of interagency cooperation in the interests of medical support of troops, public health and health protection of citizens:

- ▶ maximum mobilization (inclusion) of all types of industry resources (personnel, innovation, information, technology, material, etc.);

- ▶ development and implementation of regulations, programs, plans, activities that include interdepartmental resources, as well as special procedures for medical organizations;

- ▶ creation of operational headquarters, development and approval of the Action Plan for the transition to interagency cooperation;

- ▶ coordination and monitoring of the activities of participants in interagency cooperation;

- ▶ coordination of the use of resources and implementa-

tion of decisions taken;

- ▶ monitoring of daily activities within the framework of interagency interaction and evaluation of its results.

The positive effect of interdepartmental interaction on the implementation of innovations in medicine makes it possible to implement a new interdisciplinary direction of medical science development — "translational medicine".

An example of interdepartmental interaction between the country's scientific institutions was the creation of the world's first vaccine against COVID-19 "Sputnik V" (Fig. 2. 3).

It seems promising to create a scientific and educational cluster for military medicine to coordinate all medical and biological research in the interests of national defense.

Further development of interagency cooperation in the organization of medical support of troops (forces), in the field of health care and health protection of citizens in the conditions of wars of a new type should include:

- conducting further research in order to forecast the nature and ways of implementing military threats and their medical and biological consequences for the security of the Russian Federation;

- scientific study of the problems of medical theory and practice in the interests of improving the combat effectiveness of the Armed Forces of the Russian Federation, development and justification of innovative approaches to the management of medical support in different variants of military confrontations with the use of artificial intelligence;

- determination of prospects and directions of development of medical service of the Armed Forces of the Russian Federation, solution of problems and justification of actual forms of training of medical specialists in order to ensure their readiness to carry out tasks for their intended purpose in peacetime and wartime conditions;

- developing new standards of medical care in tactical, operational and strategic links of medical and evacuation support, taking into account existing innovations in the field of military field surgery, military field therapy, military epidemiology, etc;

- study of new technologies in the organization of medical support of associations, formations and units of branches of the Armed Forces of the Russian Federation performing special tasks in extreme conditions, under the impact of special

**Итог межведомственного взаимодействия научных учреждений страны – создание первой в мире вакцины против COVID-19 «Спутник V»**



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Рис. 2. Итог межведомственного взаимодействия научных учреждений – создание первой в мире вакцины против COVID-19 "Спутник-V"  
Fig. 2. The result of interdepartmental cooperation of scientific institutions – the creation of the world's first vaccine against COVID-19 "Sputnik-V"

**Итог межведомственного взаимодействия научных учреждений страны – создание научного труда «Медицина чрезвычайных ситуаций»**



**Военно-медицинская академия имени С.М. Кирова Минобороны России**



**ВЦМК «Защита» ГНЦ – Федеральный медицинский биофизический центр им. А.И.Бурназяна ФМБА России**



Рис. 3. Итог межведомственного взаимодействия научных учреждений страны – создание научного труда «Медицина чрезвычайных ситуаций»  
Fig. 3. Result of interdepartmental interaction of scientific institutions on creation of scientific work "Medicine of Emergency Situations"

factors of the military environment, as well as during the use of weapons of mass destruction, weapons based on new physical principles, new types of non-lethal weapons and means of information wars, new coronavirus infection;

- study of the issues of medical and psychological support of troops (forces) activities, training and education of the personnel of the Armed Forces of the Russian Federation and training of scientific personnel;

- study of current problems of the history of medical support in combat conditions and in the daily activities of the troops (forces);

- study and scientific substantiation of the development of interdepartmental interaction between the military medical service of the Russian Ministry of Defense, the Russian Ministry of Health, Rospotrebnadzor and the Federal Medical and Biological Agency during emergency response and during peacekeeping and humanitarian activities.

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## АНАЛИЗ РИСКОВ ГИБЕЛИ ЛИЧНОГО СОСТАВА ФЕДЕРАЛЬНОЙ ПРОТИВОПОЖАРНОЙ СЛУЖБЫ МЧС РОССИИ В 2006–2020 гг.

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**Резюме.** Цель исследования – анализ рисков гибели личного состава Федеральной противопожарной службы (ФПС) МЧС России в 2006–2020 гг. по категориям персонала, причинам получения смертельных травм и видам профессиональной деятельности.

**Материалы и методы исследования.** Показатели травм у личного состава ФПС МЧС России взяты: за 2006–2015 гг. – из банка данных по заболеваемости, травматизму, инвалидности и гибели при исполнении служебных обязанностей в МЧС России; за 2016–2020 гг. – из донесений по МЧС России. Риски смерти рассчитаны на 100 тыс. чел. или  $\times 10^{-5}$ .

**Результаты исследования и их анализ.** За 15 лет (2006–2020) при исполнении служебных обязанностей погибли вследствие травм 224 чел. из числа личного состава ФПС МЧС России, в среднем –  $(15 \pm 1)$  чел. в год. Среднегодовой риск гибели составил  $(8,53 \pm 0,83) \times 10^{-5}$ , у работников Российской Федерации – мужчин он был статистически достоверно больше –  $(13,23 \pm 1,12) \times 10^{-5}$  ( $p < 0,01$ ). Полиномиальные тренды показателей риска гибели личного состава ФПС МЧС России и работников Российской Федерации – мужчин при разных по значимости коэффициентах детерминации показывают тенденцию уменьшения данных. Согласованность трендов – низкая и статистически незначимая ( $r = 0,228$ ;  $p > 0,05$ ), что может указывать на влияние разных (разнонаправленных) ведущих факторов на получение травм со смертельным исходом. Рассчитаны среднегодовые риски гибели по причинам получения смертельных травм, видам профессиональной деятельности и категориям личного состава.

**Ключевые слова:** личный состав, охрана труда, производственный травматизм, риски гибели, смертельные травмы, Федеральная противопожарная служба МЧС России

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## ANALYSIS OF THE RISKS OF DEATH OF PERSONNEL OF THE FEDERAL FIRE SERVICE OF EMERCOM OF RUSSIA IN 2006–2020

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**Summary.** The aim of the study is to analyze the risks of fatalities among the personnel of the Federal Firefighting Service of the Ministry of Emergency Situations (EMERCOM) of Russia in 2006–2020 by categories of personnel, causes of fatal injuries, and types of professional activity.

**Materials and research methods.** Injury rates of Russian EMERCOM Federal Firefighting Service personnel were taken for 2006–2015 from the data bank on morbidity, injury, disability, and death during the performance of official duties in the Russian EMERCOM; for 2016–2020 – from the reports of the Ministry of Emergency Situations of Russia. Risks of death were calculated per 100 thousand people or  $\times 10^{-5}$ .

**Results of the study and their analysis.** Over 15 years (2006–2020), 224 members of the Federal Firefighting Service of the Russian EMERCOM died as a result of injuries received during the performance of their official duties, averaging  $(15 \pm 1)$  deaths per year. The average annual risk of death was  $(8.53 \pm 0.83) \times 10^{-5}$ . That is statistically reliably lower, than the average risk for Russian Federation male workers –  $(13.23 \pm 1.12) \times 10^{-5}$  ( $p < 0.01$ ). The polynomial trends of the indicators of risk of death of Federal Firefighting service personnel and of male workers of the Russian Federation with different significance coefficients of determination show a decreasing trend in the data. The consistency of the trends is low and statistically insignificant ( $r = 0.228$ ;  $p > 0.05$ ), which may

indicate the influence of different (multidirectional) leading factors on fatal injuries. The average annual risks of fatal injuries by causes of fatal injuries, types of professional activity and personnel categories were calculated.

**Key words:** Federal Firefighting Service of the Ministry of Emergency Situations of Russia, fatal injuries, occupational safety, occupational traumatism, personnel, risks of death

**Conflict of interest.** The authors declare no conflict of interest

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An important indicator of occupational safety is the data on injuries and fatalities at work. According to the International Labor Organization, each year in the world the workers at work get 370 million work injuries, about 2.75 million people die as a result of work accidents or occupational diseases (7.5 thousand people daily) [1]. Economic losses in the world from occupational injuries are no less than 4% of the world's gross product [2].

Risk is the probability of the occurrence of any event — usually negative — in a certain period of time, for example, in one year. Unfortunately, for a number of reasons it is impossible to reduce to zero the risks of industrial injuries and death of workers — they can only be minimized. Improving working conditions leads to a decrease in injuries and fatalities. Analysis of 84 behavioral, environmental, occupational, and metabolic risks across 195 countries from 2007-2017 showed a 6.5% decrease in work-related fatalities from all causes, including a 14.2% decrease in occupational exposures to heat, fire, and smoke [3].

The decrease in the number of occupational fatalities is also observed in Russia. According to the data of Rosstat [<https://rosstat.gov.ru>], over the 15 years from 2006 to 2020 25,970 people died at work, of them 24,180 men, 1,800 women. Whereas in 2006 the risk of death at work was  $2.9 \times 10^{-5}$  people, or 2.9 per 100,000 workers, in 2020 it was  $0.91 \times 10^{-5}$ , a decrease of 3.2 times.

The professional activity of the personnel of the Federal Firefighting Service (FFS) of the Ministry of Emergency Situations of Russia refers to the extreme, in which an overstrain of functional reserves of the organism can occur, erroneous actions are committed, workers receive injuries, including fatal ones, and they have professionally accelerated diseases [4].

According to researches, an average territorial division of firefighting service goes on fires (extinguishing of fires and liquidation of consequences of other emergencies — ES) not less than 250-350 times in a year. The share of such departures makes about 35% of all departures connected with fire-tactical drills, working off of standards on fire training and operational-tactical study of possible object of fire extinguishing, checks of fighting readiness and others, and also with refueling, repair and service of fire techniques, rendering of technical aid to other subdivision and so forth [5].

It should be noted that without taking into account the exposition of combat work, the comparison of the levels of industrial injuries of categories of personnel of the Federal Firefighting Service of the Russian Emercom will not be quite correct. The average time of service of one call with combat work is about 1,5 h, the average number of departures — 300. The rest of the time the firefighters, who are on stand-by duty, perform the duties of everyday work. If one formally calculates the time of extreme activity operational firefighter ( $1,5 \times 300$ ), it could be 450 hours — 56 days or 2 months per year. When on working mode "operational duty — 1 day, rest — 3 days" operational staff performs an annual amount of extreme activity for 4-6 months. In this case the calculated level of industrial injuries for one year should be increased at least by 2 times [6].

In 2006-2020, 3758 injuries, mostly of moderate and severe severity, including 224 fatal ones, were registered in the personnel of the Federal Firefighting Service of the Russian Ministry of Emergency Situations. The ratio of occupational to fatal injuries was 16.8. It is worth noting that such a ratio in foreign countries with developed economies is 300-500, while in Russia during the same period of time it was 22.6. Probably Russia as a whole and the Russian EMERCOM in particular do not keep complete records of injuries — only injuries with severe consequences are registered or injuries are sometimes concealed by employers.

An assessment of occupational injuries by categories of Russian EMERCOM Firefighting personnel is presented in the previous article [7]. In 2006-2020, the average annual risk of injuries in the performance of official duties for all the members of the Russian Federal Service for Emergencies was  $(14.66 \pm 2.01) \times 10^{-4}$  or per 10,000 people, which proved to be statistically significantly lower ( $p < 0.001$ ) than that for male employees in Russia as a whole —  $(22.73 \pm 2.18) \times 10^{-4}$ . The average annual risk of injuries was  $(14.47 \pm 2.06) \times 10^{-4}$  for operational staff,  $(12.33 \pm 2.33) \times 10^{-4}$  for preventive staff,  $(10.86 \pm 1.58) \times 10^{-4}$  for technical staff,  $(18.65 \pm 2.49) \times 10^{-4}$  for managerial staff.

No data on the deaths of EMERCOM of Russia firefighting personnel over a long period of time have been found.

**The aim of the study** was to analyze the risks of fatalities among the personnel of Russia's Federal Firefighting Service of Russian EMERCOM including those by personnel categories, causes of fatal injuries, and types of professional activity.

**Materials and Methods.** Data on fatal injuries in the personnel (employees with special ranks and workers) of the Federal Firefighting Service of the Russian Ministry of Emergency Situations were obtained: for 2006-2015 — from the data bank on morbidity, injury, disability, and death in the Russian Ministry of Emergency Situations during the performance of official duties; for 2016-2020 — from the reports of the Russian Ministry of Emergency Situations [8].

Data on the deaths are correlated with the types of professional activities: extinguishing fires and eliminating other emergencies; training and sports activities — participation in exercises, drills, physical training and sports and mass events and daily activities. Circumstances of fatal injuries are summarized into generalized groups of causes: technical, organizational, psychophysiological (personal factor) causes and fire hazards [9].

Estimation of the risk of death of the personnel of the Federal Firefighting Service of the Ministry of Emergency Situations of Russia is calculated for 100 thousand people ( $\times 10^{-5}$ ). Only 1.5% of women serve (work) in the Russian EMERCOM, so the data on the deaths of EMERCOM personnel were compared with the results of risks among male employees of the Russian Federation as a whole, which were taken from the official Rosstat website [https://rosstat.gov.ru].

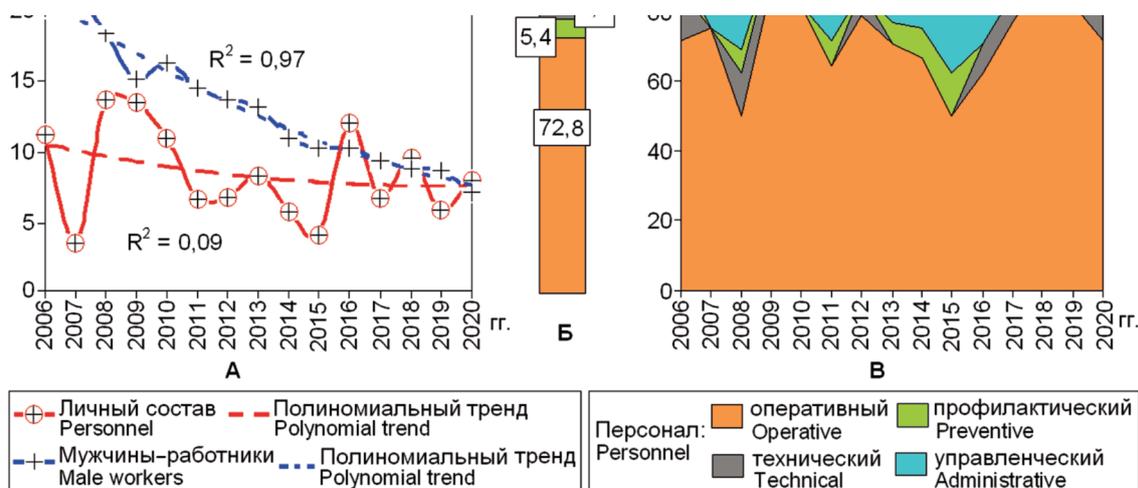
When studying the dynamics of the indicators of the deaths of EMERCOM personnel, there were difficulties associated with the heterogeneity of the data and their significant fluctuations in different periods of time. To reduce the contribution of the random component, which leads to significant fluctuations, we used the method of smoothing time series, which consists in replacing the actual values with calculated ones characterized by less variability, and smoothing the death rates using the methods of moving average and exponential smoothing [10]. Both methods yielded close results, but the mean values and standard deviations of the smoothed distributions differed significantly from the corresponding parameters of the original distribution. In the final analysis, we did not use the smoothing procedure to exclude possible distortion of the results.

Arithmetic mean values and their errors ( $M \pm m$ ) are presented in the article. Due to small rates of fatal injuries for some causes, the calculated annual mean risk differed from the normal distribution, and the sum in the table rows may not differ significantly when percentages are rounded to decimals. The development of injury rates was assessed by means of a dynamic series, for which a second-order polynomial trend was used. The coefficient of determination ( $R^2$ ) showed the connection between the constructed trend and the real tendency of the indicators development: the higher  $R^2$  was (maximum — 1.0), the more objective the trend turned out to be [10]. Consistency (congruence) of the studied trends of the risks of death was achieved using the Pearson correlation coefficient ( $r$ ).

**Results of the study and their analysis.** During 15 years (2006-2020) 224 members of the Russian EMERCOM Firefighting Service personnel died as a result of fatal traumas in the performance of their official duties, on average ( $15 \pm 1$ ) per year. The average annual risk of death was  $(8.53 \pm 0.83) \times 10^{-5}$ , for male employees in Russia as a whole it was statistically significantly higher —  $(13.23 \pm 1.12) \times 10^{-5}$ ;  $p < 0.01$ .

The polynomial trends of the risk of death for Russian personnel and male workers, with different significance coefficients of determination, showed decreasing trends in the data (Fig. 1A). For example, the risk of personal death was: in 2006 —  $11.23 \times 10^{-5}$ ; in 2020 it was  $8.09 \times 10^{-5}$ , a decrease of 1.4 times; for male workers,  $20.1 \times 10^{-5}$  and  $7.2 \times 10^{-5}$ , respectively, a decrease of 2.8 times. The consistency of the trends is low and statistically insignificant ( $r = 0.228$ ;  $p > 0.05$ ), which may indicate the influence of different (multidirectional) leading factors in the development of fatal injuries.

An assessment of the risks of fatal injuries to Firefighting Service of Emergencies Ministry personnel, including by category, cause and type of activity, is presented in the table below. There were 89 (39.7%) fatal injuries caused by dangerous factors of fires, 97 (43.3%) by psychophysiological reasons (personal factors), 20 (15.2%) by organizational reasons and 4 (1.8%) by technical reasons.



**Рис. 1.** Динамика показателей риска гибели личного состава и мужчин–работников России (А); структура (Б) и динамика структуры риска гибели (В) по категориям личного состава ФПС МЧС России  
**Fig. 1.** Dynamics of indicators of the risk of death of personnel and male workers in Russia (A), structure (Б) and dynamics of structure of the risk of death (B) by categories of personnel of the FFS of the EMERCOM of Russia

The average annual risk of death of the personal staff due to the dangerous factors of fires is  $(3,36 \pm 0,53) \times 10^{-5}$ ; psychophysiological reasons—  $(3,79 \pm 0,38) \times 10^{-5}$ ; organizational —  $(1,21 \pm 0,34) \times 10^{-5}$ ; technical—  $(0,17 \pm 0,11) \times 10^{-5}$  (see Table).

The number of fatal injuries of the personnel during fire fighting was 123 (54,9%), during training and sporting activities — 7 (3,1%), during daily work — 94 (42%). The average annual risk of personnel deaths was: during fire fighting —  $(4,61 \pm 0,67) \times 10^{-5}$ ; during training and sporting activities —  $(0,24 \pm 0,11) \times 10^{-5}$ ; during daily work —  $(3,67 \pm 0,38) \times 10^{-5}$ . As indicated earlier, taking into account the exposure to extreme activity, risk of death in fire-fighting should be increased by at least 2 times. A fairly significant risk of death of personnel in everyday activities also can be noted. We believe that this risk is a manageable process: an analysis of the causes of injuries and their consequences in everyday activities will allow to develop effective preventive measures.

155 employees with special ranks (69.2%) and 69 workers (30.8%) lost their lives in the line of duty. The average annual risk of employee deaths,  $(10,24 \pm 1,06) \times 10^{-5}$ , was

statistically significantly higher ( $p < 0.05$ ) than that of workers,  $(6,09 \pm 1,07) \times 10^{-5}$ . The main reason for the increased risk of death of employees, as compared to workers, is the difference in the location of fire protection units staffed by employees and workers: in large cities, where fires are more frequent and more complex, there are more employees in the fire protection units; in small communities — there are more workers. Accordingly, employees of the Federal Firefighting Service of the Ministry of Emergency Situations of Russia went more often to more dangerous fires and more often experienced significant risk than employees.

During professional activities the operational staff sustained 163 fatal injuries (72.8%); preventive personnel — 9 (4%); technical staff — 12 (5.4%); managerial staff — 40 injuries (17.9%) (see Fig. 1B). The dynamics of the structure shows an increasing trend in the proportion of fatalities among operating personnel and preventive personnel; a decreasing proportion of fatalities among technical and managerial personnel (see Fig. 1B).

In the period 2006-2020 the average annual risk of death among the operational staff was  $(9,13 \pm 1,00) \times 10^{-5}$ ; preventive personnel —  $(4,48 \pm 1,01) \times 10^{-5}$ ; technicians —

Таблица/Table

**Среднегодовые показатели рисков гибели (n=224) личного состава ФПС МЧС России, в том числе по категориям личного состава, причинам смертельных травм и видам деятельности, в 2006–2020 гг.,  $(M \pm m) \times 10^{-5}$**

Average annual risk indicators of death (n=224) of personnel of the FFS EMERCOM of Russia, including by category, cause and type of activity in 2006–2020,  $(M \pm m) \times 10^{-5}$

Причины смертельных травм Causes of fatal injuries	Деятельность / Activity							
	общий показатель General indicator		тушение пожаров Fire fighting		учебно-спортивная Educational and sports		повседневная Daily	
	риск /risk	%	риск /risk	%	риск /risk	%	риск /risk	%
Весь личный состав /All personnel								
Технические /Technical	0,17±0,11	1,8	–	–	–	–	0,17±0,11	1,8
Организационные Organizational	1,21±0,34	15,2	0,43±0,18	5,4	–	–	0,78±0,32	9,8
Психофизиологические Psychophysiological	3,79±0,38	43,3	0,82±0,17	9,8	0,24±0,11	3,1	2,72±0,37	30,4
Опасные факторы пожаров Hazardous factors of fire	3,36±0,53	39,7	3,36±0,53	39,7	–	–	–	–
Общие /Common	8,53±0,83	100,0	4,61±0,67	54,9	0,24±0,11	3,1	3,67±0,38	42,0
Оперативный состав /Operative personnel								
Технические /Technical	0,08±0,08	0,4	–	–	–	–	0,08±0,08	0,4
Организационные Organizational	1,29±0,42	11,2	0,50±0,26	4,5	–	–	0,79±0,37	6,7
Психофизиологические Psychophysiological	3,45±0,46	26,8	1,13±0,25	8,9	0,24±0,12	2,2	2,07±0,38	15,7
Опасные факторы пожаров Hazardous factors of fire	4,30±0,63	34,4	4,30±0,63	34,4	–	–	–	–
Общие /Common	9,13±1,00	72,8	5,93±0,84	47,8	0,24±0,12	2,2	2,94±0,50	22,8
Профилактический персонал /Preventive personnel								
Технические /Technical	0,46±0,46	0,4	–	–	–	–	0,46±0,46	0,4
Организационные Organizational	4,02±1,03	3,6	–	–	–	–	4,02±1,03	3,6
Общие /Common	4,48±1,01	4,0	–	–	–	–	4,48±1,01	4,0
Технический персонал /Technical personnel								
Технические /Technical	0,59±0,59	0,4	–	–	–	–	0,59±0,59	0,4
Организационные Organizational	0,40±0,40	0,4	–	–	–	–	0,40±0,40	0,4
Психофизиологические Psychophysiological	3,25±1,13	3,1	–	–	0,41±0,41	0,4	2,84±1,13	2,7
Опасные факторы пожаров Hazardous factors of fire	1,54±0,85	1,3	1,54±0,85	1,3	–	–	–	–
Общие /Common	5,78±1,79	5,2	1,54±0,85	1,3	0,41±0,41	0,4	3,83±1,45	3,5
Управленческий персонал /Administrative personnel								
Технические /Technical	0,42±0,29	0,9	–	–	–	–	0,42±0,29	0,9
Организационные Organizational	1,67±0,58	3,1	0,56±0,39	0,9	–	–	1,11±0,42	2,2
Психофизиологические Psychophysiological	5,46±1,11	9,8	0,42±0,29	0,9	0,23±0,23	0,4	4,81±1,11	8,5
Опасные факторы пожаров Hazardous factors of fire	2,09±0,95	4,0	2,09±0,95	4,0	–	–	–	–
Общие /Common	9,64±1,83	17,8	3,07±1,08	5,8	0,23±0,23	0,4	5,14±0,69	11,6

$(5.78 \pm 1.79) \times 10^{-5}$ ; managerial staff —  $(9.64 \pm 1.83) \times 10^{-5}$  (see Table 1B).

With a high variability of the indices and low coefficients of determination, the polynomial trends of the risk of death showed a tendency for a decrease in the corresponding data for the operational and administrative personnel (Fig. 2A), while for the technical and preventive personnel they resembled a U-curve with an increasing tendency for the last period of observation (Fig. 2B).

It appeared, that in operative personnel the greatest risks of death were caused by dangerous factors of fires at extinguishing and psychophysiological reasons — at work in a mode of daily activity; at the preventive personnel — by psychophysiological reasons at work in a mode of daily activity (see Table).

At the technical and administrative personnel risks of death were defined by psychophysiological reasons — at work in a mode of daily activity and by dangerous factors of fires — at extinguishing (see Table).

As stated earlier, in 2006-2020 there was a tendency for the Russian Ministry of Emergency Situations to reduce the number of fatalities for almost all causes and types of activities. According to the authors, minimizing the risks of fatalities will be facilitated by:

- Strict and constant supervision by occupational safety officials over firefighters in the course of their service, including firefighting and day-to-day work;
- Strict disciplinary measures against the heads of subdivisions and staff of the Federal Firefighting Service of the Russian Emergencies Ministry, who violate the requirements of regulations in the field of labor protection and concealment of cases of occupational accidents;
- Using mobile robotics to extinguish complex fires, which can result in the collapse of building structures over large areas, explosions of pressurized containers, electric shocks, etc;
- Providing firefighters with certified personal protective equipment — PPE — special clothing and equipment, respiratory and visual protective equipment;

- Conducting certification of workplaces for working conditions in accordance with the requirements of Article 212 of the Labor Code of Russia and the Federal law "On Special Assessment of Working Conditions" from December 28, 2013 № 426-FZ;

- Organization of training sessions with the heads of subdivisions and personnel of the Federal Firefighting Service of the Ministry of Emergency Situations of Russia to study the order of the Ministry of Labor and Social Protection of Russia "On Approval of the Rules of labor protection in fire protection units" from December 11, 2020 № 881n in the system of service training;

- Preparing and sending analytical materials to territorial management bodies, research and fire-technical educational institutions, as well as training units of the Russian Federal Firefighting Service of the Ministry of Emergency Situations on the circumstances and causes of injuries and fatalities of the Russian Federal Firefighting Service of the Ministry of Emergency Situations personnel;

- Effective control over the use of financial resources allocated for health and safety.

### Conclusion

Over 15 years (2006-2020), the average annual risk of death among the Federal Firefighting Service personnel of Russian EMERCOM was  $(8.53 \pm 0.83) \times 10^{-5}$ ; for male workers it was statistically reliably higher ( $p < 0.01$ ) —  $(13.23 \pm 1.12) \times 10^{-5}$ . The polynomial trends of the risk of death of personnel and male workers in Russia, with different coefficients of determination showing a decreasing trend in the data. The consistency of the trends is low and statistically insignificant ( $r = 0.228$ ;  $p > 0.05$ ), which may indicate the influence of different (multidirectional) leading factors on fatal injuries.

The greatest risk of a fatality for the operational staff was observed for the firefighting personnel —  $(5.93 \pm 0.84) \times 10^{-5}$  — taking into account an exposition of the extreme activity, connected with fire-fighting, this parameter should be increased, at least by 2 times.

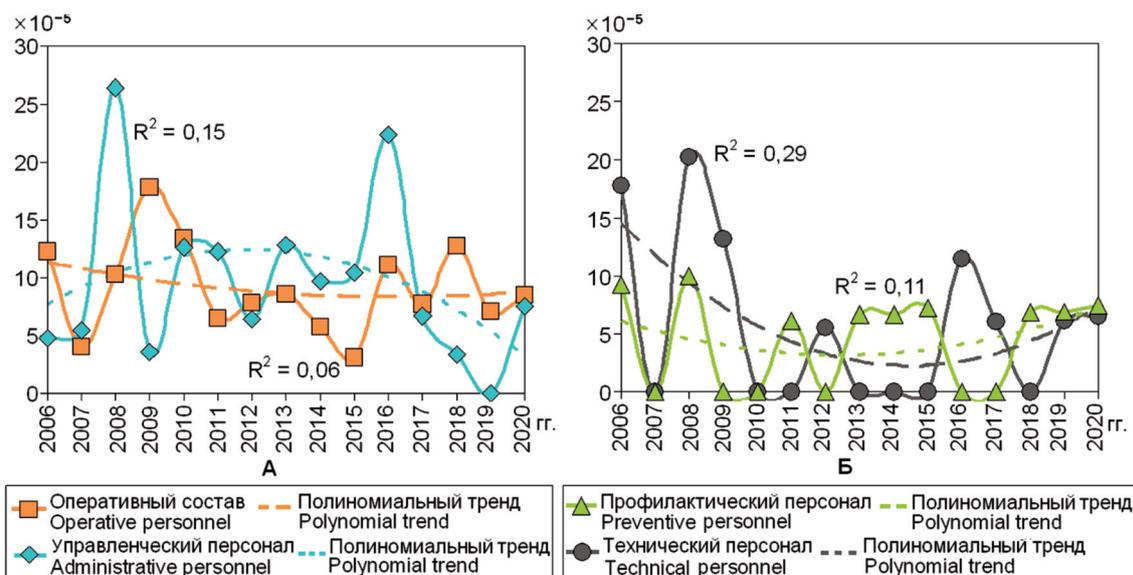


Рис. 2. Динамика рисков гибели оперативного состава и управленческого персонала (А), технического и профилактического персонала (Б)  
 Fig. 2. Dynamics of the risks of death of operational and administrative personnel (A), technical and preventive personnel (B)

A sufficiently significant risk of death of the personnel during work in everyday activities was revealed —  $(3,67 \pm 0,38) \times 10^{-5}$ . We believe that the analysis of the causes of occupational traumatism and its consequences in everyday activities will allow us to develop effective preventive measures.

According to the International Labor Organization, the ratio of occupational and fatal injuries is: in economically developed

foreign countries — 300-500; in Russia as a whole — 22.6; in the Russian Emergencies Ministry — 16.8. Unfortunately, the Russian Federation does not keep complete records on injuries; it is possible that only injuries with serious consequences are registered or that employers conceal some of them. Only by keeping track of all injuries and analyzing their causes and consequences with the participation of interested specialists can make occupational injuries manageable.

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## ОЦЕНКА УРОВНЯ ГОТОВНОСТИ МЕДИЦИНСКИХ СПЕЦИАЛИСТОВ РАЗНЫХ ВЕДОМСТВ В СОСТАВЕ НЕШТАТНЫХ ФОРМИРОВАНИЙ СЛУЖБЫ МЕДИЦИНЫ КАТАСТРОФ К ЛИКВИДАЦИИ МЕДИКО-САНИТАРНЫХ ПОСЛЕДСТВИЙ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ

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**Резюме.** Цель исследования – изучить и оценить показатели готовности и удовлетворенности работой военно-медицинских специалистов и гражданского персонала военно-медицинских организаций (ВМО) Минобороны (МО) России центрального и окружного подчинения (группа ВМО-МО), а также показатели готовности и удовлетворенности работой медицинских специалистов из состава медицинских организаций Минздрава России и Федерального медико-биологического агентства (группа МЗ-ФМБА) в составе нештатных формирований (НФ) Службы медицины катастроф (СМК) к деятельности по ликвидации медико-санитарных последствий чрезвычайных ситуаций (ЧС).

**Материалы и методы исследования.** Материалы исследования: анкеты социологического обследования медицинских специалистов НФ, распределенных на 2 группы (группа МЗ-ФМБА, n = 255; группа ВМО-МО, n = 227). Оценивались: общая характеристика медицинского специалиста, его профессиональная деятельность по основному месту работы и в составе НФ при работе в режимах повышенной готовности и чрезвычайной ситуации; готовность медицинских специалистов НФ к ликвидации медико-санитарных последствий ЧС. Методы исследования: аналитический, логический, статистический (описательная статистика, корреляционный и факторный анализ).

**Результаты исследования и их анализ.** Отмечена удовлетворенность работой военно-медицинских специалистов и гражданского персонала ВМО МО России центрального и окружного подчинения, а также медицинских специалистов из состава медицинских организаций Минздрава и ФМБА России. Определено, что среди факторов, влияющих на профессиональную деятельность медицинских специалистов разных ведомств в составе НФ, наиболее важными следует считать специальную подготовку и обеспеченность НФ медицинским и другим материально-техническим имуществом, готовность НФ при работе в режиме повседневной деятельности к выполнению задач по предназначению.

**Ключевые слова:** медико-санитарные последствия, медицинские специалисты разных ведомств, нештатные формирования, показатели готовности, Служба медицины катастроф, чрезвычайные ситуации

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Оценка уровня готовности медицинских специалистов разных ведомств в составе нештатных формирований Службы медицины катастроф к ликвидации медико-санитарных последствий чрезвычайных ситуаций // Медицина катастроф. 2022. №3. С. 23-31. <https://doi.org/10.33266/2070-1004-2022-3-23-31>

## ASSESSMENT OF THE LEVEL OF PREPAREDNESS OF MEDICAL STAFF OF DIFFERENT DEPARTMENTS IN THE NON-STAFF UNITS OF THE EMERGENCY MEDICINE SERVICE TO ELIMINATE MEDICAL AND SANITARY CONSEQUENCES OF EMERGENCIES

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**Summary.** The aim of the study was to investigate and to evaluate the readiness and job satisfaction rates of military medical specialists and civilian personnel of military medical organizations of the Russian Ministry of Defense of central and district subordination (ММО-MOD group), as well as the readiness and job satisfaction indicators of medical specialists from medical organizations of the Russian Ministry of Health and the Federal Medical and

Biological Agency (MOH-FMBA group) within the non-staff units of the Disaster Medicine Service for medical and sanitary consequences of emergencies elimination activities.

**Materials and research methods.** Materials of the study: sociological survey questionnaires of the non-staff medical specialists divided into 2 groups (MOH-FMBA group, n = 255; MMO-MOD group, n = 227). The following was assessed: general characteristics of a medical specialist, his/her professional activity at the main place of work and in the non-staff formations when working in high readiness and emergency modes; readiness of non-staff medical specialists to eliminate medical and sanitary consequences of emergencies. Research methods: analytical, logical, statistical (descriptive statistics, correlation and factor analysis).

**Results of the study and their analysis.** Satisfaction with the work of all military medical specialists and civilian personnel of the Russian Ministry of Defense of central and district subordination, as well as medical specialists from medical organizations of the Ministry of Health and the Federal Medical and Biological Agency of Russia were noted. It is marked that among the factors influencing professional activity of medical specialists of different departments in non-staff formations the most important should be considered special training and provision of non-staff formations with medical and other material and technical equipment, readiness of non-staff formations when working in the mode of daily activity to perform tasks on purpose.

**Key words:** Disaster Medicine Service, emergencies, medical and sanitary consequences, medical specialists of various departments, non-staff formations, readiness indicators

**Conflict of interest.** The authors declare no conflict of interest

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#### **Introduction**

According to the current regulations, medical aid to the victims of emergencies is provided by mobile emergency medical teams (EMTs), emergency response teams (ERTs), medical workers of multidisciplinary hospitals and medical organizations (MOs), providing assistance in outpatient and inpatient conditions, as well as by staff and non-staff formations (hospitals, detachments, brigades, groups), which in case of an emergency come under the operational subordination of the management bodies of the All-Russian Disaster Medicine Service of the corresponding level [1].

In 2020 in the Russian Federation 4.3 thousand different medical teams were engaged to eliminate medical and sanitary consequences of emergencies, and almost all of these teams that provided medical aid to victims of emergencies in the pre-hospital period belonged to the Disaster Medicine Service (DMS) of the subjects of the Russian Federation (hereinafter – subjects). In particular, a landmark event in that year was the medical support of events with a large number of participants, such as the forum "Tavrida" (Sudak) and "Big Change" (Artek), where medical care for Roscosmos employees (Baikonur, Svobodny) was provided by specialists of the combined mobile medical unit (CMU) of the Federal Medical and Biological Agency (FMBA) – [2].

Despite changes in the foreign policy of the Russian Federation, work continues to be done on certification, improving the level of medical and logistical equipment, improving the organization of work at the national and international levels of international emergency medical teams (EMTs) [3, 4].

The involvement of specialists from military-medical organizations (MMO) of district and central subordination into non-staff formations (NF) of the Emergency Medicine Service of the Russian Ministry of Defense is a significant aid for EMT specialists [5]. These formations are designed to reinforce special-purpose medical units and civil and military health care organizations which carry out mass reception of victims in emergencies. The peculiarity of the formation of non-staff units of the Ministry of Defense of Russia is that in determining their composition an important role is played by the definition, taking into account the experience of military medicine, of the structure and medical and evacuation characteristics of sanitary losses in emergencies of natural and man-made nature [6]. The organizational core of the non-staff formations are the specialized medical aid brigades (SMAB) in the structure of which the surgical (19,0%), therapeutic (11,8%), anesthesiologist-resuscitation (9,5%), infectious (8,8%) and traumatology (8,6%) profile brigades prevail. Visiting brigades are represented by paramedic (72.0%), general practitioner (21.0%), and physician specialized teams (7.0%) – [7].

An actively developing concept is the achievement of comprehensive interaction of the involved forces and means of ministries, agencies and services, solving the task of elimination of medical and sanitary consequences of emergencies and included in the All-Russian Medical Center, with unified levels of management and interaction under the current regulatory legal framework, unified views on the organization of medical and evacuation support of population af-

affected in emergencies, unified systems of personnel training, information and statistical work and comprehensive support. At the same time, medical specialists of different departments often have different views on the organization of medical support of the population affected in emergencies, which, in turn, may have a negative impact on the continuity and sequence of measures for the wounded, sick and injured. The effective operation of non-staff formations of DMS (hospitals, detachments, brigades, groups) of different departments is impossible without vertical and horizontal feedback, first of all, in the format of responses to the emerging requests from the medical specialists within the non-staff formations of DMS, taking part in the liquidation of medical and sanitary consequences of the emergency. Thus, the optimization of the involvement of medical staff of hospital-type organizations in various formations in the liquidation of medical and sanitary consequences of emergencies is an urgent problem.

**The aim of the study** was to investigate and to evaluate the readiness of military medical specialists and civilian personnel of the Ministry of Defense of Russia's central and district military units, as well as of medical specialists from organizations of the Ministry of Health and FMBA of Russia, involved in the non-staff units to work on the elimination of medical and sanitary consequences of emergencies.

**Materials and Methods.** The study was conducted by two groups of respondents: medical specialists of different levels in the medical institutions of the Russian Ministry of Health and the Federal Medical and Biological Agency (MOH-FMBA group,  $n = 255$ ) and military medical specialists and civilian personnel of the Russian Ministry of Defense, central and district levels of responsibility (MMO-MD group,  $n = 227$ ). The source of the data was the questionnaires of the sociological study of non-staff specialists from the MOH-FMBA and MMO-MD. The general characteristic of a medical specialist was studied, his/her professional activity was evaluated both at the main place of work and as a member of the DMS non-staff formations in the modes of high alert and emergency situations. A separate block of the questionnaire was an assessment of medical specialists' readiness to work to eliminate medical and sanitary consequences of emergencies. In addition, their satisfaction with their practical work was assessed (in parentheses the abbreviations are given):

- staffing of the DMS non-staff units with medical personnel when working in the modes of high readiness and emergency (staffing);
- compliance of the organizational and staff structure of control bodies of the DMS non-staff units with the mission objectives (adequacy);
- indicators of readiness of the DMS non-staff units (readiness);
- availability of medical specialists trained in air ambulance evacuation (air evacuation staff\*);
- level of theoretical knowledge and practical skills of medical specialists of the DMS non-staff units (knowledge and skills);
- system of professional training of medical and paramedical staff of the DMS non-staff units (training system);
- availability of necessary collective and personal protective equipment (PPE) and the possibility of using it in the emergency area (provision of PPE);
- procedure for staffing and inspections of the DMS non-staff units (order of staffing);

- availability of a set of medical equipment appropriate for work in the emergency zone (availability in the emergency zone);

- availability of governing documents regulating the activities of the medical service of the Armed Forces of the Russian Federation in response to the medical and sanitary consequences of an emergency (emergency regulations).

Responses to the questionnaire questions were evaluated on a five-point scale: "not satisfied" — 1 point; "difficult to answer" — 2 points; "not fully satisfied" — 3 points; "more satisfied than not satisfied" — 4 points; "fully satisfied" — 5 points.

For the statistical analysis of the data, we selected a number of programs that are most suitable for the solution of the set tasks. In particular, we used the PAST program (<https://www.nhm.uio.no/english/research/resources/past/>), which uses the most reliable modern nonparametric procedures for statistical processing and checking the statistical significance of the observed effects. The bulk of the obtained data was statistically processed using the software product IBM® SPSS® Statistics version 25. Normality of distribution of the studied groups was assessed using the Shapiro-Wilk criterion. Continuous normally distributed data were presented as mean and standard deviation ( $M(SD)$ ); in case of distribution different from normal, data were presented as median and interquartile range —  $Me(Q1-Q3)$ . Categorical data are presented as units and percentages (fractions). In some cases, in addition to the median and interquartile range, the survey results are presented as absolute values of the number and frequency of responses for each categorical score, as well as the mean score and standard deviation. Significance of differences between groups of variables compared for continuous data was assessed using: t-test for normal distribution of data; Mann-Whitney U-test for independent groups in case of non-normal distribution. When analyzing categorical data, the significance of differences between the groups was determined using the  $\chi^2$  criterion. Correlation analysis with calculation of Spearman's rank correlation coefficient ( $r_s$ ) was performed to study the dependence between quantitative characteristics [8]. The method of exploratory factor analysis was used to identify the most significant features [9]. In all cases differences were considered statistically significant at  $p < 0.05$  values.

**Results of the study and their analysis.** The mean age of the respondents from the MOH-FMBA group ( $n = 255$ ) was significantly greater than that of the MMO-MOD group ( $n = 227$ ). Women predominated in the MOH-FMBA group (60.6%); men predominated in the WMO-MOD group (69.2%). The WMO-MOD specialists had a narrower specialization of the teams, while the MOH-FMBA group had more general and broader team profiles. In both groups, the physician-nursing teams dominated among the various SMAB, but whereas in the WMO-MOD group the therapeutic general and surgical general teams ranked second and third in prevalence, 14.5% and 11.0%, respectively, in the MOH-FMBA group, the emergency medical team and toxic-therapeutic team ranked second and third, 16.9% and 14.5%, respectively. Subspecialized SMABs accounted for the smallest share (Fig. 1).

\*In the scientific literature on disaster medicine the term "air ambulance evacuation" is used to refer to medical evacuation with the use of air transport. In this article, the terms "air ambulance evacuation" and "air evacuation" are equivalent

The specialists of the MOH-FMBA group had significantly more years of service in the non-staff formations and more experience in dealing with medical and sanitary consequences of emergencies. In addition, employees of the MOH-FMBA group were significantly more likely to be involved in the elimination of medical and sanitary consequences of emergencies.

In most cases, the respondents were completely satisfied with the state of readiness and the results of the practical work of medical specialists of DMS non-staff formations to eliminate medical and sanitary consequences of emergencies. At the same time, the attribute "availability of medical specialists for air ambulance evacuation" caused confusion among the respondents when choosing the appropriate assessment — in most cases (34.9%) the answer "difficult to answer" was preferred (Table 2).

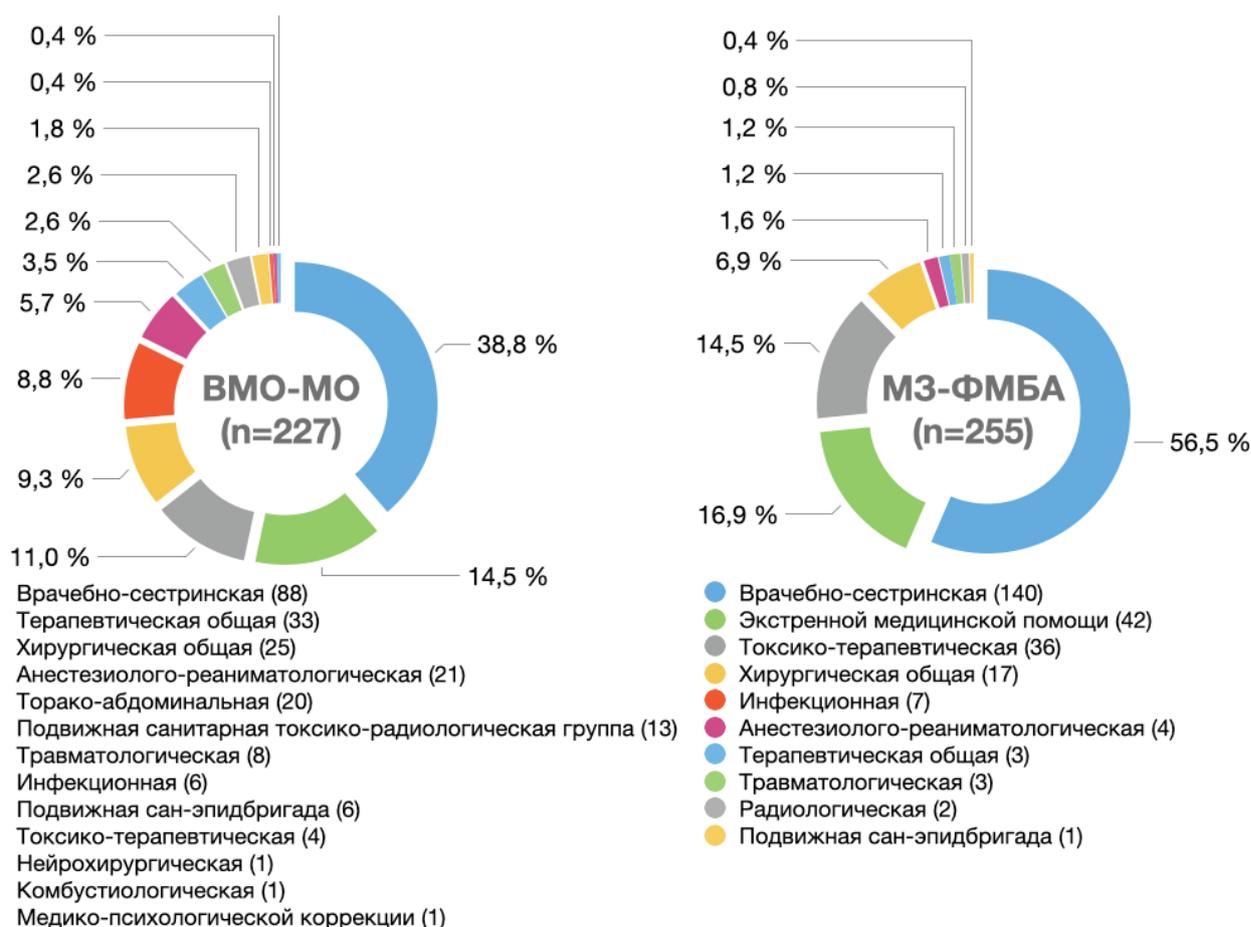
Thus, with the exception of the question about air evacuation staffing, most respondents in both groups were satisfied with the state of readiness and the results of practice (28.4-42.9%). Nevertheless, there were a number of nuances behind the respondents' positive responses and satisfaction, which necessitated a detailed analysis of all responses.

At least a quarter of the respondents gave each questionnaire item the highest rating; in almost all questions the median was 4, i.e., at least half of the respondents gave rat-

ings of 4 and 5. The correlation analysis of the respondents' answers revealed the following significant correlations between the indicators of readiness for emergency response and satisfaction with the results of practical activity: questions 5 (knowledge and skills) and 6 (training system),  $r = 0.780$ ; 7 (provision with protective equipment) and 9 (provision in the emergency zone),  $r = 0.600$ ; 2 (compliance of organizational and staff structure with the tasks) and 3 (readiness) —  $r = 0.580$ . All correlations were positive, i.e. there were no such pairs of questions when a positive answer to one question implies a negative answer to the second question (Fig. 2).

For two of the three items with statistically significant differences ("knowledge and skills" and "provision with protective equipment") the answers of medical specialists of the MOH-FMBA group, compared to the answers of respondents of the MMO-MOD group, were more positive (significance of differences  $p = 0.011$  and  $p = 0.014$  respectively, 2 criterion). Only on the issue of air ambulance evacuation were the specialists of the MMO-MOD group more satisfied,  $p = 0.014$  (Table 3).

Correlation analysis of the respondents' within-group responses revealed significant differences in opinions and judgments. The number of high correlation coefficients in the MMO-MOD group was lower than in the MOH-FMBA



**Рис. 1.** Профили бригад специализированной медицинской помощи нештатных формирований групп МЗ-ФМБА и ВМО-МО (в скобках приведено число специалистов)  
 Примечание. МЗ-ФМБА – медицинские организации Минздрава и ФМБА России; ВМО-МО – военно-медицинские организации Минобороны России центрального и окружного подчинения  
**Fig. 1.** Profiles of specialized medical care teams of non-staff groups of MZ-FMBA and VMO-MO (number of specialists is given in parentheses)  
 Note: MZ-FMBA – medical organizations of the Russian Ministry of Health and Federal Medical Biological Agency; VMO-MO – military medical organizations of the Russian Ministry of Defense of central and district subordination

**Характеристика респондентов групп ВМО-МО и МЗ-ФМБА**  
 Characteristics of respondents of WMO-MO and MZ-FMBA groups

Характеристика Characteristic	Группа ВМО-МО, n=227 WMO-MO group, n=227		Группа МЗ-ФМБА, n=255 MZ-FMBA group, n=225		Р
Средний возраст, лет – M(SD) Mean age, years - M(SD)	38,4/6,8		46,1/11,4		<0,001
Число /доля мужчин, чел./% Number/proportion of men, people/%	157/69,2		100/39,4		<0,001
Служебный статус, чел./% Service status, people/%	Военнослужащие Servicemen	174/76,7	Сотрудники МО Минздрава России Russian Ministry of Health medical organisation employee	206/80,8	-
	Лица гражданского персонала Civilian Personnel	53/23,3	Сотрудники МО ФМБА России FMBA medical organisation employee	49/19,2	
Стаж работы в составе нештатных формирований, лет – Me(Q1-Q3) Length of service in non-staff units, years - Me(Q1-Q3)	3,0/1,0-5,0		6,0/2,0-15,0		<0,001
Наличие опыта работы по ликвида- ции медико-санитарных послед- ствий ЧС, чел./% Experience in dealing with the medical and sanitary consequences of emergencies, persons/%	62/24,4		123/54,4		<0,001

Примечания. М – среднее значение; Me – медиана; Q1 – значение 25-го процентиля; Q3 – значение 75-го процентиля;  
 SD – стандартное отклонение  
 Notes. M – mean; Me – median; Q1 – 25th percentile value; Q3 – 75th percentile value; SD – standard deviation

Таблица 2/ Table No. 2

**Общие результаты анкетирования (n=482) по вопросам готовности к работе по ликвидации  
 медико-санитарных последствий ЧС и удовлетворенности результатами работы, чел./%**

Total questionnaire results (n=482) on readiness to work to eliminate  
 medical and sanitary consequences of emergencies and on satisfaction with the results of the work, people/%

№ воп- роса анкеты Question number	Показатель Indicator	Ответы / Responses				
		не удовле- творён not satisfied	затрудняюсь ответить difficult to answer	удовлетворён не в полной мере not fully satisfied	больше удовлетворён, чем не удовлетворён more satisfied than dissatisfied	полностью удовлетворён fully satisfied
1	Укомплектованность / Staffing	12/2,5	82/17,0	92/19,1	98/20,3	<b>198/41,1</b>
2	Соответствие задачам / Compliance with the objectives	6/1,2	119/24,7	69/14,3	105/21,8	<b>183/38,0</b>
3	Готовность / Readiness	18/3,7	106/22,0	81/16,8	130/27,0	<b>147/30,5</b>
4	Штаты авиаэвакуации Air evacuation staff	27/5,6	<b>168/34,9</b>	79/16,4	71/14,7	137/28,4
5	Знания и навыки Knowledge and skills	16/3,3	92/19,1	75/15,6	120/24,9	<b>179/37,1</b>
6	Система подготовки Training system	21/4,4	88/18,3	88/18,3	114/23,7	<b>171/35,5</b>
7	Обеспеченность средствами защиты Availability of protective equipment	22/4,6	91/18,9	105/21,8	93/19,3	<b>171/35,5</b>
8	Порядок комплектования Order of staffing	25/5,2	126/26,1	79/16,4	110/22,8	<b>142/29,5</b>
9	Обеспеченность в зоне ЧС Provision in the emergency area	15/3,1	70/14,5	86/17,8	104/21,6	<b>207/42,9</b>
10	Регламенты в ЧС Regulations in emergencies	12/2,5	98/20,3	79/16,4	86/17,8	<b>207/42,9</b>

group civilian specialists. This may indirectly point to the fact that for military-medical specialists and civilian MMO personnel each indicator of readiness for emergency medical and sanitary consequences elimination and their satisfaction with the results of practical activity have their own separate semantic context, while for civilian medical specialists many indicators are interrelated in their semantic context and are close to each other. For example, the order of staffing and inspections of non-staff formations (item 8) among civilian specialists is inseparable from all other items – the correlation coefficients are 0.5-0.7. At the same time, strong cor-

relations were revealed for virtually all other indicators (Figure 3).

Thus, in the MMO-MOD group a significant relationship was found only between the following questions: 5 (knowledge and skills) and 6 (training system) with  $r = 0.76$ , as well as a weak correlation between questions 4 (aviation evacuation staff) and 5 (knowledge and skills) with  $r = 0.51$ . Otherwise, military medical specialists and MMO civilian personnel did not correlate the indicators presented with any of the others - the values of all correlation coefficients were below 0.5.

The results we obtained were subjected to factor analysis, which made it possible to rank the studied indicators reflected in questions and to process them for subsequent interpretation and presentation in the form of macrocategories. Among all the respondents the first factor (factor 1) distributed its load on the following strongly correlated criteria: the level of theoretical knowledge and practical skills of the medical specialists of DMS non-staff units — factor load (FL) - 0.76; the system of professional training of medical and paramedical personnel from the DMS non-staff units — FL — 0.74; availability of guidance documents regulating the medical service of the Armed Forces in response to the medical and sanitary emergency consequences — FL — 0.6; availability of protective equipment and its possible usage in emergency — FL — .55. As a result, the contribution of factor 1 in the total variance of the initial attributes was maximum — 28,1%, and was defined by us as "Special training and provision with medical and other material and technical equipment of the DMS non-staff units in the mode of daily activities to perform tasks according to the intended purpose" (abbreviated as "Professionalism and comprehensive provision of medical specialists"). The second factor (factor 2) distributed its load on the following attributes: the indicators of advance readiness of the DMS non-staff units — FL — 0,79; correspondence of the organizational and staff structure of the DMS non-staff units management bodies to the tasks for mission — FL — 0,66; the indicators of staffing with medical personnel of the DMS non-staff units — FL—0,57; availability of medical specialists in medical and aviation evacuation — FL — 0,47. As a result, the contribution of factor 2 to the total variance of the initial characteristics was the maximum — 22.6%, and was designated by us as "Assessment of readiness of non-staff formations in the mode of daily activity to perform tasks on mission" (abbreviated as "Readiness for activity" (Fig. 4).

The analysis of the factors influencing the training of medical specialists in the DMS non-staff units and their practical

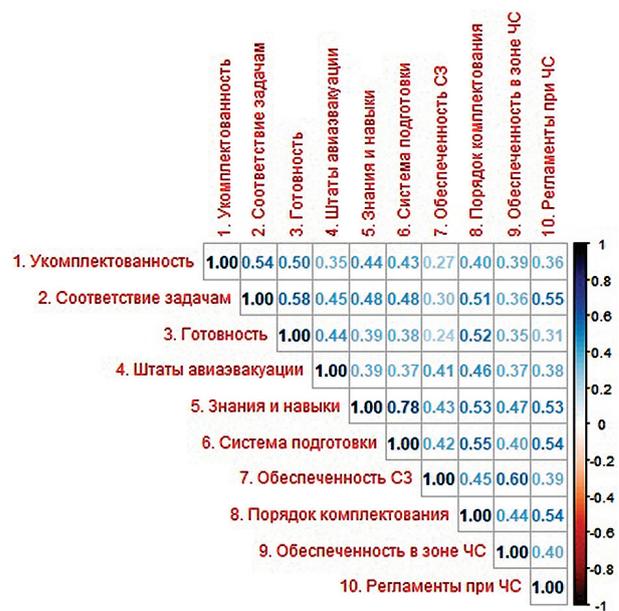


Рис. 2. Коэффициенты корреляции Спирмена для ответов всех респондентов. СЗ — средства защиты  
Fig. 2. Spearman correlation coefficients for all respondents' answers

activity in the elimination of medical and sanitary consequences of emergencies resulted in the formation of 2 groups of factors, the total variance of which was 50.7%, and the content analysis of the results allowed us to identify 2 fundamental generalizing factors: "Professionalism and comprehensive provision of medical specialists" and "Readiness for activity" (Fig. 5).

Factor analysis of the respondents' answers was performed separately for each group under study. It was determined that the principal structure of the factors did not change, but the totality of the indicators changed. It is interesting to note that the "System of professional training of med-

Таблица 3/ Table No. 3  
Результаты опроса респондентов групп ВМО-МО (n=227) и МЗ-ФМБА (n=255) по вопросам готовности к работе по ликвидации медико-санитарных последствий ЧС и удовлетворенности результатами работы

Survey results of WMO-MO (n=227) and MZ-FMBA (n=255) groups respondents on readiness to work to eliminate medical and sanitary consequences of emergencies and on satisfaction with the results of the work

№ вопроса анкеты Question number	Показатель Indicator	Группа ВМО-МО (n=227) WMO-MO group (n=227)		Группа МЗ-ФМБА (n=255) MZ-FMBA group (n=227)		P
		Me(Q1-Q3)	M(SD)	Me(Q1-Q3)	M(SD)	
1	Укомплектованность / Staffing	4,0 (3,0-5,0)	3,9(1,2)	4,0 (3,0-5,0)	3,8(1,3)	0,260
2	Соответствие задачам Compliance with the objectives	4,0 (3,0-5,0)	3,7(1,2)	4,0 (2,0-5,0)	3,7(1,3)	0,650
3	Готовность / Readiness	4,0 (3,0-5,0)	3,6(1,2)	4,0 (2,0-5,0)	3,6(1,3)	0,570
4	Штаты авиаэвакуации Air evacuation staff	3,0 (2,0-5,0)	3,4(1,3)	2,0 (2,0-5,0)	3,2(1,4)	0,014
5	Знания и навыки Knowledge and skills	4,0 (3,0-5,0)	3,6(1,2)	4,0 (3,0-5,0)	3,9(1,2)	0,011
6	Система подготовки / Training system	4,0 (3,0-5,0)	3,7(1,2)	4,0 (2,50-5,0)	3,7(1,3)	0,720
7	Обеспеченность средствами защиты Availability of protective equipment	3,0 (3,0-5,0)	3,5(1,2)	4,0 (2,5-5,0)	3,7(1,3)	0,014
8	Порядок комплектования Order of staffing	3,0 (2,5-4,0)	3,4(1,2)	4,0 (2,0-5,0)	3,6(1,3)	0,090
9	Обеспеченность в зоне ЧС Provision in the emergency area	4,0 (3,0-5,0)	3,8(1,2)	4,0 (3,0-5,0)	3,9(1,2)	0,350
10	Регламенты в ЧС Regulations in emergencies	4,0 (3,0-5,0)	3,7(1,2)	4,0 (2,0-5,0)	3,9(1,3)	0,080

Примечания. М — среднее значение; Me — медиана; Q1 — значение 25-го перцентеля; Q3 — значение 75-го перцентеля; SD — стандартное отклонение  
Notes. M — mean; Me — median; Q1 — 25th percentile value; Q3 — 75th percentile value; SD — standard deviation

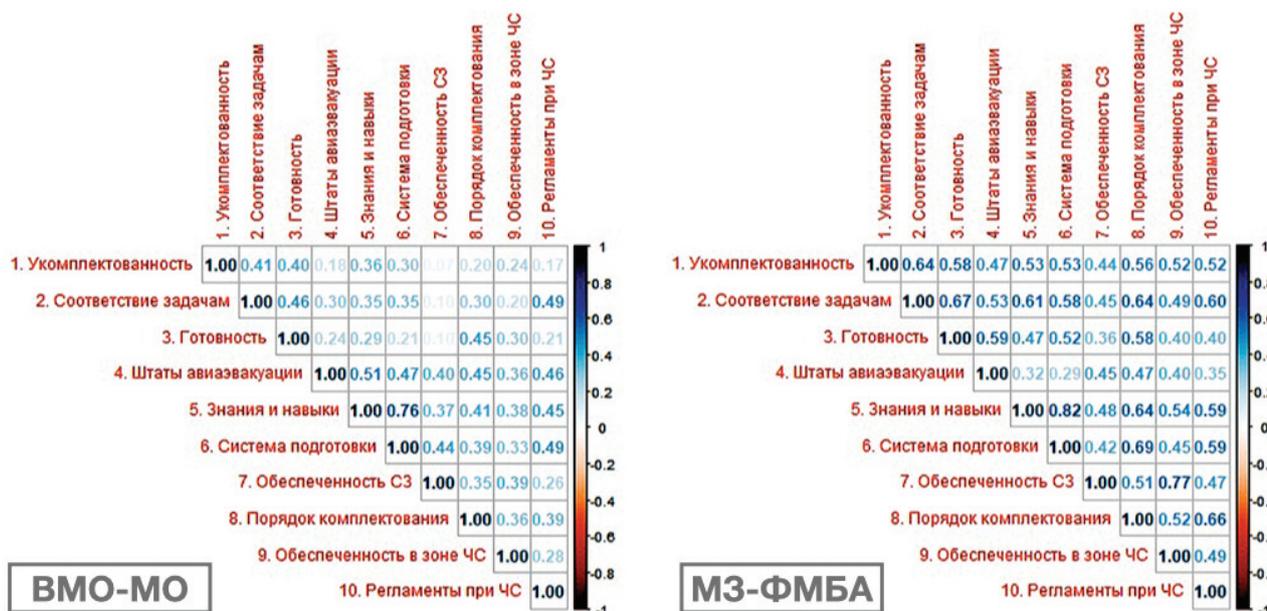


Рис. 3. Корреляционные связи между ответами на разные вопросы респондентов групп ВМО-МО и МЗ-ФМБА (критерий Спирмена). В ячейках таблицы приведены значения коэффициентов корреляции  
 Fig. 3. Correlations between answers to different questions of respondents of VMO-MO and MZ-FMBA groups (Spearman criterion). The values of correlation coefficients are given in the table cells

ical and paramedical staff from the DMS non-staff units" (FL — 0.74) in the MMO-MOD group was regarded as an element of the special training process of the DMS non-staff units in the mode of daily activity to perform tasks for destination, and for the MOH-FMBA group it was an element of the final readiness for activity for destination (FL — 0.86). Thus, for civilian medical specialists the main factor is the current readiness to perform activities to eliminate medical and sanitary consequences of emergencies, and for military-medical specialists the main factor is the system of special training of persons included in the DMS non-staff units. Indicators 5 (knowledge and skills = 0.72) and 6 (training system = 0.74) had the highest loadings on this question. Regarding the current readiness factor, the most important indicators for respondents in both groups were 1 (staffing = 0.53 and 0.59 for military medical specialists and civilian medical specialists, respectively), 2 (task appropriateness =

0.65 and 0.62 for MMO-MOD and MOH-FMBA groups, respectively), and 3 (readiness = 0.74 and 0.63 for MMO-MOD and MOH-FMBA groups, respectively). It is also interesting that indicator 4 (air evacuation staffs) proved to be the most important factor (with the highest load of 0.7) in the current readiness of civilian medical specialists, while for military medical specialists, in contrast, this indicator was significant in the factor of planned training (0.64). Accordingly, the contribution of factor 1 to the total variance of baseline traits for military medical specialists was 26.9%, and for factor 2 = 18.3%, a total of 45.2%. The contribution of factor 1 to the total variance of baseline traits for civilian medical specialists was 30.2%, factor 2 = 28.3% - total = 58.5% (Figure 6).

### Conclusion

As a result of the analysis we obtained the results reflecting the private opinion of the respondents in the general population of different professional groups of medical specialists included in the DMS non-staff units. It was noted that the majority of respondents present job satisfaction and readiness for the activities of medical and sanitary consequences of emergencies. The respondents from the medical organizations of the Russian Ministry of Health and FMBA of Russia included the most experienced medical specialists in the liquidation of medical and sanitary consequences of emergencies, which affected the general trend of their responses in assessing the readiness of the DMS non-staff units specialists to work in various modes of operation. For more frequent involvement of medical specialists of the DMS non-staff units of the Ministry of Defense of Russia it is necessary to actively promote at the regional and federal levels the use of forces and means of the medical service of the Armed Forces of the Russian Federation during joint actions of all federal executive bodies for liquidation of medical and sanitary consequences of emergencies [10].

The most important factors influencing the professional activity of medical specialists in the DMS non-staff units of dif-

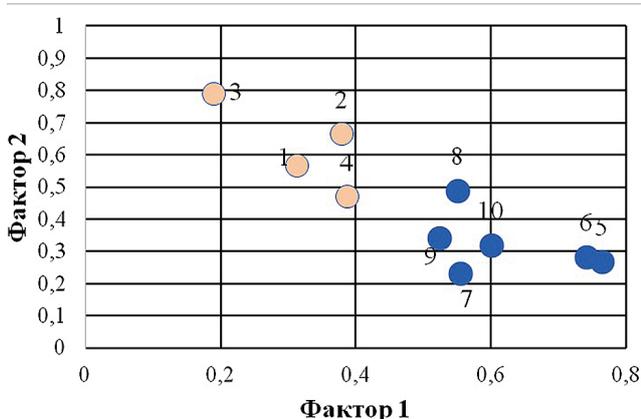


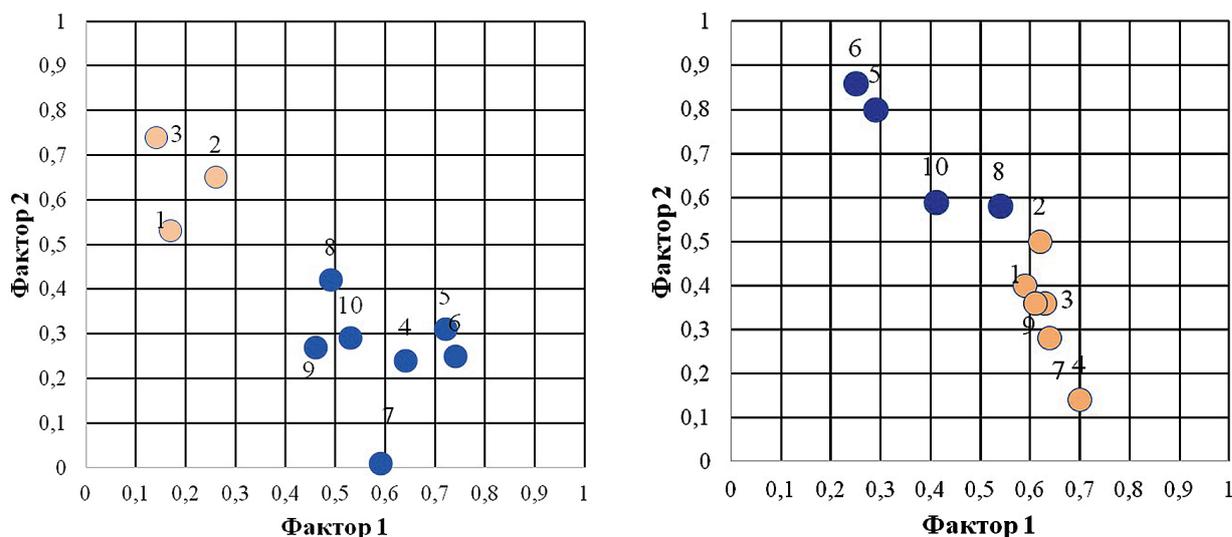
Рис. 4. Факторные нагрузки ответов всех респондентов групп ВМО-МО и МЗ-ФМБА. Цифрами обозначены номера вопросов анкеты  
 Fig. 4. Factor loadings of answers of all respondents of VMO-MO and MZ-FMBA groups. Numbers indicate the numbers of the questions in the questionnaire



**Рис. 5.** Факторные нагрузки главных факторов и их структура по ответам всех респондентов групп ВМО-МО и МЗ-ФМБА  
**Fig. 5.** Factor loadings of the main factors and their structure according to the answers of all respondents of VMO-MO and MZ-FMBA groups

ferent departments should be considered special training and provision with medical and other material and technical equipment in the mode of daily activity to perform tasks as intended, and assessment of readiness of the DMS non-staff units in the mode of daily activity to perform tasks as intended. Accordingly, health authorities of different levels should pay attention to the state of material and technical base of medical (military-medical) organizations designed (oriented) to eliminate medical and sanitary consequences of emergencies, the need to equip them with medical equipment in case of medical and aviation evacuation (on board the aircraft), availability and quality condition of medical

evacuation vehicles and their equipment, as well as the availability of sufficient means of individual protection. Assessment of readiness, in our opinion, should include both assessment of qualitative measures on organization of interaction with management bodies and medical specialists of other federal ministries, agencies and services, participating in liquidation of medical and sanitary consequences of emergency situations, and normative-legal regulation of their activity in DMS non-staff units. The studied indicators of readiness to work on liquidation of medical and sanitary consequences of emergencies, satisfaction with the results of practical activities as well as the opinion of medical spe-



**Рис. 6.** Факторные нагрузки ответов респондентов из группы «военно-медицинские специалисты и гражданский персонал ВМО Минобороны России центрального и окружного подчинения» (слева) и группы «медицинские специалисты из состава медицинских организаций Минздрава и ФМБА России» (справа)  
**Fig. 6.** Factor loadings of the answers of respondents from the group "military-medical specialists and civilian personnel of the Ministry of Defense of Russia of central and district subordination" (left) and from the group "medical specialists from medical organizations of the Russian Ministry of Health and the Federal Medical Biological Agency of Russia" (right)

cialists of different departments will allow in the medium term to eliminate drawbacks that directly or indirectly influence the organization of medical support of the population during the liquidation of medical and sanitary consequences of emergencies.

#### Final conclusion

1. The results of the study of the peculiarities of the work of the DMS non-staff units allow to conclude about the relevance of this direction in the general system of ensuring the liquidation of medical and sanitary consequences of emergencies.

2. The most important factors are special training and provision of the DMS non-staff units with medical and other logistical equipment when working in the mode of daily activities to fulfill the tasks, as well as the readiness of the DMS non-staff units.

3. The assessment of readiness should be formed of qualitative measures on the organization of interaction with the management bodies and medical specialists of federal ministries, agencies and services involved in the elimination of medical and sanitary consequences of emergencies, and normative legal regulation of their activities within the DMS non-staff units.

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## ВАРИАНТ ОРГАНИЗАЦИИ РАБОТЫ ТЕРРИТОРИАЛЬНОГО ЦЕНТРА МЕДИЦИНЫ КАТАСТРОФ РЕСПУБЛИКИ КРЫМ ПРИ УГРОЗЕ ОДНОВРЕМЕННОГО СОВЕРШЕНИЯ НЕСКОЛЬКИХ ТЕРРОРИСТИЧЕСКИХ АКТОВ

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**Резюме.** Цель исследования – выбор оптимального формата действий формирований Службы медицины катастроф (СМК), скорой медицинской помощи (СМП), гражданской обороны (ГО), территориального центра медицины катастроф (ТЦМК) Республики Крым при реагировании на угрозу одновременного совершения нескольких террористических актов.

**Материалы и методы исследования.** Проанализирована работа бригад СМП и СМК Республики Крым по защите населения при угрозе одновременного совершения нескольких террористических актов в январе-апреле 2022 г.

**Результаты исследования и их анализ.** Обоснован расчёт количества и состава формирований по оказанию экстренной медицинской помощи (ЭМП) при первичном реагировании на угрозу одновременного совершения нескольких террористических актов на пяти и более разнорасположенных объектах (территориях) в одном населённом пункте или отдельном районе. Определены состав и задачи оперативной группы по предупреждению и ликвидации медико-санитарных последствий чрезвычайных ситуаций (ЧС), в том числе террористических актов. Отмечено, что обучение личного состава СМК по вопросам гражданской обороны и защиты в ЧС в системе дополнительного профессионального образования является наиболее перспективной формой подготовки персонала к работе в условиях угрозы (возникновения) чрезвычайных ситуаций

**Ключевые слова:** гражданская оборона, ликвидация медико-санитарных последствий, Республика Крым, скорая медицинская помощь, Служба медицина катастроф, территориальный центр медицины катастроф, террористические акты, чрезвычайные ситуации, экстренная медицинская помощь

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## THE OPTION OF ORGANIZING THE WORK OF THE TERRITORIAL CENTER FOR DISASTER MEDICINE OF THE REPUBLIC OF CRIMEA UNDER THE THREAT OF SEVERAL SIMULTANEOUS TERRORIST ACTS

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**Summary.** The aim of the study is to choose the optimal format of actions of the formations of the Disaster Medicine Service (DMS), Emergency Medical Service (EMS), Civil Defense (CD), Territorial Center for Disaster Medicine (TCDM) of the Republic of Crimea when responding to the threat of several terrorist acts occurring simultaneously.

**Materials and research methods.** The work of the emergency medical teams and disaster medicine service of the Republic of Crimea on the protection of the population in case of a threat of several terrorist acts occurring simultaneously in January-April 2022 was analyzed.

**Results of the study and their analysis.** Calculation of the number and composition of emergency medical service formations for primary response to the threat of several simultaneous terrorist acts at five or more differently located objects in one settlement or separate district was substantiated. The composition and tasks of the task force for prevention and elimination of medical and sanitary consequences of emergencies (terrorist acts) were defined. It is noted that the training of DMS personnel in civil defense and protection in emergencies in the system of additional professional education is the most promising form of personnel training for work under the threat (occurrence) of emergency situations.

**Key words:** civil defense, Disaster Medicine Service, elimination of medical and sanitary consequences, emergencies, emergency medical aid, Republic of Crimea, Territorial Center for Disaster Medicine, terrorist acts

**Conflict of interest.** The authors declare no conflict of interest

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**Introduction**

The principles of emergency medical aid (EMT) to victims in emergency situations (ES) are based on the general provisions of the system of public health care and emergency medical aid [1, 2]. Recently, in the Republic of Crimea there were mass reports of simultaneous bombing of a number of educational institutions and socially significant objects, which could lead to a large number of victims in need of emergency medical care admitted to medical treatment organizations (MTOs). According to Order No. 388n of the Russian Ministry of Health "On Approval of the Procedure for the Provision of Emergency, including Specialized Emergency Medical Care" dated 20.06.2013, in each case of a threat of an emergency situation, mobile emergency medical teams are organized on duty. It should be noted that the capacity of ambulance and Disaster Medicine Service (DMS) as the most mobile formations of regional health care in case of a simultaneous threat of an emergency at dozens of facilities in one locality is limited by the available resources of the service "103", which does not allow to provide a full-time duty of emergency medical teams at the sites of possible events [3].

**The purpose of the study** is to choose the optimal format of the activities of the formations of the Disaster Medicine Service, Emergency Medical Care, Civil Defense of the State Budget Institution "Crimean Republican Center of Emergency Medicine and Emergency Medical Care" (further – TCDM) when responding to a threat of a terrorist act.

**Materials and research methods.** The functioning of units of the Emergency Medical Service and Territorial Disaster Medicine Service of the Republic of Crimea while reacting to a potential threat of an emergency situation (an act of terrorism) on the territory of the Republic in January-April 2022 was analyzed.

The organization and implementation of medical support of the population under the threat of terrorist acts, as well as the creation, preparation, preparedness and improvement of management bodies, formations and institutions of the DMS of the Republic of Crimea to act in an emergency in the following areas were evaluated:

- work of a dispatcher post for collecting information, notification, transferring calls to ambulance crews and mobile emergency response teams (MERT);
- bringing the Disaster Medicine Service and ambulance units in readiness and work under the threat of emergencies;
- civil defense activities and protection of the population from emergencies, including terrorist attacks [4-6].

**Research results and their analysis.** The TCDM includes the following structural subdivisions for rendering emergency and urgent medical aid to the citizens of the Republic of Crimea: an ambulance service consisting of 7 stations and 25 substations of the emergency medical services and 54 permanent locations for the emergency medical

teams; a department of the Disaster Medicine Service; a department for emergency consultative medical aid and medical evacuation; Republican Telemedical Center.

According to the existing standard, the Republic of Crimea should have at least 191 ambulance teams. As of the end of 2021, only 158 ambulance teams and three emergency medical teams of the Emergency Medical Service of the Republic of Crimea were functioning. There is a deficit of 37 emergency medical teams. The share of the various EMTs on the line: 108 paramedics (70.2%); 44 general practitioners (28.5%); 2 specialized (1.3%).

In each case of a terrorist threat, an DMS emergency response team or an EMT team is sent to the place of the alleged event to be on duty.

Thus, on January 21, 2022, when signals were received about the threat of simultaneous terrorist attacks of mass character at 27 sites in one settlement and more than 5 sites in two other urban districts, 28 EMTs and 3 DMS emergency response teams were sent on duty. The peculiarity of the terrorist attack was that the vast majority of follow-up reports were received in the first 2 hours after the first report.

It was found that in a short period of time to ensure security at these facilities in one settlement, almost 75% of the outreach EMTs serving the area were involved. At the same time, the time teams were on duty for medical support of demining activities ranged from 1 to 8 hours, which had a negative effect on the provision of emergency and urgent medical care to the population.

Taking into account the existing deficit of medical personnel and EMTs in the Republic of Crimea, in order to optimize the work of EMTs in case of emergency response and mass terrorist acts in one settlement and separate district, the following algorithm of organization of allocation of EMTs for ensuring demining and elimination of possible medical and sanitary consequences of emergency was proposed.

If there is a threat of an emergency or mass terrorist acts in one populated area or a separate district, when 5 or more remote objects can be attacked or become out of order, the head of the EMT station (substation) of the service area shall not simultaneously send EMTs to each vulnerable object. The place of gathering of the emergency formations (EMTs, emergency response teams, teams of specialized medical aid) is determined, taking into account its optimal remoteness both from the epicenters of emergency and from MTO of the region, ready to receive the victims, where the task force for prevention and elimination of emergency consequences is formed (Table).

The task force consists of the head of the emergency station / substation (head of the group); Civil Defense Commissioner; personnel of the teams.

The functions of the task force for prevention and elimination of the consequences of emergencies located at the as-

sembly point of the emergency medical aid formations include:

- ensuring personal safety and the safety of crews arriving at the assembly point of the emergency medical aid formations;
- organizing communications: with the operative headquarters for emergency prevention and liquidation of the response area; with the dispatch service of the ambulance station (substation); with the dispatch service of the TCDM; with other emergency services;
- report to the TCDM dispatcher on arrival of the task force to the place of gathering of the formations;
- constant communication with operational headquarters of objects for prevention and liquidation of emergencies, heads of rescue operations;
- management of subordinate forces and means involved in emergency response in accordance with the decisions of the head of emergency response.

Thus, justified and developed an algorithm of action for the allocation of EMTs and emergency response teams in case of the threat of an emergency, committing mass terrorist acts simultaneously on five or more differently located objects in one locality or district. The key point is to determine the place of assembly of EMT formations, taking into account its optimal remoteness from both the epicenters of emergency and MTOs, ready to receive the victims, in which operational group on prevention and elimination of consequences of emergency (terrorist acts) is formed, as well as to calculate the number of allocated EMT formations.

In addition, in order to provide a comprehensive response to the cases of a one-time threat of a number of terrorist acts, taking into account the need to process, receive and transmit a large volume of information, the DMS dispatch post was transferred to round-the-clock duty (2 persons) with the reactivation of a previously equipped backup workplace of the dispatcher [7-9]. Such variant of work requires

involvement of free of shift paramedics of DMS department with emergency response teams and mobile medical detachment, trained in the volume of 36 hours on additional professional program "Advanced training of duty dispatch services, integrated with "112" system".

In connection with the measures taken to optimize the number of TCDM staff and to bring the staffing table in line with the regulatory requirements for the employees of the civil defense structural subdivisions, from July 2020 the positions of authorized persons for civil defense tasks were introduced in the department of emergency medicine services with emergency response teams and a mobile medical unit.

In January-April 2022 the organizational and staffing structure of the department of emergency medicine with emergency response teams and mobile medical detachment was represented by three blocks:

- a 24-hour dispatch post (operational dispatch DMS post) — paramedics to receive calls and transfer them to the ambulance teams;
- three emergency response teams, of which one medical anesthesiologist-resuscitation and two paramedics;
- four positions of Civil Defense Commissioner.

Thanks to the work aimed at interchangeability of employees of the EMT department with emergency response teams (training of personnel in civil defense and protection from emergencies, training in working with the "112" system), opportunities were created to reinforce the duty shift of the DMS dispatch post, conduct additional civil defense and personnel protection activities by the DMS's own forces.

This organization of work of EMT formations was tested on February 24 and 25, 2022 in real conditions of responding to a threat of terrorist attacks. As a result, at 34 social infrastructure facilities that were attacked, 8 EMTs were on duty instead of 34. This format of response made it possible to free up for the provision of emergency medical care when working in the mode of day-to-day operation 26 ambulance teams and to save 150 thousand rubles.

Thus, the suggested variant of the organization of the response to the threat of mass terrorist acts in five or more simultaneously separated objects (territories) in a single settlement / a separate region, makes it possible to involve the forces and means of the emergency medical services rationally, minimizing the negative consequences of distracting the ambulance crews from servicing the calls of the population.

### Conclusion

Optimization of an order of duty of the emergency medical aid formations in case of arrival of information on threat of emergency, including acts of terrorism, simultaneously on several objects of different distance assumes creation of a point of temporary accommodation of EMT teams, emergency response teams taking into account its optimum remoteness both from epicenters of emergency, and from MTOs of the region, ready to accept victims, and creation of operative group on prevention and liquidation of consequences of emergency.

2. Additional professional education of specialists of the outreach teams of emergency response teams on civil defense and protection in emergencies, employees of the dispatch services of TCDM integrated with the system "112", allows to optimize the activities of the DMS in the threat of a terrorist attack at the expense of involvement of their own staff.

Таблица /Table  
**Расчёт количества и состава бригад скорой  
медицинской помощи**  
Calculation of the number and composition of emergency  
medical teams

Количество одновременно возникающих очагов ЧС The number of simultaneously occurring foci of emergencies	Количество бригад Number of teams	Особые условия по составу бригад Special conditions for the composition of teams
5	Не менее 2 Nevertheless 2	1 врачебная, 1 фельдшерская 1 medical, 1 paramedic
6–10	Не менее 4 Nevertheless 4	2 врачебные, 2 фельдшерские 2 medical, 2 paramedic
11–15	Не менее 5 Nevertheless 5	2 врачебные, 3 фельдшерские 2 medical, 3 paramedic
16–20	Не менее 6 Nevertheless 6	2 врачебные, 4 фельдшерские 2 medical, 4 paramedic
21–25	Не менее 8 Nevertheless 8	3 врачебные, 5 фельдшерских 3 medical, 5 paramedic
> 25	Не менее 10 Nevertheless 10	3 врачебные, 7 фельдшерских 3 medical, 7 paramedic

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## ПСИХИЧЕСКОЕ ЗДОРОВЬЕ МЕДИЦИНСКИХ РАБОТНИКОВ В УСЛОВИЯХ ПАНДЕМИИ COVID-19

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**Резюме.** На разных этапах своего развития мировое сообщество неоднократно сталкивалось с различными катастрофами, стихийными бедствиями и эпидемиями. Не стала исключением и пандемия COVID-19, последствия которой, так или иначе, затронули каждого человека, но в большей степени – медицинских работников. Именно в условиях пандемии возникли и усугубляются распространенные факторы стресса, многие люди испытывают негативные психические и психологические её последствия. Однако уже сейчас, опираясь на накопленный опыт и стремительное развитие медицины, есть возможность повлиять на сохранение психического здоровья любого человека, а также вовремя выявить риски и предотвратить негативные последствия пандемии.

Сохранение психического здоровья медицинских работников – одна из важнейших задач, стоящих перед здравоохранением. Рассмотрены факторы, влияющие на психическое и психологическое состояние медицинских работников, а также возможные организационные меры поддержки сотрудников медицинских организаций во время пандемии.

**Ключевые слова:** медицинские работники, пандемия COVID-19, посттравматическое стрессовое расстройство, психическое здоровье, эмоциональный стресс

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Review report  
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## MENTAL HEALTH OF MEDICAL WORKERS UNDER COVID-19 PANDEMIC CONDITIONS

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**Summary.** At different stages of its development, the world community has repeatedly faced various disasters, natural calamities and epidemics. COVID-19 pandemic was no exception, the consequences of which, one way or another, affected everyone, but mostly medical workers. It is in the conditions of the pandemic that common stress factors emerged and aggravated, many people experienced negative mental and psychological consequences of it. However, based on the accumulated experience and the rapid development of medicine, there is an opportunity to influence the preservation of mental health of any person, as well as to identify risks and to prevent negative consequences of the pandemic.

Preservation of mental health of medical workers is one of the most important tasks of public health. Factors influencing mental and psychological state of medical workers as well as possible organizational measures to support medical workers during the pandemic are considered in the article.

**Key words:** COVID-19 pandemic, emotional stress, medical workers, mental health, post-traumatic stress disorder

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**Introduction**

The pandemic of new coronavirus infection COVID-19 is accompanied by a high level of stress among population. The long incubation period, moderate severity and — in many cases — asymptomatic course of COVID-19 contributed to its rapid spread throughout the world, not allowing rapid identification and localization of the emerging foci. In fact, the COVID-19 pandemic was the first pharmacologically uncontrollable pandemic of the digital age, a qualitatively new challenge that exceeded the limits of the health systems of many countries, with an extremely negative impact on the physical and mental well-being of health workers.

In the conditions of the pandemic, doctors and paramedical staff worked in an environment of various risks: risk of infection, risk of possible death, risk of infection of their close environment. It is known that prolonged exposure to a stress factor leads to a depletion of a person's functional reserves. As the result the medical worker's working ability and motivation for professional activity significantly decrease, which in its turn inevitably leads to the increase in the number of medical errors, and sometimes to the manifestation of negligence.

Attention to the mental health of medical personnel and timely measures taken significantly reduce the severity of the consequences of a psychogenic nature, as well as the burden on the medical workers themselves.

In March 2020. The World Health Organization (WHO) declared the new coronavirus infection SARS-CoV-2 (COVID-19), ICD-10 U07.1 and U07.2, a global pandemic in late 2019 [1-3]. Due to the threat of the spread of COVID-19, a high alert regime has been introduced throughout the Russian Federation.

Problems associated with the spread of COVID-19 have affected, in one way or another, all countries of the world and the entire population of the planet. However, medical workers, whose working conditions have been and in many territories remain close to those of an emergency situation (ES), have borne the brunt of the blow.

As of April 14, 2021, more than 137.46 million people worldwide had been infected with the virus, and more than 2.96 million people had died. In the Russian Federation (as of April 14, 2021) 4.67 million people were infected and over 104,000 people died. [4, 5] - (Fig. 1, 2).

Due to the high level of health care system and professionalism of medical workers the number of diseases throughout the country is constantly decreasing. However, the number of infections in other countries is still increasing, with rapid growth in both European countries and other parts of the world.

Throughout the spread of COVID-19, health care professionals have worked under intense and prolonged psycho-

logical stress. The rapidly increasing number of COVID-19 cases, the number of hospitalizations, and the number of patients in critical condition have all made the work of health care providers extremely difficult [6, 7].

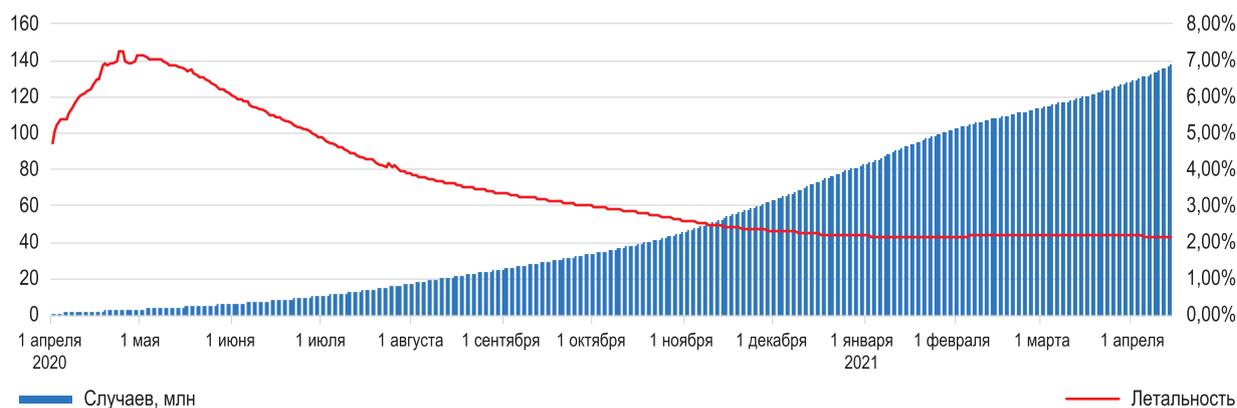
In 2020, 2,450 medical organizations of all forms of ownership were involved in the Russian Federation, more than 276,000 beds were deployed, including 41,000 beds in infectious disease hospitals and 235,000 beds in medical organizations reassigned to treat COVID-19; about 550,000 medical workers were involved at the peak of the disease, of which 156,000 were doctors, 318,000 were nurses and 76,000 were junior medical staff [8].

Due to the rapid spread of COVID-19, great danger of infection, high mortality rate in severe cases, and lack of drugs at the initial stage, the virus posed a huge threat to human life and health [9]. In addition, the virus had and still has a great impact on human mental health, causing people to experience emotional problems regardless of their physical health [10, 11].

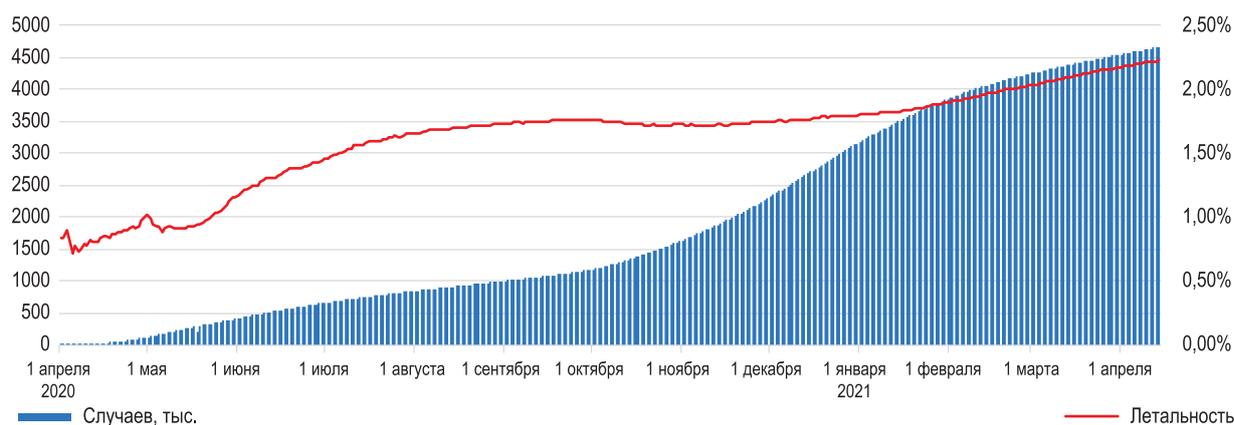
The rapid person-to-person transmission of COVID-19 and the increasing lethality caused anxiety and fear of infection in populations in all countries. The state of patients in critical condition, the anguish experienced by patients and their relatives, in many cases lead to even greater anxiety and, as a consequence, to prolonged stress and even to mental disorder [12]. In addition, for all health care professionals, fear of the possible absence of medical drugs and personal protective equipment (PPE), unverified information from various media, and anxiety about their loved ones significantly increase the risk of existing psychological discomfort. These factors increase the anxiety of medical workers and can lead to rather serious consequences [13, 14].

The problems of medical workers in a pandemic are not only a significant increase in the workload of each specialist, regardless of whether he works directly with COVID-19 or provides care to other patients in a "clean" area — it is also a huge psychological burden. In addition to the difficulties of working in a pandemic described above, need to work with new and frequently changing protocols and requirements, care of very severe patients whose condition deteriorates rapidly, and care of colleagues who become ill, makes the work of doctors and nurses close to working in an emergency or during hostilities [15, 16].

Indeed, the COVID-19 pandemic is justifiably called a war. The characteristic of working conditions of all health care professionals is comparable to military conditions. And we are talking not only about those doctors who work directly with COVID-19 patients, but about all health care workers who continue to be in health care organizations. Considering the fact that the threat to life and health under any conditions makes the situation traumatic, we can talk about possible consequences of the pandemic in medical



**Рис. 1.** Новая коронавирусная инфекция COVID-19: заболеваемость и летальность в мире, млн случаев  
**Fig. 1.** New coronavirus infection COVID-19: global morbidity and mortality, million cases



**Рис. 2.** Новая коронавирусная инфекция COVID-19: заболеваемость и летальность в Российской Федерации, тыс. случаев  
**Fig. 2.** New COVID-19 coronavirus infection: morbidity and mortality in the Russian Federation, thous. cases

workers in the form of posttraumatic stress disorder — PTSD (ICD-10 F43.1), especially in regions with heavy viral load, where doctors and other medical workers experience not just stress, but mental trauma [17].

And in these severe conditions, the outcome will depend not only on the availability of necessary medications, beds and equipment in medical organizations, and not even on a sufficient number of highly qualified medical workers, but on the ability of each of them to adequately and fully perform their professional duties, which, in turn, depends on the stability of their mental, moral and emotional status.

Of course, the problem of emotional stress among medical workers was acute even before 2020. [18]. Suffice it to

say that, according to researches of many authors, about a half of doctors have high indicators of professional burnout, which is twice as high as such indicators of the population engaged in other spheres of professional activity.

And it is especially important because emotional stress among medical workers of all specialties leads to the increased risk of medical errors, worsening of treatment prognosis and other unfavorable consequences [19]. In extreme conditions the probability and rate of formation of emotional burnout increase.

As the experience of epidemics, including the COVID-19 pandemic, shows, the sustainability and efficiency of measures taken by the state and the health care system depend



**Рис. 3.** Количество развернутых коек (тыс. коек) и численность медицинских специалистов (тыс. чел.), участвовавших в борьбе с пандемией COVID-19 в Российской Федерации в 2020г.  
**Fig. 3.** The number of beds deployed (thousand beds) and the number of medical specialists (thousand people) who participated in the fight against the COVID-19 pandemic in the Russian Federation in 2020

largely on the ability to protect the health of those directly involved in the fight against the virus spread, including medical workers [20, 21].

Stresses caused by high patient mortality rates, shortages of medical personnel, and fears about infecting oneself or family members can add to an already high workload. This rightly raises concerns among mental health professionals about the negative impact on the psychological and mental well-being of epidemic and pandemic responders [22-24].

Because of the danger of infectious disease in a number of countries, human resources are exhausted or on the verge of being exhausted and, as we know from outbreaks of epidemics, difficult decisions often have to be made about who is appropriate for invasive treatments such as life support and who is not. In some cases, these decisions will be different from the decisions that any health care provider would make under normal circumstances when the disease is learned and known or medical resources are adequate. And this greatly complicates the situation and the quality of the decisions made [16]. At the same time, it is important for medical professionals to know and to understand the algorithm of decision-making throughout the crisis [25].

It should be noted that in many cases mental pathology can go unnoticed for a long time [16]. Psychological disorders or psychiatric symptoms and illnesses can occur much later and have distant consequences.

In other words, they can manifest in the acute phase as well as in later stages (26,27).

For a deeper understanding of possible consequences, it is necessary to take into account several mechanisms underlying the specificity of psychopathological manifestations. These can include individual factors such as age, gender, and family, as well as work experience, length of work time, and availability of PPE (28).

A number of factors (prior psychiatric history, stress coping styles, cross-cultural characteristics, and, especially important in the current context, support measures) play an important role in the response to trauma.

In China, which experienced a 2019 outbreak of the new coronavirus infection COVID-19, a scientific study was conducted in 31 medical organizations that measured various factors associated with mental health changes in health care providers working with COVID-19 patients. The study found that physicians and nursing staff are at high risk for negative mental health outcomes, the severity of which is influenced by a number of factors [3, 29].

Mental or psychological traumatization of medical personnel is associated with the threat to their own lives, the lives of relatives and friends, as well as the presence of children or elderly relatives in the family, the duration of contact with an infected patient, the availability of work experience and special training, as well as the level of pay and availability of PPE; moral traumatization — with the perceived helplessness in saving people in conditions of health system overload, worrying about "inattention" from the state health system in general. Thus, according to the results of a number of researches, the average medical personnel, especially women, have higher level of symptoms and stress than doctors [2, 3, 30, 31].

The environment of exposure, its duration and personal experience have a significant impact on the psychological stress and emotional reactions of medical staff.

Scientific studies conducted in 2020 in relation to the pandemic showed that health care workers of different specialties, working in different positions, testified about their resulting anxiety, depression, stress, sleep problems, and more [6, 7, 13, 14, 20, 25]. The reasons for these symptoms may vary, but if we refer to those who work in the so-called "red" zone, it is primarily the lack of opportunities for sleep and rest, associated with an extremely heavy workload. Lack of work experience or specialized training can also exacerbate the effects on mental health.

According to a study by Shaukat, et al (International Journal of Emergency Medicine), working in a high-risk COVID-19 department, poor precautions and hygiene, inappropriate use of PPE, frequent ( $\geq 12$  times/day) contact with patients, long ( $\geq 15$  h) daily interactions with patients, and prolonged use of PPE resulting in skin damage are consequences of improper work organization of staff and often lead to mental health problems [30].

Given the fact that, over time, many health care workers may experience mental health problems and somatic complaints, the Russian Federation places great importance on measures to support health care staff — providing sufficient appropriate PPE, shift work schedules to ensure rest, and necessary training and information support at all levels.

Given the psychosocial impact of previous global epidemics, early assessment of the mental and psychological state of health care workers is vital in order to preserve their mental health and take appropriate action [32]. Accordingly, given that the mental health of the physician and nurse in an emergency setting is critical, comprehensive practices to protect health workers and preserve their mental health are a priority [14].

This makes mental health professionals think from the first months of the pandemic about what we can do now, so that we do not have to face further long-term consequences for health workers in the form of depression, PTSD and other disorders (33). Actions aimed to minimize the traumatic nature of the situation cannot, unfortunately, level the stress, but they can significantly reduce its intensity [34].

As experience shows, the following measures of prevention of consequences of long-term stress and post-traumatic stress disorder can be attributed to the most productive.

Social: providing the media with sufficient information about the arisen situation and support measures [29]; creating appropriate conditions in a health care institution. The COVID-19 pandemic has complicated the information and communication environment in health care. In such conditions absence of access to reliable information and low level of communication lead to increase of stress influence and more expressed emotional burnout of medical workers [35].

Professional: an opportunity to receive additional education on the work with epidemics; strict control over the personnel's state of health; tested algorithm of actions, from admitting patients to contacts with relatives and interaction with other personnel; opportunity to live separately if there is a risk of infection in the nearest environment; time and space for recreation, including on the territory of a medical organization. At the same time, it is important to provide access to psychological support services for medical workers.

Psychosocial support is a key factor in preventing and overcoming the negative consequences of stressful situations, both for each individual and for groups of people [36].

Since mechanisms of emotional stress development among medical workers providing care to patients with the new COVID-19 coronavirus infection are comparable to those in emergency situations, psychological support is considered to be an integral component of support measures for medical workers in the prevention of mental disorders in emergency situations.

### **Conclusion**

The new coronavirus infection COVID-19 that broke out in China in 2019 has become a global medical, social, and economic threat to all of humanity as early as 2020. The World Health Organization estimated the mortality rate from COVID-19 at 3.4%. And in spite of the fact that at present the schemes of treatment of patients with COVID-19 have been tested, vaccines have been developed and successfully applied, and a significant decrease of morbidity and mortality from the new coronavirus infection is observed in the Russian Federation, one of the most complicated issues

is the one related to the recommendations on prevention of PTSD (F43.1) and distant psychiatric consequences for those medical workers who have been exposed to high levels of distress for a long time.

In examining the emotional and psychological responses of health care workers to stress while working in a pandemic setting, a number of negative consequences affecting the mental health of health care workers were noted. To preserve and maintain the mental health of health care workers and to maximize the leveling effects of PTSD, psychological service providers and other mental health professionals should take deliberate steps to systematically address the challenges health care workers face in severe crisis situations.

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## СЛУЖБА МЕДИЦИНЫ КАТАСТРОФ ВОРОНЕЖСКОЙ ОБЛАСТИ: ИСТОРИЯ СОЗДАНИЯ И СТАНОВЛЕНИЯ

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**Резюме.** Представлена история создания и становления Службы медицины катастроф (СМК) Воронежской области и Воронежского областного клинического центра медицины катастроф (ЦМК, Центр). Рассмотрены основные направления деятельности СМК и ЦМК, структура и оснащенность Центра и др.

**Ключевые слова:** Воронежский областной клинический центр медицины катастроф, оснащенность, санитарная авиация, Служба медицины катастроф Воронежской области, структура

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## DISASTER MEDICINE SERVICE OF VORONEZH REGION: HISTORY OF CREATION AND FORMATION

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**Summary.** The article presents the history of foundation and formation of the Disaster Medicine Service of the Voronezh region and of the Voronezh Regional Clinical Center for Disaster Medicine. The basic directions of the Center's and Service's activity, the Center's structure and equipment are examined.

**Key words:** air ambulance, Disaster Medicine Service of the Voronezh region, equipment, structure, Voronezh Regional Clinical Center for Disaster Medicine

**Conflict of interest.** The authors declare no conflict of interest

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In the 1980s in the USSR, as well as in the whole world, a significant growth of the number of man-caused and natural emergencies was registered. First of all it was Chernobyl catastrophe and earthquake in Armenia that were accompanied by great human losses and huge material damage. All that changed an attitude towards the real readiness of the

state to prevent and liquidate emergencies occurring in peacetime. In the late 1980s and early 1990s our country went through times of change in politics, economics and other spheres of life. Changes affected Voronezh region as well. The Novovoronezh nuclear power plant, a number of chemically hazardous and other man-made hazardous fa-

cilities are located on the territory of the region. Federal highways (FAD) M-4 "Don", M-6 "Caspian", A-144 highway, a number of inter-district roads pass through the Voronezh region, the number of road traffic accidents (RTA) on which is 10 times higher than on FAD [1, 2]. Forest and steppe fires and other emergencies of natural, man-made and social nature are not rare in the region [3]. All these factors have determined the necessity of creation and development of the Disaster Medicine Service of Voronezh region.

The fundamental document that gave a start to the creation in Russia of a service for the prevention and liquidation of medical and sanitary consequences of emergency situations was the Resolution of the Council of Ministers of the RSFSR "On creation of the emergency medical aid service in emergency situations" <sup>1</sup>192 of June 14, 1990. In Voronezh Oblast, the Department of Emergency and Planned-Consultative Medical Care, which was part of the Oblast Clinical Hospital (OKB) No. 1, was at the origins of the emergency medical services. The department was located in the main building of OKB. The main function of the department was rendering specialized and highly qualified medical aid to the residents of 32 districts of the region, as well as coordinating the work of interregional centers (toxicology, cardio-surgery, hemodialysis, burns, etc.) and the residents of neighboring regions.

The first mention of the Service dates back to 1938, when it was called "Sanitary Aviation Station" and was headed by Chief Doctor M.K. Komissarov (Fig.1). In that year only 9 calls were registered. In 1939-1951 there were 120-130 calls annually. The station was equipped with air transport and cars [4, 5].

During wartime, due to the evacuation of medical institutions from Voronezh, the air ambulance station temporarily stopped its work. During the Great Patriotic War in the areas of the most active combat operations air ambulance stations evacuated the wounded and sick by air transport to hospital bases. Even during the preparation for the operation on the Central Front in March 1943 over 16 thousand wounded were evacuated by this type of transport from the Kursk region to the district of Yelets. On separate days transport aircraft evacuated up to 1.6 thousand wounded. By the beginning of the defensive battle the hospital base of the Central Front included 3 and 2 echelons of Voronezh Front. In

addition, Voronezh Front had reserve hospitals with 3,500 beds. During the defensive battle the hospital bases of the Central Front received 45 000 wounded and 59 638 wounded and sick persons, which were transported from the troops to hospital bases of the armies of Voronezh Front. In the front line the wounded were evacuated mainly by railway transport. Great experience was gained by medical service in the organization of mass evacuation of the wounded and sick by transport aviation. During the counteroffensive at Kursk up to 20,000 wounded and sick were evacuated by transport planes [6].

Immediately after the liberation of Voronezh from the Nazi occupation, the station resumed its activities. In August 1943 it had one aircraft, in 1944 — two. After the end of the Great Patriotic War sanitary aviation began to replenish with new aircrafts. The peak of its development was in the second half of the XX century. At that time helicopters were widespread, the appearance of which made it possible to land the aircraft (AC) where previously it was not technically possible [4]. From 1939 to 1952 the service was headed by 5 chief physicians. In 1952-1974 the sanitary aviation was headed by Cherkasov Petr Andreevich. Since 1974 the service of urgent and planned-consultative medical assistance is headed by Lev Ivanovich Kochetov — surgeon, obstetrician-gynecologist, public health organizer of higher qualification category.

Flights to the region were made by different types of aircrafts and helicopters — Po-2, Yak-12, An-2, Mi-1, Mi-4, K-26. Sanaviation had 6 vehicles and 2-4 airplanes for calls provision; during spring floods a helicopter was provided. There were 13 flight operators and 10 flight attendants, 128 attached consulting physicians, specialists from regional medical institutions and employees of Voronezh State Medical Institute departments. The flight attendants and doctors-consultants, assigned to the sanaviation, had to be on call 24 hours a day in order to provide emergency qualified medical aid. Emergency skilled medical care was provided in more than 40 specialties (Figure 2).

In 1954 the air ambulance station was united with the regional hospital, which positively influenced the conditions of its work and the quality of emergency and urgent medical aid rendering to the patients in the countryside. In 1970 the air ambulance station had three airplanes, a staff consisting of qualified doctors, necessary equipment and instruments. Professors, associate professors and assistants of the medical institute, as well as residents of clinical hospitals were sent to the districts of the region. In 1960 the number of persons who received medical assistance was 1,881, in 1970 — almost three times more. In 1970, the air ambulance station of the regional hospital received 1360 calls, performed 716 departures. On the spot were performed 189 different operations, 218 blood transfusions, about 1 thousand of laboratory, X-ray and other instrumental examinations. In addition to emergency departures on calls, medical workers of sanitary aviation carried out a lot of work on transportation of patients from rural areas to regional specialized medical institutions and consultations in the order of scheduled departures [7]. The dispatcher service provided round-the-clock reception of calls from rural medical preventive institutions and the organization of specialist consultations by telephone. The head of the sanaviation service was responsible for the profile and staffing of outreach teams, as



**Рис. 1.** Комиссаров Михаил Козьмич (1895–1976 гг.) – кандидат медицинских наук, доцент, Заслуженный врач РСФСР  
**Fig. 1.** Komissarov Mikhail Kozmich (1895-1976) – candidate of medical sciences, associate professor, Honored doctor of the RSFSR

well as for the order of emergency specialized medical care. For the purpose of quick collection and timely delivery of consultants, blood products and medicines, the work of the vehicles on the line was corrected by walkie-talkies. For better work of specialists of the department and for control of continuity in the work of medical institutions of the districts and the department of emergency and planned-consultative medical aid, incoming calls and consultations were recorded on a tape recorder by telephone.

On May 27, 1991 in our region on the basis of the emergency and planned-consultative medical care department of the Regional Clinical Hospital <sup>1</sup> 1 for medical care to victims of the emergencies the Regional Center of Emergency Medical Care was established. This date can be considered as the day of establishment of the Disaster Medicine Service of the Voronezh region, because from that moment all the activity of the Center was carried out in the sphere of disaster medicine. L.I. Kochetov, who previously headed the Department of Emergency and Planned-Consultative Medical Care, was appointed Chief Physician of the Center.

Taking into account the great experience of the Voronezh Regional Hospital emergency and consultative medical care department in delivering specialist teams to remote areas of the region and in carrying out medical evacuation of severe patients from districts to regional medical preventive institutions, the Voronezh Territorial Disaster Medicine Center (further — Center) included emergency medical care department for providing assistance to victims on site of emergency and during the first stage of medical evacuation, as well as emergency department for providing emergency medical care to the injured.

Later on, in compliance with the requirements to render specialized emergency medical aid not only in the hospitals of the regional hospitals but also during medical evacuation of severe and extremely severe patients to the regional clinics, mobile resuscitation-anesthesiology teams were formed based on which the resuscitation-anesthesiology department was created. The correctness of this concept was further confirmed by the decision of the Russian Ministry of Health, which used the Voronezh Center experience to create such centers in other constituent entities (hereinafter, constituent entities) of the Russian Federation.

The staff structure of the Center, approved on the basis of such a multifunctional approach to its activity, allowed the regional Disaster Medicine Service to form staff formations consisting of highly qualified specialists to provide medical aid in the first and second stages of medical evacuation, to create teams of permanent and highly prepared specialists.

In March 1996 the first All-Russian Scientific Conference on disaster medicine "Tasks and organization of work of the territorial and regional centers of disaster medicine" was held in Voronezh. The organizers of the conference, along with the Voronezh Center for Disaster Medicine, were the Regional Health Committee and the All-Russian Center for Disaster Medicine "Zaschita" of the Ministry of Health of Russia.

From the very beginning of the regional Center establishment, sanitary aviation was organically included in its composition — its use significantly reduced the time of arrival of the specialists to the patient of the district hospital. For his many years of work on the development of medical aviation and his significant contribution to the formation of the Disaster Medicine Service of the Voronezh region the chief doctor of the Center L.I. Kochetov was awarded the honorary title "Honored Doctor of the Russian Federation" in 1997 (Fig.3).

For a long time the main aircraft of the Center was An-2. In 2012-2014 along with it the medium-range Pilatus PC-12 air ambulance plane with resuscitation module on board was used. During this period 130 sanitary flights were performed, 154 patients were evacuated, including 68 children, including 37 newborns. In 2015, a pilot project was launched in the region to use a Eurocopter EC-135 ambulance helicopter equipped with a life support system. Currently, the Center uses a new domestic-made Ansat helicopter with a medical module, equipped with various medical equipment, including artificial lung ventilation (ALV), oxygen cylinders, pulse oximeters, infusion pumps and other equipment necessary to transport resuscitation patients [7].

The Voronezh Regional Clinical Center for Disaster Medicine has about 50 doctors, including surgeons, intensive care specialists, neurosurgeons, emergency physicians, trauma surgeons and vascular surgeons. There are 4-5 teams of specialists on duty round the clock: intensive care, general surgery, neurosurgery and vascular surgery teams. If necessary, trauma surgeons and thoracic surgeons are involved.

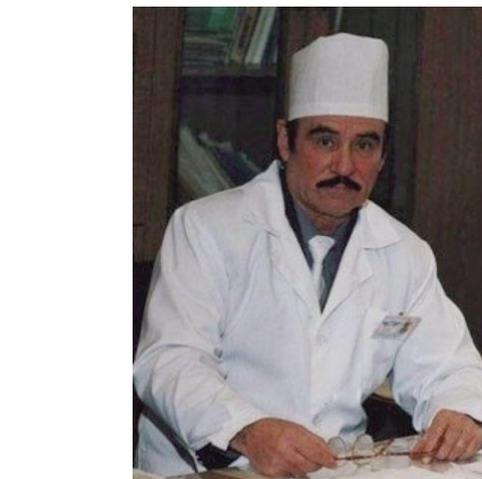


Рис. 2. Работа станции санитарной авиации  
Fig. 2. The work of the air ambulance station

The teams are in constant readiness to leave or fly out to the district hospitals. If the patient's condition does not allow his/her transportation, the doctors travel to conduct consultations or perform surgical interventions on site.

In 2020, the Center specialists conducted 2,638 visits by ambulance and 166 flights by Ansat ambulance helicopter to district hospitals in the region. 1,467 remote consultations were conducted: 630 telemedicine consultations and 837 telephone consultations [8]. Emergency consultative medical aid was rendered to 4636 patients. The surgeons of the Center operated on 390 patients in district hospitals and performed 174 fibroendoscopic therapeutic and diagnostic procedures. Resuscitation teams and ambulance crews evacuated 2,540 patients; in 65 cases, interregional medical evacuations were performed, including 38 evacuations of children, 25 of whom were under one year of age [9]. An air ambulance was used to evacuate 161 patients, 97% of them were evacuated within the first 24 hours of the call. Medical specialists performed medical evacuation of patients with new coronavirus infection, including the use of EVI [10, 11]. The Center for Disaster Medicine organized 849 telemedical consultations of COVID-19 patients on ventilation, which were performed by medical specialists of the Federal Intensive Care Consultation Center. 45.1 liters of blood products were delivered to district hospitals.

The Center has a training and methodological department [12]. In 2020 its specialists taught the rules of first aid to more than 200 road users, held 12 field events, of which 2 — in the districts of the Voronezh region. Three training sessions were held for the staff of the emergency medical teams. Within the framework of implementation of the regional program of providing medical organizations with ambulance vehicles, the Center was equipped with 15 class "C" ambu-



**Рис. 3.** Кочетов Лев Иванович (1939 г.р.) – врач-организатор здравоохранения высшей квалификационной категории, Заслуженный врач Российской Федерации

**Fig. 3.** Kochetov Lev Ivanovich (born 1939) – doctor-organizer of public health services of the highest qualification category, Honored doctor of the Russian Federation

lances. At present, the Center's vehicle fleet includes almost 70% of ambulances with less than 5 years of service life.

In the beginning of 2021 the Voronezh Regional Clinical Center for Disaster Medicine won the All-Russian contest "The best territorial center for disaster medicine of the Ministry of Health of the Russian Federation in 2020" (Fig.4). The main evaluation criteria were: readiness to work in emergency situations; level of development of technologies of emergency medical care and improvement of the regional structure of the Center.



**Рис. 4.** Коллектив Воронежского областного клинического центра медицины катастроф. В центре – главный врач ЦМК А.Н.Артемов (2021)

**Fig. 4.** The staff of the Voronezh regional clinical center for disaster medicine. Head doctor of the center – A.N. Artemov (2021)

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# CLINICAL ASPECTS OF DISASTER MEDICINE КЛИНИЧЕСКИЕ АСПЕКТЫ МЕДИЦИНЫ КАТАСТРОФ

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## ПРИМЕНЕНИЕ КИНЕЗИОТЕЙПИРОВАНИЯ ПРИ РЕАБИЛИТАЦИИ СОТРУДНИКОВ СИЛОВЫХ СТРУКТУР, УЧАСТВУЮЩИХ В ЛИКВИДАЦИИ ПОСЛЕДСТВИЙ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ

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**Резюме.** Цель исследования – определение современной доказательной базы, свидетельствующей об эффективности кинезиотейпирования (КТ) у сотрудников МЧС России, страдающих остеоартрозом коленного сустава. Материалы и методы исследования. Проанализированы данные отечественной и зарубежной литературы об эффективности применения метода кинезиотейпирования при остеоартрозе. Поиск проводился с использованием электронных баз данных MEDLINE, Embase, Scopus, Web of Science, eLIBRARY и PEDro за период с 2007 по 2021 г. Для поиска использовались следующие ключевые слова и их сочетания: кинезиотейпирование, коленный сустав, остеоартроз, реабилитация.

Результаты исследования и их анализ. В результате поиска были найдены и проанализированы более 1 тыс. статей. Семь исследований соответствовали критериям включения.

Анализ результатов исследования позволил сделать следующие выводы:

1. Кинезиотейпирование можно считать апробированным методом уменьшения боли без каких-либо побочных эффектов.
2. Установлено положительное влияние КТ на проприорецепцию и диапазон движения в суставе.
3. В то же время доказательная база положительного воздействия кинезиотейпирования как эффективного инструмента реабилитации – неоднозначна, что говорит о необходимости проведения дальнейших исследований.
4. Отсутствие стандартизации типа используемого кинезиотейпа, его адгезионных качеств, толщины, эластичности, места наложения и продолжительности ношения затрудняют определение эффективности КТ у пациентов с остеоартрозом.
5. Так как в большинстве исследований участвовали люди в возрасте до 30 лет, остается невыясненным, влияет ли изменение текстуры и структуры кожи, связанное с возрастом, на воздействие КТ.

**Ключевые слова:** кинезиотейпирование, коленный сустав, остеоартроз, реабилитация, сотрудники силовых структур, чрезвычайные ситуации

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Review report  
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## APPLICATION OF KINESIOTAPING IN THE REHABILITATION OF EMPLOYEES OF POWER STRUCTURES PARTICIPATED IN ELIMINATION OF EMERGENCY CONSEQUENCES

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**Summary.** The aim of the study was to determine the current evidence base for the effectiveness of kinesioteaping in Russian EMERCOM employees suffering from osteoarthritis of knee joint.

**Materials and research methods.** The data of the Russian and foreign literature on the efficacy of the kinesioteaping method in osteoarthritis were analyzed. The research was performed using electronic databases MEDLINE, Embase, Scopus, Web of Science, eLIBRARY and PEDro for the period from 2007 till 2021. The following key words and their combinations were used: kinesioteaping, knee joint, osteoarthritis, rehabilitation.

**Study results and their analysis.** More than 1,000 articles were found and analyzed as a result of the search. Seven studies met the inclusion criteria.

Analysis of the results of the study led to the following conclusions:

1. Kinesiotaping can be considered a proven method of pain reduction without any side effects.
2. A positive effect of kinesiotaping on proprioception and range of motion in the joint has been established.
3. At the same time, the evidence base for positive effects of kinesiotaping as an effective rehabilitation tool is ambiguous, which suggests the need for further research.
4. The lack of standardization of the type of kinesiotape used, its adhesive qualities, thickness, elasticity, place of application and duration of wear make it difficult to determine the effectiveness of kinesiotaping in patients with osteoarthritis.
5. Since most studies have involved people under 30 years of age, it remains unclear whether age-related changes in skin texture and structure affect the effects of kinesiotaping.

**Key words:** emergency situations, kinesiotaping, knee joint, law enforcement officers, osteoarthritis, rehabilitation

**Conflict of interest.** The authors declare no conflict of interest

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## Introduction

Russian Emergencies Ministry employees in the course of their professional activities are subjected to significant physical and emotional stress. Events such as rescue operations, elimination of the consequences of emergency situations of natural and man-made character, require from the people involved in them, the maximum physical strain for a long period of time. At the same time, prolonged and unbalanced load on the joints can cause the development of inflammatory and dystrophic changes in the synovial membrane and cartilage tissues and lead to osteoarthritis (OA). Osteoarthritis is a major cause of loss of function of the lower extremities and is now considered a serious medical problem. According to various data, the prevalence in the population of this form of degenerative joint disease ranges from 15 to 40% [1]. Osteoarthritis ranks sixth among the causes of moderate to severe disability. The main symptoms of OA include pain, motor disturbances, and proprioception disorders [2]. One of the most frequent localizations of this disease is the knee joint.

Treatment methods for OA of the knee joint can be divided into three categories: drug therapy and invasive conservative methods, surgical treatment, and rehabilitation. In mild cases, drug therapy is used, the basis of which are anti-inflammatory drugs from the group of nonsteroidal anti-inflammatory drugs -[3]. The main limitations of this method include the risk of complications from the gastrointestinal tract (GIT) – bleeding, peptic ulcer, etc. [3]. Surgical treatment includes intraarticular injections, endoscopic interventions and joint endoprosthesis. The performance of these manipulations is associated with a very significant risk of postoperative complications, which limits the use of surgical methods in general practice [4]. Based on the above, the most optimal treatment option for mild forms of osteoarthritis is the use of various rehabilitation techniques. Methods of conservative non-medical therapy are relatively inexpensive and widely used to improve the quality of life, extend the range of motion, and reduce pain in patients with knee OA.

In clinical practice, chiropractic care, acupuncture, and

physical therapy are used for conservative treatment of patients with knee OA. Recently, the method of kinesiotaping (KT) has become very popular [5]. Kinesiotaping increases elasticity and strength of muscle tissue and improves proprioception in patients with various musculoskeletal disorders [6]. Kinesiotapes are made mainly of cotton with stretch fibers, which allows achieving elasticity similar to that of the skin. Since the first practical application of KT in 1970, this method has been successfully developed and improved. Currently, there are various methods of kinesiotaping. The "Lifting" method is based on the ability of KT to increase the interstitial space and thereby improve blood circulation and lymph circulation [7]. The "Pain control" method is based on the reduction of pain intensity by stimulation of skin mechanoreceptors. And finally, the method "Neurorelief" is a stimulation of mechanoreceptors of the skin, causing positive changes in the nervous system.

**The purpose of the study** is to determine the current evidence base for the effectiveness of kinesiotaping in the employees of the Ministry of Emergency Situations of Russia who suffer from osteoarthritis of the knee joint.

**Materials and methods of the study.** Electronic databases including MEDLINE, Embase, Scopus, Web of Science, and Cochrane Review were searched for articles on this topic using the following keywords: "kinesiotaping", "knee joint", "osteoarthritis", "rehabilitation", published from 2007 to 2021. [7]. The materials of the published studies were analyzed. Materials from articles were included in the review if they met the following criteria:

1. The study examined the effect of KT on osteoarthritis of the knee joint.
2. The study was original: systematic reviews and meta-analyses were excluded.
3. No history of knee surgery among emergency responders.

**Results of the study and their analysis.** A database search revealed 1062 articles. After reviewing all materials, we identified 7 articles meeting the research search criteria

and published in 2008-2021 that reported the effect of KT on the course of knee osteoarthritis [8-14]. The authors of the articles conducted randomized controlled trials. The sample size in the studies was 22-61 people; the age range was 22-70 years. In five studies, the authors reported the degree of OA; in two studies, the degree of OA was not reported [8, 9]. Visual analog scales were used to assess pain severity. Three studies reported the effect of KT in the long-term follow-up period [10-12]. The rest evaluated the short-term effect of KT [8, 9, 13, 14].

All studies evaluated the effect of KT on pain. Six studies reported that the use of KT leads to a decrease in pain in patients with OA [9-11, 13-15]. One study reported a positive effect of KT on proprioception [9]. The results of two studies showed that using KT increases the volume of active and passive movements [9, 10]. In one study, the assessment of quadriceps torque showed that, compared with placebo, the KT method significantly improved this index [13].

Stauffer et al. investigated resting pain after KT in patients with knee OA. This type of pain does not seem to limit the function of the patient's limb, but creates significant discomfort. The use of KT significantly reduced the severity of this type of pain [16]. In contrast, a study performed by Cho et al. showed that there was no significant difference in pain in patients in the KT and placebo groups during rest. At the same time, there was shown a significant reduction in pain after walking in the KT group [9]. The results of a study performed by Aytar et al. showed that the use of KT in patients with patellofemoral pain syndrome (PFBS) is not effective in reducing pain after walking [8]. Kaya Mutlu E. et al. used KT in patients with OA 3 times within a month [10]. The results showed a decrease in pain syndrome at rest and during walking compared to the group without KT.

In a study by Cho et al., the range of active range of motion amplitude was significantly increased in the KT group [9]. Previous studies have also shown that joint mobility can improve after the use of KT [17]. In a study by Cho et al., the use of KT not only reduced pain when walking, but also effectively improved proprioception when measured at three angles. Similar results in terms of improved proprioception were obtained in a study by Shakoor et al. which used KT in combination with a set of physical exercises for 8 weeks [12].

In 2014. Anandkumar et al. determined the effectiveness of KT by isokinetic torque of the quadriceps muscle in patients with OA [13]. Their results confirmed the positive effect of KT on reducing pain and improving quadriceps muscle strength. In 2015. Kocyigit et al. proved using visual analog scale (VAS) a positive effect of KT on pain level [15]. The authors also showed a significant improvement of the Nottingham health profile in the experimental group that received KT therapy.

In 2016. Kaya Mutlu et al. divided 42 patients into 2 groups. Kinesiotape was applied in 3 stages to the quadriceps muscle and hamstring area [10]. The intervals between each KT application were 3-4 days. Compared with the control group, patients in the study group showed a significant decrease in pain according to VAS and walking task scores. The group of patients with KT after a one-month

follow-up period showed an increase in the volume of active movements in the knee joint. However, the authors found no significant differences between the two groups in the assessment of muscle strength. This study showed that, compared with the control group, the effect of KT scanning can reduce pain in walking and flexion of the knee joint in a short-term manner in patients in the observation group.

In 2018, t et al. included 61 women in the study [11]. All patients were divided into 2 groups. Patients in both groups received: myostimulation — for 30 min; heating — for 30 min; ultraphonophoresis — for 10 min a day 5 days a week for three weeks. In addition, in one group (31 patients) the KT method and physical exercises were used. In the group with KT there was a significant decrease of pain according to VAS within the first month after treatment. The KT group also had a significant reduction in pain on the Western Ontario McMaster Universities OA Index (WOMAC) and the overall WOMAC score after treatment compared to the group that did not receive KT. In both groups the peak torque measured in the quadriceps muscle increased significantly after treatment. Thus, the use of KT in women with knee OA appears to be effective in reducing the severity of pain and increasing physical capacity [11].

Castrogiovanni et al. investigated the effect of exercise and KT on the degree of physical limitation in patients with knee OA [14]. A total of 57 participants took part in the study. The patients were randomly divided into 3 groups. Group 1 patients performed a complex of exercises; Group 2 patients performed a complex of exercises with application of kinesiotape with tension; Group 3 patients performed a complex of exercises with application of KT without tension. The study showed that the patients who received KT and exercised needed less analgesics for at least four months. According to the authors of the study, knee KT in combination with moderate physical activity is an effective way to overcome pain and motor limitations in patients with knee OA [14].

A 2018 meta-analysis by Lu et al. studied the effect of kinesiotaping on pain intensity and physical activity levels in patients with knee OA. The results of the analysis showed that 308 patients who were included in the study and received the KT method showed a significant improvement in pain scores by VAS, WOMAC index and range of motion [18].

### Conclusion

1. Kinesiotaping can be considered a proven method of pain reduction without any side effects.
2. A positive effect of KT on proprioception and range of motion in the joint has been established.
3. At the same time, the evidence base for positive effects of kinesiotaping as an effective rehabilitation tool is ambiguous, which suggests the need for further research.
4. The lack of standardization of the type of the kinesiotape used, its adhesive qualities, thickness, elasticity, place of application and duration of wearing the KT makes it difficult to determine the effectiveness of KT in patients with osteoarthritis.
5. Because most of the studies involved people under 30 years of age, it is unclear whether age-related changes in skin texture and structure affect the effects of KT.

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# ACTUAL PROBLEMS OF MEDICAL EVACUATION АКТУАЛЬНЫЕ ПРОБЛЕМЫ МЕДИЦИНСКОЙ ЭВАКУАЦИИ

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## РЕЗУЛЬТАТЫ ИСПОЛЬЗОВАНИЯ ПРАКТИЧЕСКИХ РЕКОМЕНДАЦИЙ ПО ОРГАНИЗАЦИИ ВНУТРЕННЕГО КОНТРОЛЯ КАЧЕСТВА И БЕЗОПАСНОСТИ МЕДИЦИНСКОЙ ДЕЯТЕЛЬНОСТИ ВНЕ МЕДИЦИНСКОЙ ОРГАНИЗАЦИИ

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**Резюме.** Цель исследования – оценить результаты практического применения критериев контроля качества и безопасности медицинской деятельности при оказании скорой, в том числе скорой специализированной, медицинской помощи (СМП) и проведении медицинской эвакуации.

**Материалы и методы исследования.** Проанализированы результаты лечения 763 пациентов, поступивших в госпиталь по неотложным показаниям в период с сентября 2021 г. по сентябрь 2022 г. На основании медицинских документов (историй болезни) изучалась работа общепрофильных врачебных бригад госпиталя по оказанию скорой медицинской помощи: 451 пациенту медицинская помощь была оказана в режиме повседневной деятельности; 312 – в режиме чрезвычайной ситуации (ЧС).

При проведении исследования использовались методы экспертной оценки и сравнительного анализа. В качестве экспертов были привлечены 30 врачей, имевших высшую врачебную категорию по специальности «организация здравоохранения и общественное здоровье» и стаж работы не менее 5 лет.

С целью проверки достаточности критериев (показателей) контроля качества оказания медицинской помощи авторами была разработана специальная анкета, в которой экспертам предлагалось оценить по 10-балльной шкале значимость каждого показателя и их достаточность для полного описания всех возможных клинических ситуаций. Результаты анкетирования оценивали с помощью статистического анализа с использованием возможностей таблиц Microsoft Excel.

**Результаты исследования и их анализ.** Результаты исследования показали, что наиболее значимым критерием контроля качества выездных форм работ в догоспитальном и госпитальном периодах является своевременность проведения медицинской эвакуации. Они также показали необходимость включения дополнительных показателей для оценки пациентов с особо опасными инфекциями в Предложения (практические рекомендации) по организации внутреннего контроля качества и безопасности медицинской деятельности вне медицинской организации.

**Ключевые слова:** выездные формы работы, контроль качества и безопасности медицинской деятельности, медицинская деятельность вне медицинской организации, медицинская эвакуация, скорая медицинская помощь, скорая специализированная медицинская помощь

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## RESULTS OF THE USE OF PRACTICAL RECOMMENDATIONS ON THE ORGANIZATION OF INTERNAL QUALITY CONTROL AND SAFETY OF MEDICAL ACTIVITY OUTSIDE A MEDICAL ORGANIZATION

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**Summary.** *The aim of the study was to assess the results of application of the criteria for controlling the quality and safety of medical activity in the provision of emergency, including specialized emergency, medical care and medical evacuation.*

**Materials and research methods.** *The results of treatment of 763 emergency patients admitted to the hospital from September 2021 to September 2022 were analyzed. The work of general medical teams of the hospital in rendering emergency medical aid was studied based on medical documents (case histories): 451 patients received medical care during routine activities; 312 patients received medical care within an emergency situation.*

*During the study, methods of expert review and comparative analysis were used. Thirty physicians with the highest medical category in the specialty "organization of health care and public health" and with work experience of not less than 5 years were involved as experts.*

*In order to check sufficiency of criteria for quality control of medical care, the authors developed a special questionnaire, in which experts were asked to assess on a 10-point scale the significance of each indicator and their sufficiency for a complete description of all possible clinical situations.*

*The results were assessed by statistical analysis using the capabilities of Microsoft Excel tables.*

**Study results and their analysis.** *The results of the study showed that the most significant criterion of quality control of field forms of work in pre-hospital and hospital periods is the timeliness of medical evacuation, as well as the need to include additional indicators to assess patients with especially dangerous infections in the practical recommendations for the organization of internal quality control and safety of medical activity outside a medical organization.*

**Keywords:** *field forms of work, emergency medical care, emergency specialized medical care, medical activity outside a medical organization, medical evacuation, quality and safety control of medical activity*

**Conflict of interest.** *The authors declare no conflict of interest*

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#### **Introduction**

In the world practice of health care the concept of "quality" is complemented by the concept of "safety of medical activity". This process is reflected in the technical reports of the World Health Organization (WHO) on key problems in the area of the safety of medical care, the introduction of international standards ISO 9000 series "Quality Management Systems" in the field of health care, etc.

Obligatory application of clinical recommendations and empowerment of the Russian Ministry of Health to establish requirements for organization and implementation of internal control of quality and safety of medical activities are regulated by the Federal Law "On Fundamentals of Health Care in the Russian Federation" from November 21, 2011 N°323-FZ [1].

When implementing the requirements of Order No. 785n of the Russian Ministry of Health "On Approval of Requirements for Organizing and Conducting Internal Control of Quality and Safety of Medical Activity" dated July 31, 2020, both practicing physicians and heads of medical organizations face difficulties when controlling the quality and safety of emergency medical care – EMC [2].

New approaches to the formation and functioning of the system of internal quality and safety control in medical treat-

ment organizations were approved in the Practical Recommendations on the organization of internal control of the quality and safety of medical activity outside a medical organization (hereinafter – Recommendations) in 2021. [3].

The outreach forms of work defined by these Recommendations include: provision of emergency, including specialized emergency, medical care outside the hospital; medical evacuation by various types of transport; work of emergency response teams, mobile medical units, field hospitals, route medical stations, evacuation receptions (near-airport, near-rail) in the emergency zone 1 [4].

These normative legal documents do not reflect all the features of internal control of quality and safety of medical activity outside a medical organization, which requires further comprehensive study.

**The aim of the study** is to assess the results of the practical application of the criteria of quality and safety control of medical activity in the provision of emergency, including specialized emergency, medical care and medical evacuation.

<sup>1</sup> On Approval of the Procedure for Providing Emergency, including Specialized Emergency Medical Care: Order of the Ministry of Health of Russia of June 20, 2013 No. 388n

**Materials and methods.** There were analyzed the results of treatment of 763 patients admitted to the hospital on emergency indications from September 2021 till September 2022. The work of general medical teams of the hospital in rendering emergency medical aid was studied based on medical documents (case histories): 451 patients received medical care during routine activities; 312 patients received medical care during emergencies.

In the course of the study, methods of expert evaluation and comparative analysis were used. The experts were 30 physicians, who had the highest medical category in the specialty "organization of health care and public health" and work experience of not less than 5 years. The work of medical teams at the stage of providing medical care outside the medical organization and at the stage of the patient's stay in the admission department of the hospital was evaluated.

In order to check the sufficiency of criteria (indicators) of quality control of medical care, specified in the Recommendations, the authors developed a special questionnaire, in which experts were asked to assess on a 10-point scale the significance of each indicator and their sufficiency for a complete description of all possible clinical situations, which the expert encounters when assessing the quality and safety of medical activity. On this scale: more than 8 points - important; 4 to 8 - very important; 1 to 4 - not important; 0 to 1 point - not important. The experts' opinions were evaluated at each of the two stages of the study.

The data were evaluated by statistical analysis using the capabilities of Microsoft Excel tables.

**Results of the study and their analysis.** The analysis of the results of the significance of the criteria for assessing the performance of medical teams under conditions of daily activities and in emergency conditions in the pre-hospital period is presented in Table 1.

The analysis of the results of significance of the criteria for assessing the performance of medical teams under conditions of daily activities in the hospital period is presented in Table 2.

It was determined that the most significant criterion of quality control of medical evacuations both in pre-hospital and hospital conditions is the timeliness of medical evacuation.

### Discussion

In modern scientific medical literature there are sporadic works devoted to the issues of quality control and safety of medical activity outside a medical organization, which is associated with the inclusion of this concept in the Federal Law of November 21, 2011 №323-FZ only in 2018. Our study has shown that the criteria proposed in the Recommendations are important for an objective assessment of the quality of medical care provided to patients both outside the medical organization and in the hospital period.

However, the criteria specified in the Recommendations do not take into account the situations arising when patients with suspected particularly dangerous infections appear, including in the mode of emergency. Indicators for assessing

Таблица 1/ Table No. 1

### Значимость критериев контроля качества выездных форм работы в догоспитальном периоде, баллы

The most significant positions of criteria for quality control of outreach forms of work in the prehospital period, points

Место Place	Позиция / Position	Режим повседневной деятельности Daily activities mode		Режим чрезвычайной ситуации Emergency mode	
		среднее к-во баллов average score	станд. отклонение, $\sigma$ standard deviation, $\sigma$	среднее к-во баллов average score	станд. отклонение, $\sigma$ standard deviation, $\sigma$
1-е	Своевременность проведения медицинской эвакуации - МЭ / Timeliness of medical evacuation	4,40	0,87	4,56	1,00
2-е	Организация МЭ / Organisation of medical evacuation	4,32	0,92	4,46	0,99
3-е	Набор мед. оборудования, оснащение / Set of medical equipment	4,26	1,07	4,26	1,02
4-е	Защита мед. персонала при МЭ / Protection of medical personnel during medical evacuation	4,21	0,89	4,35	1,15
5-е	Маршрутизация МЭ / Medical evacuation routing	4,23	1,13	4,25	1,14

Таблица 2/ Table No. 2

### Значимость критериев контроля качества выездных форм работы в госпитальном периоде, баллы

The most significant positions of criteria for quality control of outreach forms of work in the hospital period, points

Место Place	Позиция / Position	Режим повседневной деятельности Daily activities mode		Режим чрезвычайной ситуации Emergency mode	
		среднее к-во баллов average score	станд. отклонение, $\sigma$ standard deviation, $\sigma$	среднее к-во баллов average score	станд. отклонение, $\sigma$ standard deviation, $\sigma$
1-е	Своевременность проведения медицинской эвакуации - МЭ / Timeliness of medical evacuation	3,40	0,88	4,58	1,00
2-е	Организация МЭ / Organisation of medical evacuation	3,32	0,91	4,36	0,99
3-е	Набор мед. оборудования, оснащение / Set of medical equipment	3,26	1,06	4,16	1,02
4-е	Защита мед. персонала при МЭ / Protection of medical personnel during medical evacuation	3,21	0,88	4,15	1,15
5-е	Маршрутизация МЭ / Medical evacuation routing	3,23	1,12	4,15	1,14

**Показатели оценки качества оказания медицинской помощи пациентам с ООИ, баллы**  
 Indicators for assessing the quality of medical care for patients with especially dangerous infections, points

№ пп / No.	Показатель / Indicator	Режим повседневной деятельности Daily activities mode		Режим чрезвычайной ситуации и массового поступления пациентов Emergency mode and mass influx of patients	
		догоспитальный период prehospital period	госпитальный период hospital period	догоспитальный период prehospital period	госпитальный период hospital period
1.	Наличие алгоритмов по вопросам идентификации у пациентов с особо опасными инфекциями –ООИ / Availability of algorithms for identification in patients with - OOI	3	2	9	9
2.	Наличие системы маркировки у пациентов с особо опасными инфекциями / Availability of a labeling system for patients with especially dangerous infections	2	2	9	9
3.	Наличие укладки ООИ / The presence of laying OOI	3	2	9	9
4.	Наличие транспорта с применением транспортировочного изолирующего бокса (ТИБ) / Availability of transport using a transport insulating box	2	2	9	9

the quality and safety of medical activities in this case have not been developed so far [5, 6]. The pandemic of a new coronavirus infection COVID-19, considered to be a particularly dangerous infection, has convincingly demonstrated the necessity of development and specification of both treatment-diagnostic and evacuation measures, and improvement of medical care quality assessment in this pathology. In this connection the authors proposed new indicators, not included in the Recommendations, for patients with particularly dangerous infections, presented in Table 3.

### Conclusion

Analysis of the results of the practical application of the criteria for quality control and safety of medical activity in the provision of emergency, including specialized emergency, medical care and medical evacuation showed the need to include additional indicators to assess patients with particularly dangerous infections in the Recommendations on the organization of internal quality control and safety of medical activity outside the medical organization.

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## ОПЫТ ВЫПОЛНЕНИЯ РЕСПИРАТОРНОЙ ПОДДЕРЖКИ У ПОСТРАДАВШИХ С ТЯЖЕЛЫМИ ТРАВМАМИ В ХОДЕ ПРОВЕДЕНИЯ САНИТАРНО-АВИАЦИОННОЙ ЭВАКУАЦИИ ВЕРТОЛЕТАМИ ЛЕГКОГО КЛАССА

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**Резюме.** Цель исследования – определить оптимальные виды респираторной поддержки при острой дыхательной недостаточности (ОДН) у пострадавших с тяжелыми травмами при проведении медицинской эвакуации вертолетами легкого класса.

**Материалы и методы исследования.** Материалы исследования – данные о выполнении респираторной поддержки у пациентов с различными видами травм и ОДН за 2016–2021 гг., содержащиеся в автоматизированной информационно-аналитической системе «Медицина катастроф города Москвы» ГБУЗ г.Москвы особого типа «Московский территориальный научно-практический центр медицины катастроф (ЦЭМП) Департамента здравоохранения города Москвы» (далее – ЦЭМП).

При выполнении исследования применялись исторический, статистический и аналитический методы.

**Результаты исследования и их анализ.** Результаты анализа показали:

- доля пострадавших с различными травмами, полученными в чрезвычайных ситуациях (ЧС) на территории г.Москвы, составляет 31,9% всех санитарных потерь в ЧС. Из них 12,9% находились в крайне тяжелом и тяжелом состоянии, в том числе 1,1% нуждались в выполнении искусственной вентиляции легких (ИВЛ) и интубации трахеи;

- тяжелая форма ОДН, требующая выполнения ИВЛ и интубации трахеи, была вызвана: в 49,7% случаев – политравмой; в 38,4 – изолированной травмой; в 8,7 – термической травмой и в 3,2% случаев – комбинированной травмой.

Определены показания и особенности проведения ИВЛ с интубацией трахеи у пострадавших с различными травмами, подлежащих медицинской эвакуации санитарным вертолетом легкого класса.

**Ключевые слова:** авиамедицинские бригады, вертолеты легкого класса, искусственная вентиляция легких, пострадавшие с тяжелыми травмами, респираторная поддержка, санитарно-авиационная эвакуация

**Конфликт интересов.** Авторы статьи подтверждают отсутствие конфликта интересов

**Для цитирования:** Потапов В.И., Гуменюк С.А., Шептунов Г.А., Писаренко Л.В. Опыт выполнения респираторной поддержки у пострадавших с тяжелыми травмами в ходе проведения санитарно-авиационной эвакуации вертолетами легкого класса // Медицина катастроф. 2022. №3. С. 55-59. <https://doi.org/10.33266/2070-1004-2022-3-55-59>

## EXPERIENCE PERFORMING RESPIRATORY SUPPORT IN VICTIMS WITH SEVERE INJURIES DURING AIR AMBULANCE EVACUATIONS BY LIGHT-CLASS HELICOPTER

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**Summary.** The aim of the study was to determine the optimal types of respiratory support for acute respiratory failure in patients with severe trauma during medical evacuation by light-class helicopters.

**Materials and research methods.** The materials of the study are the data on the performance of respiratory support in patients with various types of trauma and acute respiratory failure for 2016-2021, contained in the automated information-analytical system "Disaster Medicine of Moscow" of the State Budget Institution "Moscow Territorial Scientific and Practical Center for Disaster Medicine of the Moscow City Health Department".

When performing the study, historical, statistical and analytical methods were used.

**Study results and their analysis.** The results of the analysis showed:

- proportion of victims with various traumas received in the emergency situations in Moscow constitutes 31,9% of all sanitary losses in emergencies. Of them 12.9% were in an extremely severe and serious condition, including 1.1% who needed artificial lung ventilation and tracheal intubation;

- severe acute respiratory distress requiring ventilation and tracheal intubation was caused in 49.7% of cases by polytrauma, in 38.4 cases – by isolated trauma, in 8.7 cases – by thermal trauma, and in 3.2% of cases – by combined trauma.

The indications and peculiarities of artificial ventilation with tracheal intubation in patients with various traumas to be medically evacuated by a light-class ambulance helicopter have been determined.

**Key words:** *air ambulance evacuation, artificial lung ventilation, aviation medical teams, light class helicopters, respiratory support, victims with severe injuries*

**Conflict of interest.** *The authors declare no conflict of interest*

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**Introduction**

Respiratory support (RS) in pre-hospital period is an important element of the complex treatment of patients with severe acute respiratory failure (ARF) of various etiologies including those caused by trauma [1-3].

Management of external respiratory function is the most important component of out-of-hospital resuscitation [4, 5]. However, the topic of RS as one of the components of intensive care carried out at the scene and during medical evacuation has not been sufficiently studied yet and many issues remain debatable.

The role of the doctor at this stage is extremely important, but often due to a number of unfavorable circumstances he has to act in extremely difficult conditions [6, 7].

In severe forms of ARF, tracheal intubation is the "gold standard" in emergency airway prosthetics, providing a reliable achievement of positive effect — alternative methods are shown mainly when intubation is impossible [8, 9].

Tracheal intubation provides airway patency and prevention of aspiration complications [10, 11].

It has been noted in many studies that high quality medical care should be provided to patients and injured people without delay. Its early start, adequate assessment of the severity of the patient's condition and reduction of the time of primary medical care can improve the prognosis [12-14].

Domestic and foreign experience in the use of air ambulance indicates a number of its advantages: rapid delivery of qualified specialists to patients, timely air ambulance evacuation of patients and injured people, provision of medical assistance en route [15-19].

The results of the work of the aviation medical teams (AMT) of the Moscow Territorial Scientific-Practical Center for Disaster Medicine (Emergency Medical Care Center) of the Moscow City Health Department (hereinafter referred to as EMCC) testify to the advantage of using a light-class ambulance helicopter in megalopolitan conditions [20, 21].

An air ambulance helicopter has a qualified doctor and a paramedic on board; it is equipped with modern medical equipment, which makes it possible to deliver an anesthesiology and intensive care unit to the scene, to begin providing primary medical and sanitary care in the pre-hospital pe-

riod, and to successfully perform emergency medical evacuation of patients [22, 23].

These advantages of the use of air ambulance reduce the vital signs for medical evacuation to the nearest hospital to cases of massive, as a rule — intracavitary, bleeding that cannot be stopped outside the operating room, increase the profile of medical evacuation and, ultimately, the quality of medical care in the hospital period.

At the same time successful performance of artificial lung ventilation (ALV) in patients with various traumas accompanied by severe ARF required a differentiated approach to the choice of the method of airway patency and respiratory support regime taking into account the type and nature of injury, and that was the reason for presenting the results of the present study.

**The aim of the study** was to determine the optimal types of respiratory support for acute respiratory failure in patients with various traumas during medical evacuation by light class helicopters.

**Materials and Methods.** The study used data on the performance in 2016-2021. ALV and tracheal intubation by AMT specialists of light class helicopter during their provision of emergency medical care (EMC) to victims with severe acute respiratory failure as a result of various traumas.

Historical, statistical, and analytical methods were used in performing the study.

**Results of the study and their analysis.** Analysis of the specified data contained in the automated information-analytical system "Disaster Medicine of Moscow" showed that over the past 6 years (2016-2021) sanitary losses in emergency (ES) and non-emergency (non-standard) situations amounted to 70,217 people. The proportion of injured victims with injuries was 31.9%, of whom 12.9% were in extremely severe and severe condition; 1.1% needed ventilation and tracheal intubation.

The data on the severity of the condition of trauma victims in 2016-2021 are presented in the table.

They show that over the past 6 years there has been an increasing trend in the number of victims who were in an extremely severe and serious condition as a result of severe trauma, including those in need of ALV and tracheal intubation: if in 2016 there were 390 such victims, then in 2021 their number was 617 people, i.e. increased by 1.6 times.

Таблица / Table

**Структура тяжести состояния у пострадавших, получивших различные травмы в 2016–2021 гг., чел./ %**  
 Structure of condition severity in victims of various injuries in 2016-2021, pers./ %

Тяжесть состояния Severity of condition	2016	2017	2018	2019	2020	2021	Итого Total
Всего в крайне тяжелом состоянии Total in extremely serious condition	79/2,0	58/1,5	61/1,5	67/1,6	65/2,4	63/1,8	393/1,7
в том числе на ИВЛ including ventilated	27/0,7	30/0,8	30/0,8	32/0,8	21/0,8	17/0,5	157/0,7
Всего в тяжелом состоянии / Total in serious condition	311/7,9	288/7,3	287/7,2	511/11,9	545/19,8	554/16,2	2496/11,2
в том числе на ИВЛ including ventilated	12/0,3	16/0,4	13/0,3	18/0,4	8/0,3	12/0,3	79/0,4
Всего в крайне тяжелом и тяжелом состоянии / Total in extremely severe and serious condition	390/9,9	346/8,8	348/8,7	578/13,4	610/22,2	617/18,0	<b>2889/12,9</b>
в том числе на ИВЛ including ventilated	39/1,0	46/1,2	43/1,1	50/1,2	29/1,1	29/0,8	<b>236/1,1</b>
Средней тяжести Moderate severity	1976/50,2	2068/52,3	2151/53,8	2143/49,7	1290/47,0	1699/49,7	11327/50,7
Удовлетворительное Satisfactory	1491/37,8	1461/37,0	1419/35,5	1495/34,7	772/28,1	993/29,1	7631/34,1
Биол. смерть Biological death	84/2,1	76/1,9	81/2,0	96/2,2	74/2,7	109/3,2	520/2,3
Общее число пострадавших с травмой Total number of victims with trauma	3941/100,0	3951/100,0	3999/100,0	4312/100,0	2746/100,0	3418/100,0	<b>22367/100,0</b>

The results of treatment of severe trauma largely depend on the effectiveness of emergency medical care in the pre-hospital period. As it follows from domestic and foreign studies, the duration of transportation also affects the outcome of treatment of patients with severe traumatic brain injury (TBI), penetrating chest or abdomen wounds, and unstable hemodynamics and should not exceed 20-30 min. Domestic and foreign authors note that helicopter ambulance services have advantages over ground transportation in severe trauma, but air ambulance evacuation should be performed taking into account local conditions and specifics of trauma system resource distribution.

The use of AMTs makes it possible to start providing primary medical care in the pre-hospital period, increasing the profile of hospitalization and, as a result, optimizing the provision of medical care in the pre-hospital period.

The long-term experience of the work of the aeromedical teams of the Center for Emergency Medical Care shows that in the conditions of a megalopolis with the unforeseen course of an emergency, traffic congestion on the roads and obstructed traffic, the use of an ambulance helicopter with qualified specialists of AMT on board, equipped with modern medical equipment, allows to successfully perform emergency medical evacuations of the injured [20].

It is extremely difficult to perform intubation in the cabin of a light-class air ambulance helicopter. However, the performance of ALV with tracheal intubation is a life-saving manipulation, which cannot be delayed.

The distribution by type of injury to victims who were given ventilation during medical evacuation by light-class ambulance helicopter in 2016-2021 is shown in the figure.

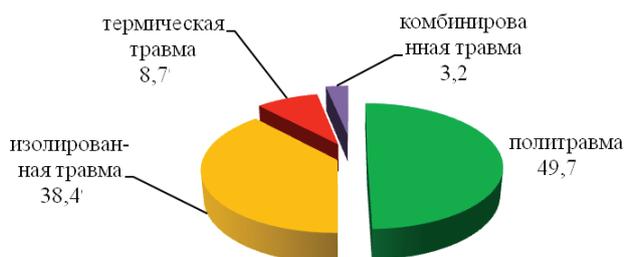
All light-class ambulance helicopter AMTs are equipped with the following ventilators: "Medumat Standard A",

"Medumat Transport" ("Weinmann Emergency", Germany); "Oxylog 2000", "Oxylog 3000+" ("Draeger", Germany); "Rulmonetic LTV-1200" (Sage Fusion, USA); Ambu bags for manual ventilations. In one case, AMT specialists used "Stephan 120 Mobil", which allows adequate invasive respiratory support for newborns with body weight <5 kg.

In addition, AMT physicians had at their disposal the tools necessary to perform tracheal intubation and noninvasive ventilatory support (nALV). The oxygen supply in 2 and 5 L cylinders was sufficient to provide respiratory support.

#### Discussion

One of the peculiarities, which influenced the determination of tactics in trauma patients, is the necessity to take into account the general medical situation in mass admissions. In these cases, the provision of medical assistance began with medical triage of the injured, which for AMT specialists was mainly to determine the indications for medical helicopter evacuation and identify victims in need of emergency medical care and medical evacuation in the first place — a light-class helicopter can take on board not more than two heavy victims



**Рисунок.** Распределение по видам травм пострадавших, эвакуированных санитарным вертолетом легкого класса, %  
**Figure.** Types of injuries in victims evacuated by a light-class ambulance helicopter, %

at a time. This took into account not only the severity of the patient's condition at the time of the initial examination, but also the predicted tendency for deterioration even against a background of relative apparent well-being.

No invasive methods were used at the triage stage. All therapeutic measures involving complex manipulations and individual approach to the patient were performed after transferring him to the ambulance/emergency medical care team, emergency response team or AMT.

The duration of this phase should not exceed a few minutes, except in cases of widening of the lesion and prolonged evacuation of victims from the lesion, for example, in a collapse.

At the next stage of emergency medical aid, when the victims were handed over to the medical teams, the help was rendered, if possible, taking into account the individual features of the victim and — necessarily — taking into account the conditions of further transportation. In the practice of AMT we mainly followed the tactics of preparing the victims for transportation in the maximum volume and in the shortest possible time before their delivery on board. The preference for such tactics was due to the limited space in the aircraft cabin, making it difficult to safely perform such manipulations as reliable venous access, tracheal intubation and pleural puncture. For the same reason, we adhered to the concept of expanding the indications for early initiation of respiratory support, including invasive one.

In case of moderate or stably severe condition without consciousness impairment, with stable systemic hemodynamics, without pronounced ALS and a tendency to deterioration in the near future, noninvasive method was preferred.

All trauma victims without unconsciousness at the time of examination and with multiple skeletal injuries received oxygen insufflation up to 10 L/min; if the effect of oxygen therapy was insufficient, the next step was continuous positive airway pressure (CPAP) or tracheal intubation and transfer to invasive ALV.

Indications for invasive respiratory support in the prehospital period were:

- progressive depression of consciousness;
- progressive bradypnoea, tachypnoea, or obstructive breathing disorders;
- psychomotor agitation not controlled by analgesia and subhypnotic doses of benzodiazepines;
- seizure syndrome;
- instability of hemodynamics — in this case, attention was paid not only to the figures of arterial pressure (BP), but also to the increase of tachycardia or, on the contrary, to the tendency to bradycardia;
- dynamic desaturation, resistant to oxygen insufflation.

The following were considered as absolute indications for invasive ALV: depression of consciousness to coma; tachypnea from 35/min; bradypnea up to 10/min; systolic BP <70 mm Hg with no effect from infusion therapy; SpO<sub>2</sub> <90% against O<sub>2</sub> insufflation.

Due to the aforementioned expansion of indications for preventive transfer to invasive ventilatory ventilation, our experience with the use of nALV in AMTs practice in trauma — in contrast to the similar experience of EMCC emergency response teams in somatic pathology, especially during the Covid-19 pandemic — is small — 2 cases of thoracic injury with chest contusion and suspected cardiac contusion from a traffic accident (RTA) with a favorable outcome. In both cases, a sparing regimen was used: P<sub>insp</sub> = 6-8 cm H<sub>2</sub>O; PEEP = 5-6 cm H<sub>2</sub>O, FiO<sub>2</sub> = 40%. The condition of the victims at the time of admission to the hospital was considered to be stably severe; no disorders of consciousness and systemic hemodynamics, gross respiratory disorders, cardiac rhythm and conduction disorders, desaturation below 93% — were noted.

During invasive ALV preference was given to sparing modes with preservation of spontaneous breathing; SIMV, P-SIMV; respiratory volume (RV) — 7-9 ml/kg of patient body weight; respiratory rate (RR) — 14-16/min in adult victims; PEEP — 5-6 cm H<sub>2</sub>O; FiO<sub>2</sub>=40-60%. For skeletal trauma, cervical spine trauma, volume-controlled ALV was generally sufficient to safely transport the casualty to the hospital; while patients with cervical trauma were better able to tolerate higher, up to 10-12 ml/kg, PEEP at lower (up to 12/min) respiratory rate. For patients with TBI and severe thoracic trauma, pressure-controlled ventilation was preferable; at the same time, we aimed for PEEP not to exceed 6-7 mm H<sub>2</sub>O, P<sub>peak</sub> — 30 cm H<sub>2</sub>O. Due to time deficit in the prehospital period, patient synchronization with the machine required deep sedation and analgesia. In case of insufficient effect of ALV in a given mode the ventilator parameters were selected individually; in addition, if necessary, additional measures were taken — drainage of pleural cavity in tension pneumothorax, deepening of sedation, muscle relaxation with transfer to forced modes of ALV. In all cases of invasive ALV saturation of the upper airway was carried out.

#### Conclusion

1. In patients with various types of trauma and acute respiratory failure, polytrauma predominated among nosological forms.

2. The choice of type and mode of respiratory support and of method of ensuring airway patency in patients with acute respiratory failure evacuated by a light-class ambulance helicopter requires a differentiated approach to the choice of method from the AMT doctors.

3. In AMT practice, when providing emergency medical care to critically injured patients using light class helicopters, the tactics of preventive transfer of patients to invasive ventilation is justified. At the same time, it is preferable to perform ventilation with preservation of spontaneous breathing and pressure control, which requires adequate analgesia and prevention of cardiodepressive and arrhythmogenic effects of tracheal intubation.

4. The use of non-invasive ventilation in the practice of AMT requires further study and development.

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## СОВЕРШЕНСТВОВАНИЕ ОРГАНИЗАЦИИ ОКАЗАНИЯ МЕДИЦИНСКОЙ ПОМОЩИ ПОСТРАДАВШИМ В ДОРОЖНО-ТРАНСПОРТНЫХ ПРОИСШЕСТВИЯХ НА ФЕДЕРАЛЬНОЙ АВТОДОРОГЕ В РЕГИОНЕ РОССИИ С НИЗКОЙ ПЛОТНОСТЬЮ НАСЕЛЕНИЯ

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**Резюме.** Цель исследования – на основе разработанной системы организации оказания медицинской помощи пострадавшим в дорожно-транспортных происшествиях (ДТП) на федеральных автодорогах (ФАД) в регионах России с низкой плотностью населения, обосновать необходимость проведения комплекса мероприятий по совершенствованию оказания медицинской помощи указанным контингентам.

**Материалы и методы исследования.** С использованием метода организационного эксперимента выполнены научное обоснование и разработка мероприятий, реализация которых позволит повысить эффективность оказания первой и медицинской помощи пострадавшим в ДТП на ФАД в регионах Российской Федерации с низкой плотностью населения.

**Материалы исследования** – выборка 206 медицинских карт пациентов, поступивших по срочным показаниям после ДТП на ФАД М-8 «Холмогоры» в медицинские организации Архангельской области и получивших медицинскую помощь в стационарных условиях (ф.003/у) в периоды с 1 января по 31 декабря 2016 г. и с 1 января по 31 декабря 2018 г. Учетные формы отбирались по критериям ретроспективного сплошного документального наблюдения – отобраны все истории болезни пострадавших в ДТП, получивших стационарное лечение в исследуемые периоды.

**Критерии включения** в исследование: пол – мужской и женский; пострадавшие в ДТП на участках ФАД М-8 «Холмогоры» в Архангельской области, получившие стационарное лечение; травма получена в указанные периоды.

**Критерии исключения** из исследования: возраст – менее 18 лет; отсутствие травмы, полученной в ДТП, в анамнезе.

Для статистического анализа использовались категориальные переменные, которые были представлены в виде процентных долей. Для определения наличия взаимосвязи между категориальными переменными использовался тест Хи-квадрат Пирсона. Статистическая обработка данных выполнена с использованием пакета прикладных статистических программ SPSS 22.

**Результаты исследования и их анализ.** Внедрение новых организационных подходов к организации оказания медицинской помощи пострадавшим в ДТП на ФАД М-8 «Холмогоры» привело к увеличению к 2018 г. по сравнению с 2016 г. доли своевременных (до 1 ч) доездов бригад скорой медицинской помощи (СМП) до места ДТП; доли пострадавших, которым специалисты бригад СМП выполнили обезболивание, транспортную иммобилизацию, внутривенную инфузию протившоковых препаратов, а также к созданию в травмоцентре I уровня регионального центра компетенций и, как следствие, к росту количества консультаций пострадавших с политравмой и количества медицинских эвакуаций пострадавших с политравмой, проведенных в травмоцентр I уровня.

**Ключевые слова:** Архангельская областная клиническая больница – травмоцентр I уровня, бригады скорой медицинской помощи, время доезда, дорожно-транспортные происшествия, медицинская помощь, медицинская эвакуация, политравма, пострадавшие, региональный центр компетенций, регионы России с низкой плотностью населения, федеральная автодорога М-8 «Холмогоры», федеральные автодороги

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## IMPROVING THE ORGANIZATION OF MEDICAL CARE FOR VICTIMS OF ROAD ACCIDENTS ON THE FEDERAL HIGHWAY IN A LOW-DENSITY REGION OF RUSSIA

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**Summary.** The aim of the study is to substantiate the necessity of a set of measures to improve medical care to the victims of road traffic accidents on federal highways in Russian regions with low population density on the basis of the developed system of medical care provision.

**Materials and research methods.** Using the method of organizational experiment, we carried out the scientific substantiation and development of measures the implementation of which will improve the efficiency of first aid and medical care to the victims of road accidents on the federal highways in the regions of the Russian Federation with low population density.

Materials of the study — a sample of 206 medical records of patients admitted for urgent indications after an accident on the federal highway M-8 "Kholmogory" to medical organizations of the Arkhangelsk region and who received medical care in hospital conditions (form 003/u) in the periods from January 1 to December 31, 2016 and from January 1 to December 31, 2018. Record forms were selected according to the criteria of retrospective continuous documentary observation — all medical histories of accident victims who received inpatient care during the study periods were selected.

Inclusion criteria for the study were: 1. Gender — male and female. 2. Victims of road accidents on the sections of the federal highway M-8 "Kholmogory" in the Arkhangelsk region who received in-patient treatment. 3. Trauma was got in the specified periods.

Exclusion criteria for the study: 1. Age — less than 18 years. 2. No previous traffic accidents trauma.

Categorical variables were used for statistical analysis and presented as percentages. The Pearson Chi-square test was used to determine if there was a relationship between the categorical variables. Statistical processing of the data was performed using a package of applied statistical programs SPSS 22.

**Study results and their analysis.** Implementation of new approaches to the organization of medical care for victims of traffic accidents on the federal highway M-8 "Kholmogory" led to an increase by 2018 compared with 2016: of share of timely (up to 1 hour) delivery of ambulance crews to the place of the accident; of share of victims to whom specialists of ambulance crews performed anesthesia, transport immobilization, intravenous infusion of antishock drugs, as well as the creation of a regional competence center in the Level I trauma center and, consequently, an increase in the number of consultations for victims with polytrauma and in the number of medical evacuations of victims with polytrauma, performed to the Level I trauma center.

**Key words:** ambulance crews, Arkhangelsk Regional Clinical Hospital — Level I trauma center, federal highways, M-8 "Kholmogory" federal highway, medical care, medical evacuation, polytrauma, regional center of competence, road accidents, Russian regions with low population density, time of arrival, victims

**Conflict of interest.** The authors declare no conflict of interest

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#### Introduction

Road traffic injuries (RTA) is one of the most acute medico-social problems the global significance of which is undoubted, especially in the aspect of the most severe traumatic injuries [1-3]. One of the leading transport arteries of the Russian European part of the Arctic is the federal highway M-8 "Kholmogory" (hereinafter — FAD M-8), which has features inherent to almost all such highways: a large total length and a significant length of runs between settlements and medical treatment organizations, often — poor visibility, due to climatic and geographical features of the region. Together, these features significantly increase the risk of road traffic accidents (RTAs) with medical and sanitary consequences, including polytrauma, and reduce the possibility of timely medical care for victims of accidents [4]. Failure to provide or poor-quality medical care within the first hour after an accident increases the risk of fatal outcomes in victims with polytrauma by 30%; from one to three hours — by 60; from three to six hours — almost 2-fold [5-7].

**The aim of the study** is to substantiate the necessity of implementing a set of measures to improve medical care for victims of traffic accidents in the regions of Russia with low population density on the basis of the developed system of organization of medical care on federal highways.

**Materials and Methods.** Using the method of organizational experiment, we carried out the scientific substantiation and development of measures to improve the effectiveness of medical care to the victims of road traffic accidents at federal highways in the regions of the Russian Federation with low population density.

Study materials: a sample of 206 medical records of patients who received medical care under inpatient conditions (f.003/u), admitted in medical organizations of Arkhangelsk region for urgent indica-

tions after an accident on FAD M-8 in the period from January 1 to December 31, 2016 and from January 1 to December 31, 2018. The record forms were selected according to the criteria of retrospective continuous documentary observation — all case histories of accident victims who received inpatient treatment during the study periods were selected.

Inclusion criteria for the study were:

1. Gender — male and female.
2. Victims of road accidents on the sections of FAD M-8 "Kholmogory" in the Arkhangelsk region who received in-patient treatment.
3. Trauma received in the specified periods.

Exclusion criteria for the study:

1. Age — less than 18 years.
2. No trauma previously got in traffic accidents.

Categorical variables were used for statistical analysis and presented as percentages. The Pearson Chi-square test was used to determine whether there was a relationship between the categorical variables. Statistical processing of the data was performed using the SPSS 22 statistical software package.

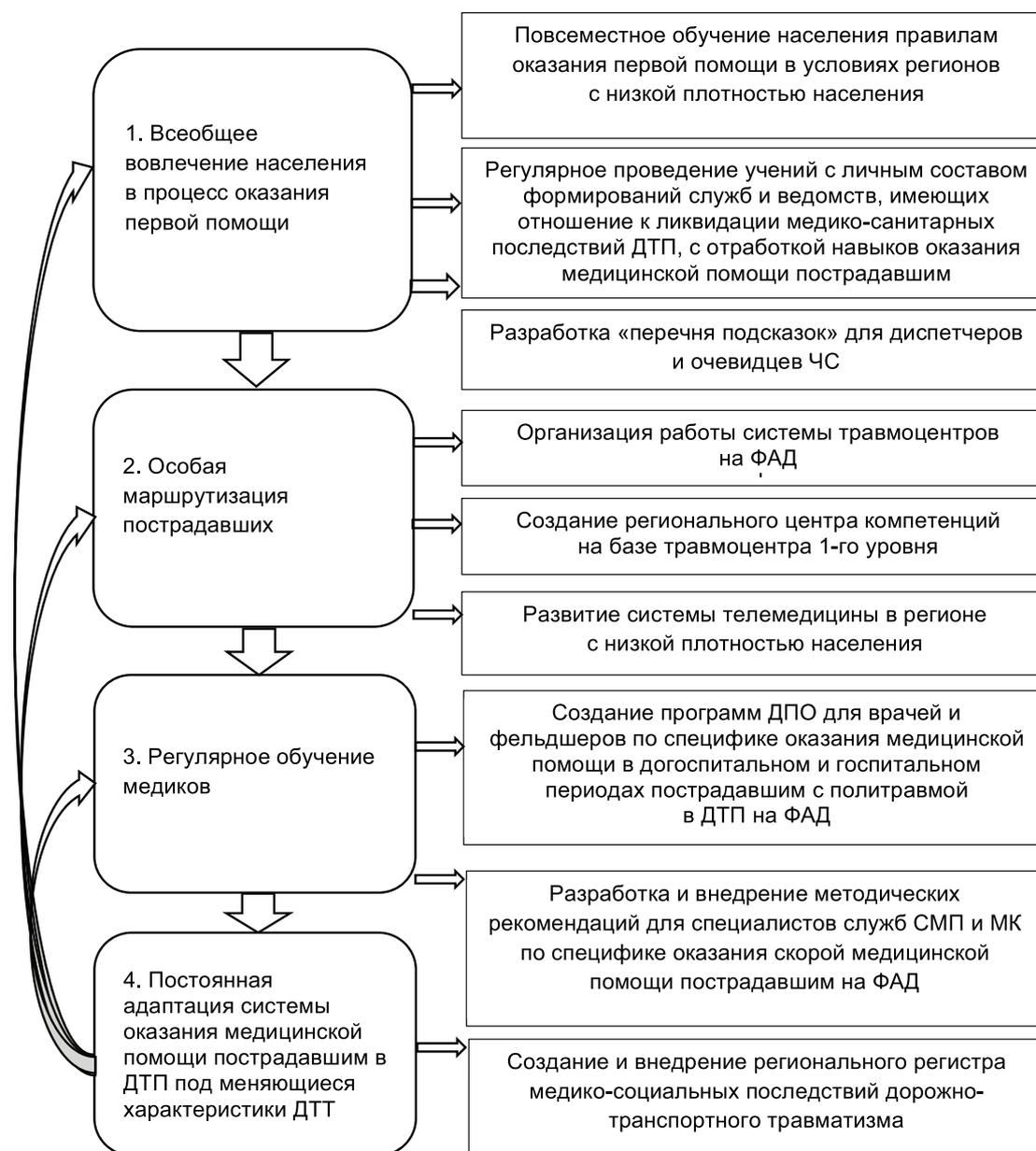
**Results of the study and their analysis.** A large number of fatalities and injured, including those with severe polytrauma, in accidents on federal highways indicates the need to organize the provision of quality and timely medical care, especially in the Russian regions with low density and uneven distribution of the population. Most of these territories are part of the Arctic Zone of the Russian Federation or regions equated to it with very difficult climatic, geographical and socio-economic conditions. It should be noted that these regions currently play a strategic role in the geopolitics of our country. In connection with the above, in 2017 a special system of organization of medical care for victims of road accidents on FAD

M-8 (hereinafter referred to as the System) in the studied subjects of the Russian Federation (hereinafter referred to as the subjects) was developed (figure).

One of the principles of the developed system includes the distribution of trauma centers on the federal highway, which ensures the availability of medical care to victims of road accidents through an equal distribution of medical forces and resources. The zones of responsibility of medical organizations for providing emergency medical assistance to victims on specific sections of FAD M-8 have been established; EMT teams are on duty to provide medical assistance in the pre-hospital period. Implementation of the mentioned technologies resulted in reduction of the time of arrival of ambulance crews to the place of accident on FAD M-8 (tab. 1).

In 2018 compared with 2016 there was an increase in the proportion of timely (up to 1 hour) arrival of ambulance crews to the scene of an accident — from 69.6 to 89.3%.

One of the organizational measures of the developed System was the scientific justification and creation of the Regional Center of Competence (Center of Competence) as part of the Arkhangelsk Regional Clinical Hospital — Level I Trauma Center and the leading medical organization of the region. The work of the Center of Competences implies mandatory forwarding of full information about a patient who has suffered in an accident with severe multiple or combined trauma (polytrauma) and who was admitted to any medical organization of the region — to the Level I Trauma Center for telemedicine consultation by the leading specialists of the Trauma Center. This information must be sent to the Level I Trauma Center by the regional medical institution that received the patient in an accident with polytrauma within twenty-four hours of the patient's admission. After the consultation, a decision is made on the tactics for managing the patient or organizing his/her emergency medical evacuation to a Level I trauma center.



**Рисунок.** Структурно-функциональная модель Системы организации оказания первой и медицинской помощи пострадавшим в ДТП на ФАД в регионах России с низкой плотностью населения; ДПО – дополнительное профессиональное образование, МК – медицина катастроф, ЧС – чрезвычайные ситуации

**Figure.** Structural and functional model of the System of organization of medical care for road traffic victims on federal highways in Russian regions with low population density

Таблица 1/ Table No. 1  
**Время доезда бригад СМП до места ДТП в 2016 и 2018 гг.**  
 Time of arrival of ambulance crews to the place  
 of an accident in 2016 and 2018

Время доезда, мин Time of arrival, min	Количество ДТП, абс./% Number of traffic accidents, abs./%	
	2016	2018
< 20	7/5,7	8/9,5
21–40	40/32,8	35/41,7
41–60	38/31,1	32/38,1
> 60	37/30,4	9/10,7
<b>Всего ДТП</b> Total of traffic accidents	<b>122/100,0</b>	<b>84/100,0</b>

Примечание. Статистически значимые различия в процентном соотношении определялись попарно с помощью критерия  $\chi^2$  Пирсона;  $p = 0,002$

Note. Statistically significant differences in percentages were determined in pairs using Pearson's  $\chi^2$  test;  $p = 0.002$

Prior to the creation of the Competence Center, counseling of victims with polytrauma sustained in a car accident was not mandatory and was done sporadically. For example, in 2016, 68 (66.7%) of 102 victims were counseled; 44 (43.1%) were evacuated to a Level I trauma center. After implementing the principles of the developed System in 2018, out of 60 people injured in accidents on FAD M-8, 52 people (86.7%) were evacuated to a Level I trauma center; 59 people (98.3%) were consulted.

Another principle of the System is regular training of medical and nursing staff in the specifics of providing emergency, including specialized emergency, medical care to victims of traffic accidents on FAD M-8, especially to victims with severe polytrauma or cold injuries. Since 2017, the Northern State Medical University of the Russian Ministry of Health (Arkhangelsk) has been training medical and paramedical staff of ambulance teams to provide specific emergency medical care to victims with multiple and combined trauma (polytrauma), who are in a state of traumatic or hemorrhagic shock, as well as the implementation of the algorithm of actions when there is a large number of victims, when they are threatened with accident hazardous or toxic substances, fire and other possible contingencies. Refresher cycles are held on an ongoing basis. The result of implementation of the above technology was an increase in 2018 compared to 2016 in the proportion of casualties who received anesthesia and transport immobilization, as well as intravenous infusion of antishock drugs (Table 2).

#### Discussion.

The staff of a number of territorial centers for disaster medicine and first-aid stations of the regions of Russia have carried out scientific researches on road traffic traumatism and peculiarities of medical aid rendering to the injured. These studies proposed options for improving and optimizing the existing systems of medical care for the injured in road traffic accidents taking into account the climatic, geographical and social features of a particular region of the country [8-12].

The studies by D.A. Tolkachev, H.H. Ruzanov, E.V. Popova (2009); I.V. Rebikov, A.M. Levin, A.A. Gushchin, S.V. Purusov (2016) presented the experience of emergency response teams (ERT) of the territorial centers for disaster medicine and assessed the effectiveness of assigning track points (TP) to specific sections of federal and major regional highways [13, 14]. The aforementioned authors noted that the competent location of these teams in assigned areas is the basis for an effective rapid response of medical forces and facilities in emergencies.

I.V. Petchin (2019) found that in the prehospital period anesthesia adequate to the severity of the injury was performed in 40.0-50.0% of victims; transport immobilization — in 30.0-40.0% of victims. The

Таблица 2/ Table No. 2  
**Распределение пострадавших в ДТП по видам медицинских вмешательств, выполненных специалистами бригад СМП в 2016 и 2018 гг.**

Distribution of victims of traffic accidents by type of medical interventions, performed by specialists of ambulance teams in 2016 and 2018

Вид медицинского вмешательства Type of medical intervention	Число пострадавших, чел./% Number of victims, people/%		p
	2016	2018	
Обезболивание Pain relief	74/60,6	68/80,9	0,002
Иммобилизация Immobilization	75/61,5	55/65,5	0,559
Внутривенная инфузия Intravenous infusion	35/28,6	26/31,0	0,727
<b>Всего пострадавших</b> Total number of victims	<b>122/100,0</b>	<b>84/100,0</b>	—

Примечание. Статистически значимые различия в процентном соотношении определялись попарно с помощью критерия  $\chi^2$  Пирсона;  $p = 0,002$

Note. Statistically significant differences in percentages were determined in pairs using Pearson's  $\chi^2$  test;  $p = 0.002$

author notes the severe nature of injuries in traffic accidents, which require special professional knowledge and the ability to quickly make verified clinical decisions from the medical specialists of the ambulance crews working in the pre-hospital period [15]. In his dissertation work A.V. Koldin (2010) points out that only 20.0-25.0% of the citizens traumatized in car accidents received in the prehospital period medical care that was adequate to the severity of the trauma; this is associated with unsatisfactory professional training of the emergency medical teams and the Disaster Medicine Service [16]. A.V. Peshkun (2013) notes that the quality of medical care provided by specialists of EMT teams in the pre-hospital period can be reduced if it is provided by specialists of linear medical or paramedic teams, rather than specialized teams [17]. The same author draws attention to the fact that these specialists are insufficiently trained to provide medical care at the scene of the accident to two or more victims, especially — with severe multiple and combined trauma, as well as those in a state of traumatic or hemorrhagic shock [17]. Thus, the data we obtained in the study on the organization of emergency medical care at federal highway in the region of the Russian Federation with low population density are quite consistent with the results of similar studies performed earlier in other regions of our country, and testify to the need for further study and practical elaboration of the raised issue.

**Summarizing the results of the study**, it should be stated that the implemented organizational measures have led to:

- increase in 2018 compared to 2016 of the share of timely (up to 1 hour) arrivals of ambulance crews to the scene of an accident on FAD M-8 from 69.6 to 89.3%,  $p = 0.002$ ;

- increase in 2018 as compared with 2016 of the share of victims to whom specialists of the emergency medical teams performed: anesthesia — from 60.6 to 80.9%; transport immobilization — from 61.5 to 65.5; intravenous infusion of antishock drugs — from 28.6 to 31.0%;

- creation of an advisory competence center in a subject I trauma center and, as a consequence, an increase ( $p < 0.001$ ) in the number of consultations for victims with polytrauma;

- increase ( $p < 0.001$ ) in the number of medical evacuations of polytrauma victims performed from central district hospitals on FAD M-8 to the Level I trauma center.

Implementation in the practical healthcare of the subject of the developed set of proposals for the provision of specialized medical care to victims of road accidents on federal highways in regions with low population density and irregularity has reduced the mortality rate among the injured with polytrauma in the hospital period from 6.7 to 3.6% by 2018.

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## ОПЫТ ТРАНСПОРТИРОВКИ КОМПОНЕНТОВ КРОВИ С ПРИМЕНЕНИЕМ БЕСПИЛОТНОГО ЛЕТАТЕЛЬНОГО АППАРАТА

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**Резюме.** Цели исследования – оценить эффективность транспортировки лейкоредуцированной эритроцитной взвеси (ЛЭВ) с применением беспилотного летательного аппарата (БПЛА) роторного типа (беспилотник, дрон); определить возможность использования ЛЭВ в клинической практике после её транспортировки с применением дрона.

**Материалы и методы исследования.** Выполнялась транспортировка 6 доз ЛЭВ объемом от 260 до 300 мл при помощи БПЛА роторного типа. Перед и после транспортировки определяли пригодность компонентов крови к использованию в клинической практике; оценивали количество эритроцитов, тромбоцитов, лейкоцитов, количество свободного гемоглобина, а также гематокрит. Оценивалась скорость доставки компонентов крови автомобильным транспортом в период минимального дорожного трафика в условиях Санкт-Петербурга. Скорость доставки автомашиной сравнивалась с расчетной скоростью доставки при помощи БПЛА.

**Результаты исследования и их анализ.** Изменения показателей лабораторных исследований ЛЭВ после транспортировки БПЛА роторного типа не являлись статистически значимыми и оставались в пределах нормы. Транспортировка компонентов крови автомобильным транспортом занимает большее количество времени, чем их доставка дроном в условиях мегаполиса – (15 мин 17 с ± 39,3 с) и 5 мин 46 с соответственно.

Результаты пилотного исследования продемонстрировали пригодность использования в клинической практике ЛЭВ после ее транспортировки БПЛА роторного типа.

Кроме того, доставка компонентов крови и других медицинских препаратов дронами в условиях мегаполиса может выполняться значительно быстрее и будет экономически эффективнее транспортировки автомобильным транспортом.

**Ключевые слова:** автотранспорт, безопасность транспортировки, беспилотные летательные аппараты, время транспортировки, дроны, компоненты крови, скорость транспортировки, транспортировка, эффективность транспортировки

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## CASE STUDY OF TRANSPORTING BLOOD COMPONENTS USING AN UNMANNED AERIAL VEHICLE

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**Summary.** The objectives of the study were to evaluate the effect of transportation of leucoreduced erythrocyte suspension (LES) using a rotary-type unmanned aerial vehicle (UAV) (drone); to determine its application and use in clinical practice after transportation on a drone.

**Materials and research methods.** Transportation of 6 doses of LES with a volume of 260 to 300 ml using a rotary-type UAV was performed. Before and after transportation suitability of blood components for clinical use was determined; the number of erythrocytes, platelets, leukocytes, free hemoglobin, and hematocrit were estimated. We evaluated the speed of blood component delivery by automobile transport during the period of minimal traffic in St. Petersburg. The speed of delivery by automobile transport was compared with the estimated speed of delivery by UAV.

**Study results and their analysis.** Changes in the indices of LES laboratory tests after transportation by UAV of rotor type were not statistically significant and remained within the norms. Transportation of blood components by motor transport takes more time than their delivery by drone under metropolitan conditions – (15 min 17 s ± 39,3 s) and 5 min 46 s, respectively.

The results of the pilot study demonstrated the suitability of using LES in clinical practice after its transportation by rotor-type UAV. In addition, delivery of blood components and other medical drugs by drones in metropolitan areas can be performed much faster and will be more cost-effective than transportation by road transport.

**Key words:** blood components, drones, road transport efficiency, transportation, transportation speed, transportation time, UAV

**Conflict of interest.** The authors declare no conflict of interest

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**Relevance**

At the present time unmanned aerial vehicles (hereinafter referred to as UAVs, drones) are widely used not only in military aims, but also in different spheres of peaceful life. Drones are used for aerial photography, delivery of various goods, search and rescue operations, crop monitoring, weather tracking, law enforcement, and assessing the integrity of engineering structures and buildings [1-3].

The successful use of drones in these areas has led to the emergence of another area of their application – medical logistics and provision of emergency and urgent medical care. The usefulness of UAVs for medical purposes is obvious. They reduce the response time to an emergency or an urgent situation. Also, they reduce transportation costs, especially in remote and/or underserved areas. The need for drones may also be relevant in urban areas, where high levels of vehicular traffic can be a serious obstacle to the provision of emergency and urgent medical care. Cases of drones application for delivery of automatic defibrillators and life-saving of patients with cardiac arrest in streets have been described [4-7].

One of the pressing problems in providing medical care to polytrauma victims, especially when they are admitted en masse, is the insufficient amount of blood components. Ground transportation of blood components is often limited due to traffic jams. In addition, delivery of blood components by ambulance (EMS) may not be possible in the context of mass casualty incidents, as EMS vehicles are primarily designed to respond to a call from the scene and to medically evacuate patients. Medical drones can help in rescuing people by reducing the time it takes to deliver blood components and medications over long distances or to trauma centers in metropolitan areas.

Since 2016, Zipline (USA) has used UAVs to deliver blood products, vaccines and antidotes in Rwanda and Ghana. Zipline drones have a range of 160 km and can carry a payload of about 4 kg. If necessary, the payload is parachuted down to medical workers. Studies have shown that the average blood delivery time has decreased from 4 hours to 30 minutes [8]. Matternet, another U.S. drone company, has successfully flown more than 1,800 flights to Switzerland, delivering more than 900 blood components and laboratory samples to Lugano, Bern and Zurich. In the U.S., this company has successfully delivered COVID-19 vaccine to remote areas of the country [8]. Thus, drones are already being used in healthcare of various countries.

In the Russian Federation, UAVs are not yet used in the healthcare system. In the Russian literature available to us, no studies have been found on the use of drones for trans-

porting blood components and its effect on the specified medical products.

**The aim of the study** is to assess the efficiency – speed of transportation compared to ground transport and suitability for use in clinical practice of leucoreduced erythrocyte suspension (LES) after its transportation using rotor-type UAVs.

**Materials and methods of the study.** We used 6 doses of 260-300 ml of LES as blood components. In accordance with the requirements for blood components for human transfusion, the number of erythrocytes, platelets, leukocytes, hemoglobin was determined before and after their transportation, the amount of free hemoglobin and hematocrit was estimated [9]. The study was carried out jointly with the staff of the laboratory of the Blood and Tissue Center of the Kirov Military Medical Academy. A total of 3 flights with LES samples were performed. For the transport of blood components UAV was used. It was built at the St. Petersburg Federal Research Center of the Russian Academy of Sciences and had the following characteristics: unfolded dimensions – 140 140 40 cm, folded – 60 60 40 cm, maximum payload mass – 15 kg, maximum horizontal flight speed – 21 m/s, flight height – 1500 m. A drone with such characteristics can stay in the air from 20 to 25 minutes, and its flight range is limited by the battery charge and is 15 km. Compared to airplane or helicopter-type UAVs, a multirotor drone can take off and land vertically, and is relatively cheap to produce and simple in its mechanics – individual UAV elements were printed on a 3D printer. Transportation of blood components using the UAV was carried out in a special isothermal container (Campingaz Isotherm, Italy). Additionally, we developed a mounting and fixation system for the thermocontainer (Fig. 1, 2).

The length of the flight route was calculated based on the fact that the Blood and Tissue Center of the Kirov Military Medical Academy provides blood components on an urgent basis to the clinic of military field surgery – trauma center of the 1st level of St. Petersburg. In a special program for UAV flight control – Mission Planner – the expected route of the drone 5600 m long – the distance from the Blood and Tissue Center to the clinic of the Military Field Surgery – was built. Estimated flight time was 5 min 46 s.

Test flights of the drone were conducted outside populated areas and away from power lines on private territory in the Leningrad region along two trajectories with the greatest number of direction changes (Fig. 3). This was done in order to test the maximum effect of acceleration on blood components during their transportation on the UAV. During the experimental flights the ambient temperature was 10 °C, wind speed – 5-6 m/s. The flight altitude was 35 m, which



**Рис. 1.** Беспилотный летательный аппарат (БПЛА) с зафиксированным контейнером для перевозки компонентов крови  
**Fig. 1.** Unmanned aerial vehicle (UAV) with fixed container for transportation of blood components



**Рис. 2.** Система крепления контейнера для перевозки компонентов крови на БПЛА  
**Fig. 2.** System of fixing the container for transportation of blood components on the UAV

did not violate the requirements for UAV flights within the city of St. Petersburg. The UAV flight consisted of takeoff, horizontal movement along a pre-programmed trajectory and landing, which took place without the pilot's involvement, in fully automatic mode, but under the operator's visual control. It was foreseen that in case of emergency the operator would control the drone manually.

When transporting 3 doses of blood components by UAV and by car — before and after transportation were additionally compared: speed of blood component delivery and effect of transportation on them. During transportation by car we determined the same parameters as during UAV transportation: number of erythrocytes, platelets, leukocytes, hemoglobin, free hemoglobin, hematocrit. We chose the period of time with the least traffic congestion on weekdays, from 11 till 12 in the afternoon. The time of ambulance ride from the Blood and Tissue Center to the clinic of the Military Field Surgery of the Military Academy was determined. The time was measured during 5 working days. In addition, the number of transported blood components was taken into account.

Shapiro-Wilk criterion at  $\alpha = 0.05$  was used to assess whether quantitative variables obtained in the experiment obeyed the normal law of distribution; equality of variances was checked by Fisher's F-criterion at  $\alpha = 0.05$ . Significance of the differences between the groups was assessed by Student's t-test using a two-sample t-test for related and unrelated samples with  $\alpha = 0.05$ . In the absence of signs of normal distribution of the compared variables, significance of differences between them was assessed by Mann-Whitney U-criterion and Wilcoxon T-criterion. Estimates of the mean values of the studied variables were presented in the text as mathematical expectation (M), 95% confidence interval of mathematical expectation (95% CI), standard deviation (SD), median (Me), mode (Mo), upper and lower quartiles (H25 and H75).

**Results of the study and their analysis.** The study of the flight of the UAV with cargo consisted in the construction of a flight mission simulating an oblique trajectory of movement in urban conditions from the starting point to the end point, where the UAV lands and transfers the cargo.

Three test flights with different flight mission parameters were performed in real conditions. The first flight mission contained a large number of turns and various curvatures along the entire route. In the second and third flight missions, the number of turns was reduced, but the missions differed in horizontal flight speeds of the UAV. All mission parameters are presented in Table 1.

One of the main problems of drones is the rather short flight time for transporting cargo. During maneuvers, drones must slow down, rotate, and accelerate, increasing flight time and therefore energy consumption. The first flight mission had the most curved flight path, so the UAV traveled a shorter distance in 15 min 44 s than the second mission. The first mis-

sion had more than 100 turn points, and the mission ended at the 84th point due to low battery power. The number of maneuvers directly affects the battery life of the UAV — the more maneuvers, the faster the battery drains. With these mission parameters in urban environments, the desired range of 5500 m from takeoff point to landing point will not be achieved. The second and third flight missions had fewer turns and contained 41 maneuver points. The best flight mission time result (13 min 51 s) for moving the UAV with a payload over a distance of 5000 m was obtained in the third mission with a flight speed of 10 m/s. The UAV flight trajectories in the three experiments, where items 3a, 3c, 3d indicate the UAV flight trajectories set in the MissionPlanner, and items 3b, 3d, 3e are the real trajectories taken from the onboard logbook of the UAV, see Fig. 3.

A comparison of the results of the study of changes in the LES parameters before and after transportation is presented in Table 2.

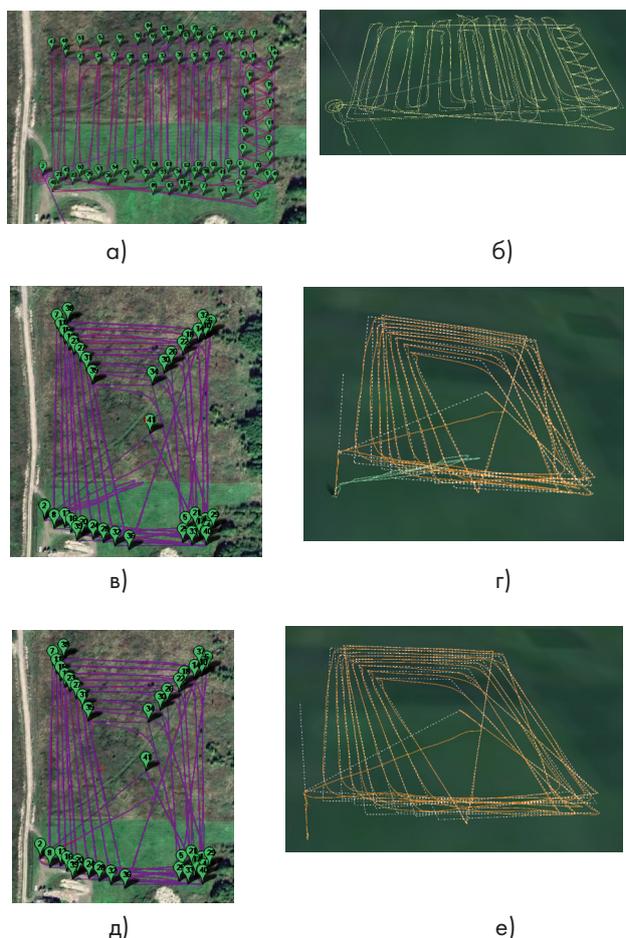
Analysis of the results showed that after transportation by UAV changes in LES samples were minimal, did not differ from changes during ground transportation ( $p > 0.05$ ), which means in accordance with the requirements of the Russian Federation Government Decree of June 22, 2019 № 797 suitability of these blood components for use in clinical practice.

Measurements of the speed of delivery of blood components by ambulance showed that in urban conditions and in the absence of high traffic, transportation time is (15 min 17 s  $\pm$  39.3 s) / (14 min 19 s  $\pm$  16 min 3 s), but during peak hours transportation time will be significantly longer. The number of transported blood components was no more than 7

Таблица 1 / Table No. 1

**Параметры и результаты экспериментов по транспортировке компонентов крови на БПЛА**  
 Parameters and results of experiments on transportation of blood components on a UAV

Параметр / Parameter	Полет №1 Flight No.1	Полет №2 Flight No.2	Полет №3 Flight No.3
Масса полезной нагрузки, кг / Payload mass, kg	8	8	8
Дальность полёта, м Flight range, m	3980	5550	5350
Высота полета, м Flight altitude, m	35	35	35
Расчетное время полета Estimated flight time	10мин 57с 10min 57s	11мин 29с 11min 29s	11мин 29с 11min 29s
Реальное время полета Actual flight time	15мин 44с 15min 44s	16мин 40с 16min 40s	13мин 51с 13min 51s
Заданная горизонтальная скорость полёта, м/с / Set horizontal flight speed, m/s	7	7	10



**Рис. 3.** Траектории полета БПЛА: а, б – в первом эксперименте; в, г – во втором; д, е – в третьем эксперименте  
**Fig. 3.** UAV flight paths: a, b – in the first experiment; c, d – in the second experiment; e, f – in the third experiment

packets (4-7) per trip – hence this cargo can be freely transported in one drone flight.

Discussion of the results of the study

Currently, the use of UAVs is a potential solution to logis-

tical problems associated with the transportation of blood components in metropolitan areas or in areas with an undeveloped road network. Drones are immune to traffic delays and have low cost and maintenance costs. At the same time, since biological samples (blood) are fragile, the use of drones is a viable solution only if they do not adversely affect blood components [3, 9, 10-12]. Thus, to determine the presence and degree of adverse effects on blood components, we had to test different modes of their transportation. The forces acting on the samples transported by the drone include sudden accelerations and decelerations, as well as changes in air pressure and temperature. The effects of these forces cannot be predicted in advance.

Studies of changes in LES samples have shown that this blood product is suitable for use in clinical practice after rotor-type UAV transport. However, there are 28 other blood components that may require similar studies in the future.

The drone used in this experiment was a multirotor drone and had a lower maximum speed and consumed more power than a comparable aerial drone. In addition, the flight path required a low flight speed: at a maximum speed of 21 m/s, the average flight speed was 7-10 m/s. It should be noted that the forces acting on aircraft-type drones (the force of acceleration at launch and when the drone lands) will be different. Given the geographical features of our country, the use of both types of drones will be relevant in Russia. Multirotor UAVs can be widely used for transporting blood components and medical products in urban areas due to their limited flight radius, the need to perform a large number of maneuvers when moving along the trajectory, and due to the lack of takeoff and landing sites for aircraft-type drones. In addition, to reduce the power consumption of UAVs of multirotor type, it is recommended to develop special algorithms for building flight paths in urban conditions. These algorithms should take into account the surrounding static and dynamic obstacles and plan trajectories smoothed by known methods (e.g., the Bezier method), reducing the number of turns. This is necessary to maintain a constant speed of the UAV during maneuvers. Constant speed also ensures that the drone's energy consumption during flight is reduced. Airplane-type drones can be used extensively when

Таблица 2/ Table No. 2

**Изменения показателей анализа образцов ЛЭВ до и после транспортировки на БПЛА и автомашине**  
 Changes in the analysis parameters of leukoreduced erythrocyte suspension samples before and after transportation by UAV and vehicle

Исследуемый образец компонента крови до и после транспортировки на БПЛА (1, 2, 3) и автомашине (4, 5, 6) Blood component sample before and after transportation by UAV (1, 2, 3) and vehicle (4, 5, 6)		Исследуемый показатель / Researched indicator						
		Эритроциты, $\times 10^{12}/л$ Erythrocytes, $\times 10^{12}/l$	Тромбоциты, $\times 10^9/л$ Platelets, $\times 10^9/l$	Лейкоциты, $\times 10^9/л$ Leukocytes, $\times 10^9/l$	Гемоглобин, г/л Hemoglobin, g/l	Гемоглобин, г/доза Hemoglobin, g/dose	Гемоглобин, свободный, г/л Free hemoglobin, g/l	Гематокрит, % Hematocrit, %
№1	До / Befour	6,68	20,1	0,002	184	51,5	0,1	63,9
	После / After	6,78	20,1	0,002	185	51,8	0,1	64,2
№2	До / Befour	6,76	19,1	0,002	180	54,0	0,5	60,0
	После / After	7,78	18,6	0,002	178	53,5	0,4	59,9
№3	До / Befour	6,72	23,9	0,001	182	52,8	0,2	61,2
	После / After	6,70	24,1	0,002	181	52,8	0,1	60,2
№4	До / Befour	6,32	18,7	0,002	165	47,8	0,3	56,1
	После / After	6,32	18,1	0,002	163	47,2	0,3	54,4
№5	До / Befour	5,65	10,7	0,003	172	49,9	0,1	60,0
	После / After	5,98	10,4	0,002	171	49,6	0,1	59,1
№6	До / Befour	6,70	14,1	0,003	167	43,9	0,2	57,3
	После / After	6,73	13,8	0,003	171	45,0	0,2	56,5

transporting heavier medical kits, stowaways, and cargo over long distances outside of large population centers.

In addition, the use of a drone will help to reduce the time of delivery of blood components to the hospital. Thus, our research has shown that even under favorable road conditions the vehicle follows the specified distance for  $(15 \text{ min } 17 \text{ s} \pm 39.3) \text{ s}$ , while the estimated time of the UAV flight along the optimal specified trajectory between the Blood Center and the clinic in St. Petersburg will be only 5 min 46 s. At the same time it should be taken into account that the time of transportation by car can significantly increase due to the difficult road situation, road repairs or accidents on the way. The economic feasibility of using a UAV is also evidenced by the fact that the average number of blood components transported by truck was 7 bags (the average need of clinics). The UAV is capable of transporting this amount of blood components, while it would be more appropriate to use a truck for other purposes.

The question of how safe it is to use drones for medical purposes remains problematic, because not enough experience has yet been accumulated in the use of this type of aircraft. So, despite the reliability of modern UAVs, it is necessary to provide for an additional system of insurance and safe landing of the transported cargo and the drone itself. Parachute systems can be used for this purpose, triggered when the engines stop. At the same time, if the container is accidentally disconnected, biological fluids may leak out. To prevent this situation, the blood in the shipping container must be placed in a package with absorbent material capable of quickly absorbing the leaking material and preventing it from leaking into the soil or water. In addition, it is necessary

to monitor compliance with the temperature regime of transported blood components or medicines, which can be achieved by installing additional temperature sensors in thermocontainers with the possibility of remote monitoring. Currently, these problems can be solved quite easily.

An important factor is also the creation of a regulatory framework for the use of UAVs for medical purposes in various territorial conditions, especially within the city. The construction of UAV routes should be carried out in accordance with the already developed legal requirements, taking into account the location of no-fly zones and performing flights over the places of least congestion of people and vehicles.

The experiment is the first study to assess the safety of transporting blood components using UAVs in Russia. We hope that the design of this experiment will be used in experiments using other classes of drones to transport other blood components, as well as other biological material and medical devices.

### Conclusion

1. The pilot study demonstrated the suitability of leucoreduced erythrocyte suspension in clinical practice after its transportation by rotor-type UAV — minimal changes in its properties did not exceed those of transportation by ground transport.

2. The results of the study showed that the delivery of blood components and other medical preparations by drones in metropolitan areas can be carried out much faster and is more cost-effective compared to their transportation by road transport.

Further research is needed to assess the possibility of using UAVs and drones of helicopter and airplane type for the transportation of these and other blood components.

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## ПРОБЛЕМЫ СОВРЕМЕННОГО АЛГОРИТМА ДЕЙСТВИЙ ПРИ ВЫПОЛНЕНИИ БАЗОВОЙ СЕРДЕЧНО-ЛЁГОЧНОЙ РЕАНИМАЦИИ

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**Резюме.** Дана оценка современного алгоритма действий при выполнении базовой сердечно-лёгочной реанимации (БСЛР). Внесены предложения по изменению последовательности выполнения некоторых действий по спасению пострадавшего, находящегося в состоянии клинической смерти.

**Ключевые слова:** алгоритм действий, базовая сердечно-лёгочная реанимация, безопасность, искусственная вентиляция лёгких, компрессия передней стенки груди, оказание первой помощи, отсутствие дыхания, отсутствие сознания

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## PROBLEMS OF MODERN ALGORITHM IN BASIC CARDIOPULMONARY RESUSCITATION

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**Summary.** The modern algorithm of actions during basic cardiopulmonary resuscitation (CPR) is evaluated. Proposals have been made to change the sequence of certain actions to rescue a patient who is clinically dead.

**Key words:** algorithm of actions, anterior chest wall compression, artificial lung ventilation, basic cardiopulmonary resuscitation, first aid, lack of breathing, safety, unconsciousness

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An up-to-date algorithm for basic cardiopulmonary resuscitation (CPR) is recommended by the Russian Ministry of Health for use in first aid training and is posted on the website of the Russian Ministry of Health in the "All about First Aid" section of the "First Aid" textbook. [1].

The Department of Disaster Medicine and Emergency Medical Care at the I.P. Pavlov Ryazan Medical University has been teaching first aid for more than 10 years. When practicing skills with students, we, of course, rely on general recommendations, but some of them raise doubts about their correctness.

In the section "First Aid Provision for Unconsciousness, Respiratory and Circulatory Stops" of this manual, the following sequence of actions is recommended:

1. At the scene, the first aid worker must assess the safety of himself, the victim(s), and those around him. Thereafter, the threatening factors should be eliminated or the risk to themselves, the victim(s) and others should be minimized.

2. Next, it is necessary to check the presence of consciousness of the victim. To check consciousness, it is necessary to gently shake the victim by the shoulders and ask loudly: "What is wrong with you? Do you need help?" An unconscious person will not be able to respond and answer these questions.

3. If there are no signs of consciousness, determine if the victim is breathing. To do this, you must restore the patency of the victim's airway: place one hand on the victim's forehead, grasp the chin with two fingers of the other, tilt the head, and lift the chin and lower jaw (Fig. 1). Lack of breath determines the necessity of calling an ambulance.

5. At the same time as calling the ambulance, it is necessary to begin pressure on the victim's sternum with your hands. At that, the base of the palm of one hand of the participant of first aid is placed on the middle of the victim's chest.

6. The pressure of the hands on the victim's sternum to a depth of 5-6 cm is performed by the body weight of the first aid participant.

7. After 30 manual pressures on the victim's sternum, it is necessary to perform mouth-to-mouth artificial respiration, etc. (Fig. 2).

### Problems of concern

Because of a number of dangers, including the possibility of prosecution by the victim's relatives, the investigating authorities may suspect the rescuer of exposing someone else to an infectious disease — in such cases it is better not to do CPR. Especially when there are no witnesses and you don't know how long the person was on the ground. In this regard, I think that the training of ordinary citizens in first aid is insufficient. First and foremost, this applies to developing practical skills to perform CPR. The negative consequences for the rescuer may be disproportionately greater than the opportunity to revive the victim. But calling an ambulance crew (EMS) is every citizen's civic duty. It is another matter when you are providing first aid to your loved ones and cannot do otherwise.

2. Calling the ambulance is recommended after determining that the person is not breathing. I believe that the ambulance should be called after determining unconsciousness. The sooner we call, the sooner the ambulance will arrive. Lack of consciousness in a person already requires an ambulance to be called. There are many reasons for unconsciousness, not only lack of breathing.

In accordance with Order No. 477n of the Ministry of Health and Social Development of Russia of May 4, 2012\*, a list of first aid measures is established for the above conditions.

This list defines calling an ambulance team, other special services, whose staff are obliged to provide first aid in accordance with federal law or with a special rule, as the second action. The first action is to check for hazards.

This is difficult to agree with. After all, a person can sleep, be intoxicated, and we call the ambulance team without even trying to determine the presence or absence of consciousness.

3. There are two options for meeting the rescuer with the victim. The first option is when the rescuer saw the person fall;

\* On Approval of the List of First Aid Conditions and the List of First Aid Measures: Order of the Ministry of Health and Social Development of the Russian Federation No. 477n of May 4, 2012



Рис. 1. Действия при определении наличия дыхания у пострадавшего  
Fig. 1. Steps to take when determining if a victim is breathing



Рис. 2. Искусственное дыхание методом «Рот-ко-рту»  
Fig. 2. Artificial respiration by mouth-to-mouth method

the second option is when he/she did not see when the person fell and how long he/she was in that state. In the second case, the person may already be biologically dead. In this case, attempting to continue first aid is pointless. The first signs of the onset of biological death will appear in the eyeballs, so it is necessary to lift the eyelids and determine the presence or absence of signs of biological death.

4. Then an oral cavity revision should be done. Checking breathing without performing this activity may send the rescuer down a false path. The rescuer will assume that breathing is absent due to cardiac arrest (in an adult victim), when in fact the cause may be mechanical asphyxia. In fact, it is not further recommended to check for a pulse, but to immediately begin compressing the anterior chest wall. Such action with a working heart can be detrimental, and artificial pulmonary ventilation (APV) will not be possible.

5. It is recommended that 2 fingers be used to tilt the head when determining breathing and ventilating. Tilt the head back, pull the chin up, and open the mouth at the same time. Example of exposure on a manikin (Fig. 3).

This way you can only do it on a mannequin, not on a person. The head can be tilted back, but the mouth will not open but close. In addition, the rescuer will not be able to tilt his head back for a long time because of pain in his fingers. Example of action on a person (Fig. 4).

This action requires a firm grip with the whole hand (fig. 5).

6. The recommendation to put the palm of the hand on the middle of the chest for pressure during CPR, without using landmarks, in the vast majority of cases will "fail" and its implementation will lead to a rib fracture with all the ensuing consequences (Fig. 6).

It would be a failure even if the victim's chest were exposed and he/she were so thin that his entire skeleton could be seen. And what if he is wearing a T-shirt or with a lot of fatty tissue? Even medical students, when practicing CPR, are not always able to find the middle sternum on a mannequin, much less ordinary citizens.

There is a more reliable way, as shown in Figs. 7-9:

- press the end of your index finger (hold it vertically) on the victim's abdomen along the midline between the umbilicus



Рис. 3. Пример действий для запрокидывания головы на манекене  
Fig. 3. An example of actions for tilting the head on a mannequin



Рис. 4. Пример действий для запрокидывания головы на человеке  
Fig. 4. An example of actions for throwing the head back on a person



**Рис. 5.** Хват кистью руки для запрокидывания головы  
**Fig. 5.** An example of actions for throwing the head back on a person



**Рис. 6.** Положение ладони руки при выполнении СЛР  
**Fig. 6.** The position of the palm of the hand when performing cardiopulmonary resuscitation



**Рис. 7–9.** Способ выполнения БСЛР / **Fig. 7–9.** How to perform basic cardiopulmonary resuscitation

and the sternum and guide it to the lower edge of the sternum — the xiphoid process;

- place two fingers of the other hand next to this finger across the sternum;

- place the base of the palm (this place is defined by the extension of the straight line passing through the first finger to the rib of the palm) of the first hand next to the two fingers of the second hand from the head side along the sternum midline so that the first finger is pointing towards the head and the other four are pointing in the opposite direction from you;

- place the base of the other hand over (parallel to) the first hand — the fingers can be intertwined and lifted upwards. The fingers should not touch the surface of the chest, and both hands should press on the sternum with their base;

- the arms should be at an angle of 90° in relation to the torso of the victim, do not bend at the elbows;

- the back must be straight (without the hump), the head and the back must form a straight line — so the back is less tired;

- firstly one should press on the chest gently (to understand the elasticity of the front wall of the chest), then — with enough force to be able to compress the heart between the chest and

the spine to a sufficient depth, but no more. However, it is better to press harder than weaker; as soon as you feel that you have hit an obstacle, no more pressure should be applied;

- the compression is done pendulum-like, smoothly, using the mass of the upper half of the body;

- frequency of pressing — 100/min;

- make 30 compressions of the anterior chest wall;

- After each compression completely free the anterior chest wall from compressions.

7. The reference to 5-6 cm pressure on an adult has no practical value, as it is not possible to determine the depth of pressure during human CPR. The first pressures should be careful to determine the elasticity of the anterior chest wall, which will not be the same for different citizens. Subsequently, it is necessary to increase the force of pressure and continue pressing until an obstruction is felt. In the end, it is better to squeeze than not to squeeze. The right pressure point is key. If you press on the sternum, the probability of rib fracture is minimal; if you move your hands forward or backward from the sternum, the probability of rib fracture with damage to internal organs increases; if you move toward the abdomen, you can break the xiphoid process [1-5].

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