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Original article

SCIENTIFIC AND METHODICAL APPROACHES TO THE ASSESSMENT OF FMBA OF RUSSIA INSTITUTIONS EMERGENCY PREPAREDNESS IN CASE OF RADIATION ACCIDENTS AND INCIDENTS

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Abstract. *The purpose of the study* is to develop approaches to the substantiation of criteria and methods for quantitative assessment of the preparedness of medical organizations of FMBA of Russia to work in case of radiation emergency situations.
Materials and research methods. Expert (analytical) and computer-based methods were used to estimate preparedness indices for medical organizations of FMBA of Russia on the basis of consensus ideas about possible medical and sanitary consequences of radiation accidents.
Research results and their analysis. A general approach to the quantitative evaluation of emergency preparedness of medical organizations of FMBA of Russia in case of radiation accidents at the enterprises and territories they serve is formulated. The peculiarity of the approach under consideration in determining the proper (baseline) level of readiness for emergency response is the identification of the scale (magnitude) of medical and sanitary consequences based on the gradation of exposure doses and the number of victims. Approaches to substantiation of federal, regional and territorial (local) levels of emergency response of medical organizations of FMBA of Russia are proposed.
Key words: *emergency response, emergency preparedness, health consequences, institutions of FMBA of Russia, radiation accident , radiation damages*

Conflict of interest. The authors declare no conflict of interest

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Оригинальная статья

НАУЧНО-МЕТОДИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ ПРОТИВОАВАРИЙНОЙ ГОТОВНОСТИ МЕДИЦИНСКИХ ОРГАНИЗАЦИЙ ФМБА РОССИИ В СЛУЧАЕ ВОЗНИКНОВЕНИЯ РАДИАЦИОННОЙ АВАРИИ

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Резюме. *Цель исследования* – разработка подходов к обоснованию критериев и способов количественной оценки готовности медицинских организаций ФМБА России к работе в случае возникновения чрезвычайных ситуаций (ЧС) радиационного характера.
Материалы и методы исследования. Использованы экспертный (аналитический) и компьютерный методы оценки показателей готовности медицинских организаций ФМБА России на основе консенсусных представлений о возможных медико-санитарных последствиях радиационных аварий (РА).
Результаты исследования и их анализ. Сформулированы общие подходы к количественной оценке противоаварийной готовности медицинских организаций ФМБА России в случае радиационной аварии на обслуживаемых предприятиях и территориях. Особенностью рассматриваемого подхода при определении должного (базового) уровня готовности к аварийному реагированию является выявление масштаба (величины) медико-санитарных последствий на основе градации доз облучения и числа пораженных. Предложены подходы к обоснованию федерального, регионального и территориального (местного) уровней аварийного реагирования медицинских организаций ФМБА России.

Ключевые слова: *аварийное реагирование, медико-санитарные последствия, медицинские организации ФМБА России, научно-методические подходы, оценка противоаварийной готовности, радиационные аварии, радиационные поражения*

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Introduction

The establishment of nuclear industry and energetics in our country, as well as in other developed countries, was accompanied by radiation accidents of different types and scales [1]. During its 75-year history the State Research Center — A.I.Burnazyan Federal Medical Biophysical Center (hereinafter referred to as the Center) has accumulated unique scientific and practical experience of eliminating medical and sanitary consequences of such accidents. The specialists of the Center directly participated in organization and implementation of large-scale radiation-hygienic activities. The treatment of the injured with severe forms of acute radiation syndrome (ARS), local radiation, lesions was organized and performed.

The basic elements of readiness of specialized organizations of FMBA of Russia to carry out a set of treatment, radiation-hygienic and physical-dosimetric measures are the availability of competent specialists and the possibility to transfer the accumulated "live" experience to the modern generation of doctors and hygienists. Conducting emergency drills and exercises on a regular basis is crucial for emergency preparedness. The importance of motivation and conscious understanding of risks for own health among the medical personnel working in conditions of complicated radiation should not be underestimated.

The aim of the study is to substantiate the necessity of improvement of quantitative methods for evaluation of readiness of medical organizations of FMBA of Russia to liquidate medical and sanitary consequences of radiation accidents and expert evaluation by the criterion "dose — number of exposed (involved) persons" to establish minimum (mandatory) and maximum (conservative) readiness levels which can be provided with available resources.

Materials and research methods. Expert (analytical) and computer methods of quantitative assessment of readiness indicators of medical organizations of FMBA of Russia — REDIAS program — were used. The algorithm of readiness level evaluation is based on the analysis of conformity of the available resources of the medical organization intended for the effective performance of the necessary volume of medical and radiation-hygienic measures with the formal requirements (indices) calculated in an experimental way with reference to the probable scale of medical and sanitary consequences in case of RA at the served enterprise. The program takes into account: the characteristics of the medical base of the organization — capacity of the hospital, polyclinics, laboratories; availability of formations for emergency response, their provision with medical equipment; training and motivation of medical personnel and other critical indicators, as well as the demographic parameters of the territory served. Calculations of the predicted health consequences are limited to the number of casualties and persons requiring medical support. REDIAS also takes into account the probability of occurrence of combined lesions.

The methodology is recommended for testing and used in the current activities of the regional emergency medical dosimetry centers of FMBA of Russia for assessing and improving the preparedness of medical organizations with the development of substantive recommendations, as well as for calculating the probable medical and sanitary consequences of RA during the exercises.

Results of the study and their analysis. Domestic and foreign authors for defining the concept of "preparedness in case of emergency" use the term "capability", i.e. preparedness is considered as a certain capacity to perform (implement) certain functions, such as a rescuer, a doctor, an institution as a whole or a management body [2].

Preparedness is closely related to the existence of a system of emergency planning. It is important to emphasize the importance of realistic planning and implementation of medical and radiation-hygienic measures in the required volume and within the established timeframes. This means, firstly, compliance of the capabilities of medical organizations of FMBA of Russia to receive and treat the victims or to carry out a set of sanitary and hygienic measures with those medical and sanitary consequences, which can be estimated for a given enterprise or territory in case of a radiation accident, and, secondly, the possibility of prompt allocation of additional forces and means and their delivery both within the departmental system of emergency response, and at the national level.

Excessively conservative assessments of the degree of potential radiological threat and, as a consequence, establishment of big planning zones of protective measures can lead to unjustified economic costs and to difficulties in the management of emergency response. To a certain extent this may also apply to the estimation of possible medical and sanitary consequences and, consequently, to the emergency preparedness of the medical organizations of the territorial and federal level.

Table 1 presents a list of indicators used to analyze the preparedness of the centers for hygiene and epidemiology of FMBA of Russia in case of emergency of radiation character [3]. The above indicators, in a sense, are administrative in nature and must be formulated for a specific medical organization of FMBA of Russia, taking into account the specifics of the enterprise served. At the same time, the official approval of such indicators and their introduction into the reporting forms will make it possible to create an electronic database for continuous dynamic monitoring and formulation of promising tasks for preparedness management and improvement.

The purpose of response is not only to ensure the implementation of emergency measures, but also to perform them in accordance with the established time parameters. One of the main elements of evaluation of preparedness of the response system as a whole as well as its separate elements are time parameters: time of deployment of emergency re-

Таблица 1/Table No. 1

Перечень показателей готовности центров гигиены и эпидемиологии ФМБА России

List of Preparedness Indicators of Centers for Hygiene and Epidemiology of FMBA of Russia

	Показатель / Indicator
1.	**Нормативная база / Regulatory framework**
1.1.	Наличие нормативно-методической документации в соответствии с установленным перечнем / Availability of regulatory and methodological documentation in accordance with the established list
1.2.	Результаты и выводы из ранее выполненных оценок готовности / Results and conclusions from previous readiness assessments
1.3.	Проведение мероприятий по результатам проверок / Activities based on the results of inspections
2.	**Подготовка персонала / Staff training**
2.1.	Подготовка врачебного персонала – квалификация, стаж работы, курсы повышения квалификации / Training of medical staff — qualifications, work experience, advanced training courses
2.2.	Подготовка инженерного персонала / Training for engineering staff
2.3.	Подготовка среднего медицинского и технического персонала / Training of nursing and technical staff
3.	**Мощность базы ЦГиЭ / Capacity of the Center for Hygiene and Epidemiology**
3.1.	Виды и объем проводимых измерений и анализов / Types and volume of measurements and tests performed
3.2.	Количество проводимых обследований, подготавливаемых отчетов и заключений / Number of examinations conducted, reports and opinions prepared
3.3.	Наличие и площадь оборудованных лабораторных помещений / Availability and area of equipped laboratory facilities
3.4.	Возможности наращивания мощности при радиационной аварии / Leviling-up possibilities in the event of a radiation accident
3.5.	Численность и укомплектованность аварийных бригад (групп) / Number and staffing of emergency teams (groups)
4.	**Материально-техническое обеспечение / Material and technical facilities**
4.1.	Наличие приборов и оборудования в соответствии с утвержденными перечнями / Availability of devices and equipment in accordance with approved lists
4.2.	Наличие аттестованных методик измерений, в том числе выполнения экспрессных анализов содержания радионуклидов в пробах внешней среды, в продуктах питания и питьевой воде / Availability of certified measurement techniques, including express analyses of radionuclide content in environmental samples, in food and drinking water
4.3.	Наличие передвижных лабораторий радиационного контроля и их оснащение / Availability of mobile radiation control laboratories and their equipment
4.4.	Обновляемость лабораторной и измерительной базы / Updateability of laboratory and measurement facilities
4.5.	Наличие вычислительной техники и расчетных программ / Availability of computer equipment and calculation programs
4.6.	Наличие современных систем связи, в том числе для обмена информацией с обслуживаемым предприятием / Availability of modern communication systems, including for the exchange of information with the enterprise served
4.7.	Наличие комплектов аварийных укладок и их соответствие утвержденному перечню / Availability of emergency kits and their compliance with the approved list
4.8.	Вопросы финансирования обеспечения потребностей в технике, приборном оснащении, оснащении аварийными укладками и др. / Funding of equipment, instrumentation, emergency kits, etc.
5.	**Отработка действий персонала на учениях и тренировках / Personnel training in exercises and drills**
5.1.	Знание персоналом должностных инструкций по действиям в случае радиационной аварии / Personnel knowledge of job instructions for actions in the event of a radiation accident
5.2.	Результаты и выводы из проведенных тренировок и учений / Results and conclusions from training and exercises
5.3.	Планы проведения тренировок, учений и учебных занятий / Plans for drills, exercises and training sessions

sponse facility; time of notification of the managerial and personnel personnel; time of gathering of the formations; time of performance by emergency formations of separate operations and tasks, including medical and sanitary orientation, etc. Taking into account the IAEA recommended time parameters for emergency response activities at radiation hazardous facilities, during exercises and drills the optimal time is determined, which is formalized in time parameters of emergency preparedness [4, 5].

Table 2 presents the possibilities of a differentiated approach to preparedness management and planning of medical and sanitary support in accordance with the level of anticipated radiological threats or the scale of RA in case of its occurrence. The unique features of the Russian Federal Medical and Biological Agency system are the maximum approximation of the medical base to the serviced radiation hazardous facility, knowledge of the medical and hygienic specificity of harmful industrial factors, including the characteristic factors of possible RA. All previous experience of FMBA of Russia emergency response organization is based on the staged system of medical care and close combination of therapeutic and radiation-hygienic measures depending on specific conditions and consequences of radiation accident — see Table 3 [3, 6]. Scientific and methodological support from leading scientific centers and regional emergency medical and dosimetry centers created on their basis, including specialized emergency brigades, occupies an important place. At the same time in case of a major RA a large number of interaction issues are supposed to be solved, including those with territorial health care authorities and medical organizations.

One of the important features of the differentiated approach, established, in particular, in the Decree of the Government of the Russian Federation "On the classification of emergencies of natural and man-made character" from May 21, 2007 No.304, as well as formulated in the IAEA publications — the desire to avoid excessive planning and complex decisions when putting into operation the system of emergency response [4, 5, 7, 8]. Without considering the fundamental differences between the classification of emergencies of natural and man-made nature and the classification of the RA, we should emphasize the failure of direct comparisons, for example, by the number of deaths, direct economic damage, etc. Thus, in practice, often even in the case of overexposure of a single person, the issues of diagnosis and subsequent treatment are addressed at the federal level in a specialized clinical center. Of course, an important role is also played by the territorial (local) link:

Таблица 2/Table No. 2

Участие медицинских организаций ФМБА России в ликвидации медико-санитарных последствий радиационных аварий на обслуживаемых объектах и территориях

Participation of medical organizations of FMBA of Russia in elimination of medical and sanitary consequences of radiation accidents at serviced facilities and territories

Уровень Level	Медицинские последствия Medical consequences	Санитарно-эпидемиологические последствия Sanitary and epidemiological consequences
Федеральный Federal	Участие нескольких специализированных клинических центров ФМБА России в обследовании и лечении пораженных с различными формами и степенью тяжести лучевых поражений. Проведение широкомасштабных клинико-диагностических мероприятий по обследованию пораженных и вовлеченных лиц Participation of several specialized clinical centers of FMBA of Russia for examination and treatment of patients with various forms and severity of radiation injuries. Large-scale clinical-diagnostic activities to examine the affected and involved persons	Проведение масштабных мероприятий по дозиметрическому обследованию населения с целью оценки обоснованности принятых защитных мер. Контроль и проведение мероприятий по ограничению потребления населением местной сельскохозяйственной продукции и водопользования могут охватывать территории нескольких административно-территориальных образований Large-scale activities on dosimetric survey of the population in order to assess the validity of the protective measures taken. Control and implementation of measures to limit the consumption of local agricultural products and water use by the population — may cover the territory of several administrative territorial formations
Региональный Regional	Участие специализированного клинического центра ФМБА России, в том числе отделения с асептическим режимом ведения больных, в лечении ОЛБ и местных лучевых поражений. Использование спектрометров излучений человека (СИЧ), биофизических и цитогенетических лабораторий Involvement of a specialized clinical center of FMBA of Russia, including a department with an aseptic patient management regime, for the treatment of acute radiation sickness and local radiation lesions. Use of human radiation spectrometers (HRS), biophysical and cytogenetic laboratories	Проведение мероприятий по дозиметрическому обследованию населения с целью оценки эффективности принятых защитных мер. Контроль и проведение мероприятий по ограничению потребления населением местной сельскохозяйственной продукции и водопользования могут охватывать ареалы расположения нескольких сельских населенных пунктов Activities on the dosimetric survey of the population in order to assess the effectiveness of the protective measures taken. Control and implementation of measures to limit the consumption of local agricultural products and water use by the population may cover the areas of several rural settlements
Местный Local	Амбулаторное медицинское и дозиметрическое обследование, включая СИЧ, использование биофизических и цитогенетических исследований, пораженных и вовлеченных лиц Outpatient medical and dosimetry examinations, including HRS, use of biophysical and cytogenetic studies of affected and involved persons	Участие в организации мониторинга пораженных и вовлеченных лиц. Контроль и проведение мероприятий по ограничению потребления населением местной сельскохозяйственной продукции и водопользования Participation in the organization of monitoring of affected and involved persons. Control and implementation of measures to limit the consumption of local agricultural products and water use by the population

a health unit, a medical-sanitary unit, a professional pathology center, a regional department, an interregional department and the Federal Medical and Biological Agency of Russia.

The peculiarity of the approach under consideration in determining the proper (baseline) level of preparedness of the medical organization of FMBA of Russia for an emergency of radiation character is the identification of the scale of medical and sanitary consequences based on the gradation of exposure doses and the number of affected persons. Besides, this approach is based on the analysis of the historical experience of liquidation of radiological consequences of radiation accidents and the established ideas about the capability of FMBA organizations to carry out the necessary diagnostic procedures and treatment of patients with various forms of radiation injuries. In the initial period of the accident, the assessment of doses to the personnel and population may imply significant errors associated with the shortcomings of the used calculation methods and incompleteness of the obtained information. Therefore, clinical manifestations of radiation exposure and operational dosimetric values are used in medical triage, medical care of the injured and assessment of the severity of their condition [9, 10]. Nevertheless, exposure dose is a universal integral indicator, which allows assessing the level of participation of FMBA organizations in the emergency response taking into account the number of exposed persons (Table 4).

Thus, for example, in the case of availability of more than 5 people with radiation doses higher than the threshold values for deterministic effects it is necessary to ensure the readiness of all specialized clinics of FMBA of Russia, and in the case of a considerable number (several dozens) of patients with severe forms of acute radiation sickness it may be necessary to cooperate with medical institutions of other ministries and departments. According to the above-mentioned expert evaluation, the use of the resources of medical organizations of the Federal Medical and Biological Agency of Russia at the federal level should also be envisaged in case of a need for an in-depth medical and dosimetric examination of over 50 people with radiation doses exceeding 200 mSv. In this case it may be necessary to involve several laboratories for human radiation spectrometry and biophysical laboratories, to use cytogenetic techniques for examination and verification of dose burdens. The mentioned situations will most likely concern the personnel of the emergency facility and the emergency rescue teams who took part in the liquidation of the RA consequences.

Exposure in the dose range of 50-200 mSv, including those within the limits of doses used as criteria for making urgent decisions in accordance with the Radiation Safety Standards, can affect a larger number of people. The exposed contingents can be both the personnel of the enterprise and emergency rescue teams and separate groups of population, applying protective measures to which have been insufficiently effective. In any case, the proposed mandatory level of preparedness, which requires participation in the emergency response of the Federal Medical and Biological Agency of Russia organizations of the federal level, is the availability of 500 people with dose loads in the specified range. The peculiarity of organizing and, therefore, ensuring preparedness for mass clinical dosimetry examination of the population is the need to plan not only for specialized medical centers, but also for several mobile specialized emergency response teams. At the same time, the tasks to be

Таблица 3/Table No. 3

Этапы и оптимальные сроки оказания первой и медицинской помощи

Stages and optimal timing of first aid and medical care

Этап медицинской эвакуации Medical evacuation stage	Медицинские формирования и организации Medical formations and organizations	Первая помощь, виды медицинской помощи First aid, types of medical care	Оптимальное время начала оказания первой и медицинской помощи Optimal time to start of first aid and medical care
Место аварии Accident site	Персонал предприятия, спасательные службы Personnel of the enterprise, rescue services	Первая помощь в виде само- и взаимопомощи, расширенная первая помощь First aid in the form of self- and mutual aid, extended first aid	Сразу после установления факта радиационного воздействия Immediately after establishing the fact of radiation exposure
Санитарный пост, санитарный пропускник Sanitary post, sanitary passageway	Формирования гражданской обороны – санитарный пост, санитарная дружина Civil defense formations — sanitary post, sanitary squadron	Первичная доврачебная медико-санитарная помощь, санитарная обработка Primary pre-hospital medical care, sanitation	Первые 10–20 мин First 10-20 min
Здравпункт Health Station	Фельдшер здравпункта, радиологическая бригада МСЧ* Medical assistant of the health center, radiological team of the medical unit	Первичная доврачебная, первичная врачебная медико-санитарная помощь Primary pre-hospital, primary medical and sanitary care	Первые 20–30 мин First 20-30 min
Сортировочная площадка, автомобиль СМП** Sorting area, ambulance	Бригада СМП Ambulance team	Медицинская сортировка, первичная врачебная медико-санитарная помощь Medical triage, primary medical care	Первые 20–60 мин First 20-60 min
Специализированное приемное отделение МСЧ Specialized admission department of the medical unit	Радиологическая бригада МСЧ Radiological team of the medical unit	Первичная врачебная медико-санитарная помощь, санитарная обработка Primary medical and sanitary care, sanitation	Первые 1–2 ч First 1-2 h
Профильные отделения МСЧ Specialized departments of the medical unit	Стационар МСЧ: - отделение профпатологии; - отделение травматологии; - отделение интенсивной терапии и реанимационное отделение Inpatient unit of the medical unit: - occupational pathology department; - traumatology department; - intensive care unit	Первичная медико-санитарная помощь с элементами специализированной медицинской помощи Primary medical care with elements of specialized medical care	Начиная с первых одного-двух часов Starting with the first one or two hours
Специализированный стационар Specialized hospital	Профильные отделения Specialized departments	Первичная специализированная, в том числе высокотехнологичная, медицинской помощь Primary specialized, including high-tech, medical care	Не позднее 24 ч No later than 24 h

* МСЧ – медико-санитарная часть / medical unit
** СМП – скорая медицинская помощь / ambulance

solved by them should include: conducting selective dosimetric examination of the population using mobile complexes; blood sampling for cytogenetic studies; radiation and hygienic examination of the territory of settlements and their agricultural areas.

The above examples, to a certain extent, will also be characteristic of preparedness at the regional level. With the above scale of medical and sanitary consequences, there is reason to believe that the FMBA organizations of Russia can provide a sufficient level of preparedness and to carry out medical-diagnostic and radiation-hygienic activities in full scope.

At any scale of a radiation accident, participation in the medical and sanitary support and emergency response of the units of FMBA of Russia is certainly a priority and will be mandatory. In the medical-sanitary unit, when it is necessary to treat the injured with high radiation doses, the main attention should be paid to stabilizing their condition and to preparing them for evacuation to the specialized hospital of the federal level. Important measures are to conduct a simplified dosimetric examination (preliminary assessment of surface radioactive contamination of the injured, as well as the intake of radioactive substances into the body), selection, preparation and transfer of biological samples of the required volume for subsequent research in specialized laboratories.

In the case of RA, the development of spatial and temporal models of the formation of dose loads on personnel under uncontrolled exposure is associated with even greater uncertainties than the results of forecasting of radiological consequences for the population in the event of an accidental release. For this reason, expert approaches, based on the historical experience of liquidation of the consequences of past radiation events, are used to assess the possible medical and sanitary consequences.

The data of the Burnazyan Federal Medical and Biological Center and the information published by the IAEA on the RA consequences in 1945-2010 suggest that as a result of

a single emergency event (with the exception of the accident at the Chernobyl NPP in 1986) the number of victims of acute radiation injury of varying severity ranges from several people to several dozens of them [11]. To illustrate a conservative estimation of possible medical and sanitary consequences of different scales of RA, quantitative characteristics and structure of affected persons from among the personnel of the NPP at the operating power unit with RBMK-1000 reactor are presented in Table 5. These calculations were performed using the computer program REDIAS on the basis of the data on the number of the affected persons and the structure of the radiation injuries of the personnel and the liquidators of the Chernobyl accident as well as on the available data on the medical and sanitary consequences of the RA in our country and abroad (Fig. 1). Such modifying factors as the number of personnel on maximum shift, combined lesions as a result of thermal and mechanical injuries and other factors were taken into account by expert judgment.

On Fig. 2 there is a principal scheme of algorithm of medical organization preparedness in case of RA on the object of I category of potential radiation danger - according to sanitary rules 2.6.1.2612-10 (OSPORB 99/2010).

The presented assessments are indicative, but at the same time the use of the calculation program allows to quickly assess the structure of radiation injuries, depending on the initial data and the scenario under consideration. The resulting tables can be analyzed by experts to determine whether the estimates are realistic.

In general, in determining the level of preparedness of medical institutions of FMBA of Russia in case of large-scale RA (level 6-7 according to the INES scale) it should be oriented (according to maximum estimates) on the need to provide medical care to about 100 patients with various forms of radiation injuries, including 10 patients with life-threatening indications (see Table 5). These values correspond to a two-threefold reserve in planning the medical and sanitary provision of the injured in full and in an optimum time. We should also take into account the possibility of a large number of the wounded as a result of overdiagnosis and their self-referral for medical help.

Таблица 4/Table No. 4

Уровни участия медицинских организаций ФМБА России в аварийном реагировании в зависимости от доз облучения и числа пораженных и/или вовлеченных лиц

Levels of involvement of medical organizations of FMBA of Russia in emergency response depending on exposure doses and the number of victims and/or persons involved

Уровень Level	>1Гр на все тело >1 Gy for the whole body	0,2–1,0 Зв / Sv	0,05–0,2 Зв / Sv	0,005–0,05 Зв / Sv
Число пораженных и/или вовлеченных лиц, чел. Number of victims and/or persons involved, pers.				
Федеральный Federal	>5	>50	>500	>5000
Региональный Regional	1–5	10–50	100–500	1000–5000
Местный Local	Нет / No	<10	<100	<1000

It is assumed that the severely injured will be mainly with combined lesions, and almost always there will be a need to carry out their sanitary treatment in the organization of the sanitary-access regime in the medical institution[12].

Currently, the developed indicators and methodology for assessing the preparedness of medical organizations of FMBA of Russia are used as a research and analysis tool. On this basis, consultations are conducted and targeted recommendations are prepared to improve certain readiness indicators. In our opinion, taking into account the accumulated experience and existing comments, the pilot version of the methodology and the REDIAS program can be officially used in the practice of FMBA organizations of the medical and sanitary-hygienic profile. The main arguments in favor of adopting this proposal are the possibility of identifying the "weak link", independent control and management of readiness to eliminate emergencies of radiation nature.

Conclusion

The article formulates general approaches to the quantitative assessment of emergency preparedness of Russian Federal Medical and Biological Agency organizations in case of emergency situations at the enterprises and territo-

Таблица 5/Table No. 5

Прогноз медико-санитарных последствий в случае возникновения крупной радиационной аварии на АЭС – программа REDIAS

Forecast of health consequences in case of a major radiation accident at a nuclear power plant — REDIAS program

Факторы аварии / Accident factors	Структура контингента пораженных, чел. Contingent structure of victims, pers.
Внешнее облучение / External exposure	Тяжелопораженные – до 5 /Severely injured — up to 5 Средней степени тяжести – до 35 /Moderate severity — up to 35 Легкой степени тяжести – до 50 / Mild degree of severity, up to 50 Без прогноза клинических эффектов – до 150 / No prognosis of clinical effects — up to 150
Внутреннее облучение / Internal exposure	Тяжелопораженные – 0–1 / Severely injured — 0-1 Средней степени тяжести – до 5 / Moderate severity — up to 5 Без прогноза клинических эффектов – до 15 / No prognosis of clinical effects — up to 15
Общее число лиц, нуждающихся в оказании специализированной медицинской помощи / Total number of persons in need of specialized medical care	До 100 / Up to 100 Доля лиц с сочетанным поражением – 60% Percentage of persons with co-morbidities — 60% Доля лиц, нуждающихся в полной санобработке – 60% Percentage of persons in need of complete sanitation — 60%
Общее число лиц, нуждающихся в проведении медицинского обследования и профилактических мероприятий / Total number of persons in need of medical examination and preventive measures	Более 1 тыс. / More than 1 thousand pers.

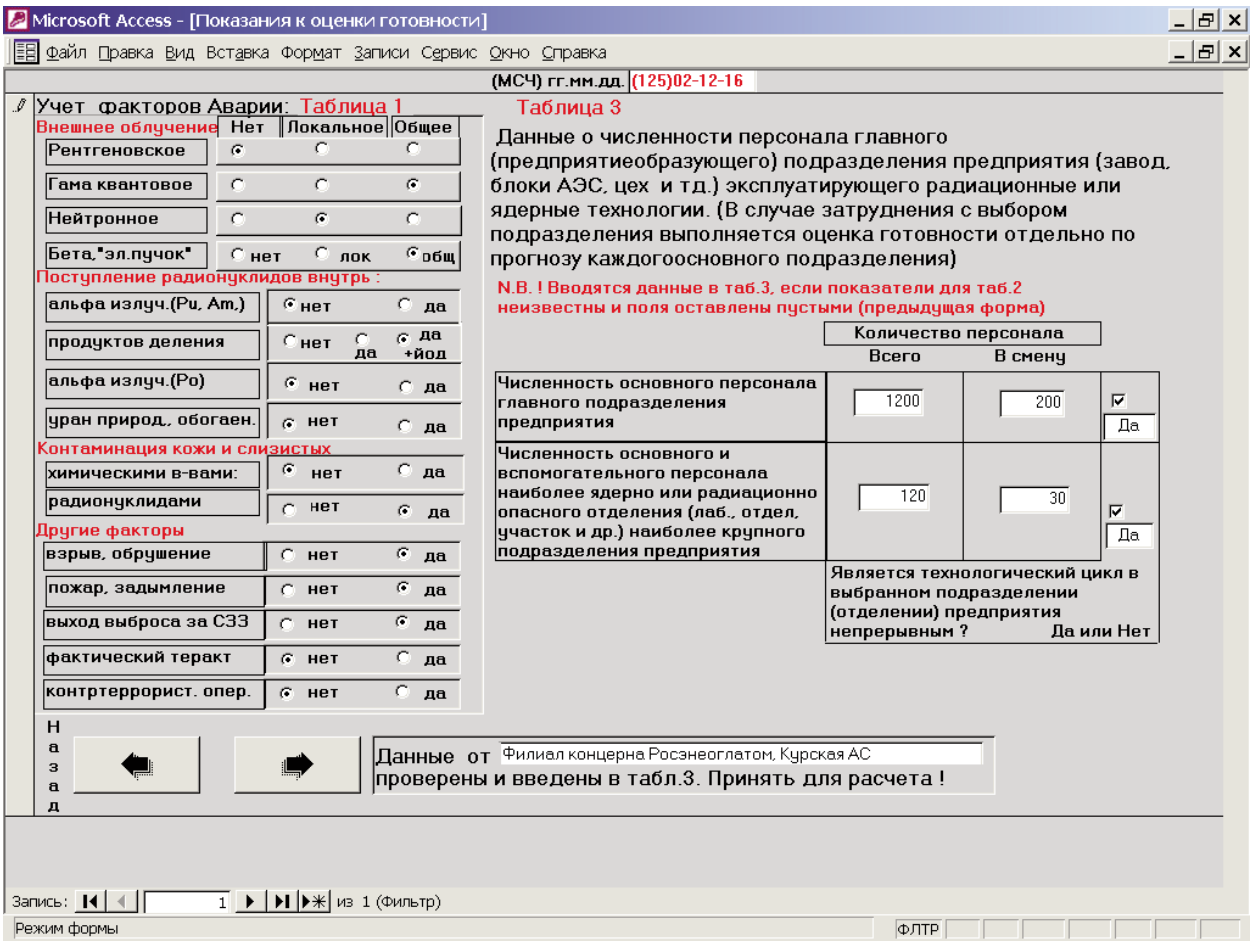

Рис. 1. Интерфейс программы REDIAS
Fig. 1. REDIAS Program Interface

ries they serve. The maintained level of preparedness must correspond to the potential or situational threat of RA and be based on the results of assessments of radiation consequences. As a rule, these results contain significant uncertainties associated with the complexity of modeling the factors and conditions of emergency development. Therefore, quantitative assessments of medical and sanitary consequences contained in site plans for personnel protection measures should be treated with a fair degree of caution. For example, the experience of participation in comprehensive emergency drills at NPPs shows that the maximum medical and sanitary consequences, included by the operating organization in the exercise scenario, are, as a rule, 1-3 people from among the NPP personnel. In this case the radiation consequences are also minimal. The practical conclusion from this experience is the necessity of developing medical scenarios for exercises and drills in order to work out the thematic issues of preparedness of the organizations of FMBA of Russia [13]. An important element of maintaining the preparedness of the stages of medical care in the pre-hospital period is the close interaction between the emergency services and the medical organization of the Federal Medical and Biological Agency of Russia. In 2016, for effective implementation of measures to provide first and subsequent medical aid to the injured in emergencies at NPPs, the "Model Agreement on Cooperation between the Branch of Rosenergoatom JSC — Operating Nuclear Power Plant and Medical Organization of FMBA of Russia during establishment and operation of the NPP rescue medical service" was put into effect.

The Burnazyan Federal Medical and Biological Center has developed a standard program of exercises and drills aimed, among other things, at studying such issues as medical triage of the injured; assessment of the capacity of medical and sanitary departments; time parameters for a set of dosimetry and laboratory tests.

At present, it is necessary to introduce into the practice of FMBA organizations of the medical and sanitary-hygienic profile a pilot version of the methodology and computer program REDIAS to assess the readiness for emergency response. One of the mechanisms for assessing and managing preparedness is the creation of an information-management system (database), which greatly simplifies the collection and storage of necessary information and maintenance of documentation, allowing to assess the dynamics of development of the emergency response system, to draw conclusions and justifications for its further development.

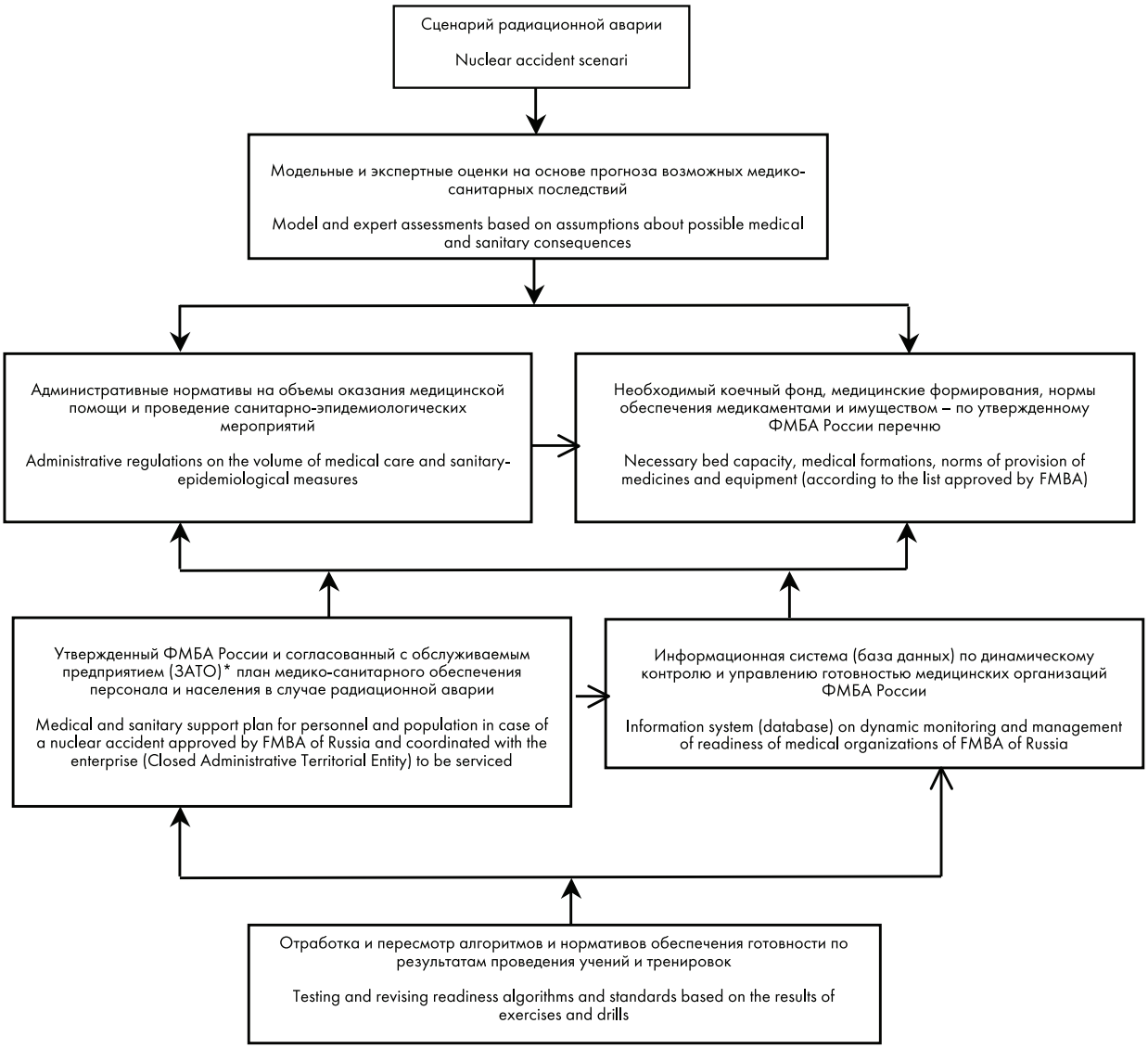

Рис. 2. Принципиальная схема оценки показателей и алгоритма обеспечения готовности медицинской организации ФМБА России
* ЗАТО – закрытое административно-территориальное образование
Fig. 2. Schematic Diagram of the Assessment of Indicators and the Algorithm for Ensuring the Preparedness of the FMBA of Russia Medical Organization

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