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# **Pharmaceutical care of premedical and first aid in case of injuries: impact of biological and nuclear weapons and radiation exposure from military destruction of nuclear power plants**

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## **Abstract**

The relevance of the topic is due to the increased risk of radiation hazards on the territory of Ukraine caused by the frequent shelling of nuclear power plants in the Zaporizhzhya region. This research work aims to calculate the percentage of the population that is sufficiently aware of the issues in providing medical care for radiation and other injuries. During the scientific research, the authors used analytical, statistical, and diagnostic methods to study information on radiation hazards and define the specifics and consequences of the use of various types of biological weapons. The main results achieved within the framework of this scientific study would be a clear justification and assessment of the radiation hazards for Ukrainians and a determination of the feasibility and indications for the use of certain medicines. The results obtained and the conclusions formulated on their basis are of practical importance for the military, territorial defence fighters, students of medical universities, sanitary workers, police officers, teachers, drivers, and civilians.

## **Introduction**

The need to study the issues of providing premedical and first aid in cases of injuries caused by biological or nuclear weapons arose due to the increase in the level of radiation hazards in Ukraine. It resulted from frequent shelling of the Zaporizhzhya Nuclear Power Plant (NPP) as well as a low level of awareness among the civilian population about providing quality assistance to victims. The study of radiation safety issues has been undergoing research by various authors for a long time,

since the topic of radiation damage has been relevant in Ukraine and Europe since the Chernobyl disaster on April 26, 1986. Most of the previous studies tried to weigh the risks of radiation or bacteriological hazards and the probability of certain consequences, as well as create recommendations against the risk of explosion. The problem of past studies was the lack of consideration of the issues related to the provision of first aid with certain pharmacological drugs, as well as the absence of a basic algorithm of action to help victims.

According to R. Peel,<sup>1</sup> the risk of violation of radiation safety standards has increased significantly due to the constant shelling of the Zaporizhzhya NPP. In the event of an accident at this NPP, not only Ukrainians but also residents of other countries will be under threat, since the spread of radiation particles fully depends on the direction and strength of the wind. Because of the high risk of radiation hazards, the people of Ukraine should learn a clear set of steps for what to do in the event of radiation exposure and how to give first aid. Following these simple rules could greatly reduce the number of victims and prevent major problems. According to a study by A. Dehghani,<sup>2</sup> approximately 45% of the civilian population believes that only the use of personal respiratory protection equipment will be effective in cases of radiation exposure, as well as staying in a safe and maximally closed place with no direct connection to contaminated air.

According to Suksompong and Khamtuikrua,<sup>3</sup> the authorities and the World Health Organisation (WHO) should convey the importance of first aid provision to ordinary citizens. Some authors, such as Roffey *et al.*<sup>4</sup> recognise that awareness of the use of biological weaponry is low, as about half of the civilian population does not even know how biological weapons are used. However, J.P. Dudley<sup>5</sup> notes that the main problem now is the ignorance of the basic algorithm of actions for the provision of premedical care and the refusal to use medicines in the event of a nuclear or bacteriological threat. It should be noted that if an accident occurs at the NPP, the number of victims on the territory of Ukraine might be very high.

In this regard, the purpose of this study is to analyse the problems currently faced by health services as well as formulate recommendations and certain hypotheses for their resolution. This study is to

identify the percentage of the civilian population of Ukraine who are not aware of the issues of providing premedical and first aid and to assess the level of public interaction. The authors described the feasibility of using certain medicines that will help reduce the number of victims from potential accidents or the impact of nuclear or bacteriological weapons. In addition, the authors formulated a basic algorithm for first aid actions and provided victims with designated drugs that will help to improve their well-being and prevent the development of acute conditions. The authors elaborated on recommendations aimed at raising awareness of the stated issues among the civilian population of Ukraine.

## **Materials and Methods**

During the study, the authors qualitatively combined various research methods, including statistical, analytical, and some theoretical methods (data analysis, explanation, generalisation, and method of analogies). With the help of these research methods, it was possible to identify the core issues of the declared topics and to analyse all possible risks and consequences in the case of the use of biological or nuclear weapons on the territory of Ukraine. This allowed the formulation of certain statements and hypotheses that will contribute to improving the level of knowledge and skills of the civilian population in providing quality premedical and first aid for the declared types of injuries. The statistical method helped identify the percentage of Ukrainian civilians able to provide proper assistance in cases of radiation or biological weapons exposure. The analytical method of the research involved studying previous studies and observations of military and/or medical personnel on nuclear and biological hazards, as well as providing victims with the necessary assistance. The use of theoretical research methods helped to study the material more thoroughly, substantiate certain opinions on the issues presented, and formulate clear conclusions from this study.

This study was carried out in several main stages. The first stage implied the search and detailed study of literature and other information materials containing issues related to the provision of premedical or first aid to victims of biological or nuclear weapons. The authors studied the specifics

of the use of the declared types of weapons, their danger, and the possibilities of protecting the civilian population by applying certain safety measures and taking medicines that will have a protective pharmacological effect on the human body. In addition, the authors clarified the relevance of the topic, outlined the main problems and purpose of the study, and defined the main tasks.

In the second stage of the study, the authors compared the analysed information with the current military situation in Ukraine. The authors also came up with a clear basic plan for what to do for first aid in case biological or nuclear weapons were used. They also looked at how useful it would be to use certain medicines, whose pharmacological effects should protect the body from the harmful effects of radiation or biological weapons.

The third stage of the study included the formulation of recommendations that will contribute to improving the level of knowledge and practical skills in providing quality premedical and first aid to victims among the civilian population of Ukraine. In addition, the main results and logical conclusions of the study are presented, as well as their comparison with the findings of previous research on this topic.

The previous studies of Ukrainian, American, Norwegian, German, and other scientists and authors contributed to addressing the stated issues. The authors would like to note that the results presented in this study could serve as a fundamental theoretical basis for further research.

## **Results**

Currently, nuclear, biological, and chemical weapons are recognised as the most dangerous among weapons of mass destruction.<sup>6</sup> In the study, the authors covered only biological and nuclear weapons. The biological weapons include various types of microorganisms, including viruses, bacteria, and fungi. The spread of living microorganisms provokes serious illness or death in humans, animals, and plants. The use of this type of weapon is unlikely in modern warfare, but the civilian population should be aware of the issues in providing quality premedical or first aid against

the use of various types of biological weapons. The main problem with the biological hazard is the complexity of its indication. Eventually, it becomes difficult to ensure quality protection for the population and the military. However, it takes a lot of time to identify the agent and establish the fact that they are using bacteriological weapons (usually 12 hours or more), which requires the assistance of qualified personnel and high-quality laboratory equipment.<sup>7</sup> In addition, the governing bodies should analyse the effectiveness of the protection systems applied in the infected area throughout the whole epidemic or threat of infection and improve preventive measures if necessary. It should be noted that currently Ukraine and other European countries are poorly prepared against using biological weapons.

According to Boivin and Piret,<sup>8</sup> a large number of disease cases (typically the incidence rate is between 60% and 90%) and infection-related deaths are evidence of the use of bacteriological weapons. It also includes unusual symptoms of the disease, a high mortality rate in animals, and signs of an outbreak of several diseases at once. It should be noted that medical means of civilian protection imply the introduction of vaccines against the infectious agent (often the bacteriological hazards result in anthrax, plague, and smallpox). In addition, it is advisable to conduct chemoprophylaxis, administer passive antibody therapy, and take antimicrobial drugs. However, an obligatory aspect of preventing the spread of pathogenic particles from biological weapons is prevention. The primary prevention is about detecting the pathogenic agent, revealing the origin of biological weapons, and providing maximum protection to the population from damage. Secondary prevention involves early detection and proper treatment of the disease. Tertiary prevention has the objective of preventing deaths, the consequences of illness, and the disability of the population. The key stage is secondary prevention, as this step determines the impact of the use of bacteriological weapons on the population.<sup>9,10</sup> The study by S. Riedel<sup>11</sup> shows that, currently, primary and secondary prevention is rather flawed. The author says that more research needs to be done to improve epidemiological surveillance and find quick diagnostic tools that can help with responding

to the use of biological weapons. This will make the secondary prevention measures even more effective.

The ignorance of basic algorithms of action in cases of radiation and bacteriological damage leads to a sharp increase in the number of deaths and disabilities in the population due to the use of declared kinds of weapons.<sup>12-14</sup> The survey by Skidan and Tkachenko,<sup>15</sup> which was conducted in Ukraine, was taken into account. The number of respondents was 338 citizens of Ukraine, including 67.2% women and 32.8% men. In addition, the respondents fall into the following age categories: 20-25 years old: 3.1% of respondents; 25-35 years old: 70.9%; and 36-45 years old: 26%. The survey contained 11 questions, including an understanding of the “radiation” concept, awareness of the damaging factors of nuclear weapons and types of weapons of mass destruction, as well as knowledge of personal protective equipment by category. The following questions also included understanding the destructive impact of a nuclear explosion, comprehension of the expediency of using iodine tablets, the ability to decipher the abbreviation IACP-11 (Individual Anti-Chemical Package), and taking action in the case of a mushroom-like cloud. The results of this survey showed that only 2-3% of ordinary civilians could answer the questions correctly. The percentage among other categories of the population is shop workers (3-4%), drivers (up to 5%), schoolchildren (1-2%), students of higher education institutions (2-3%), teachers of preschool institutions (5-7%), teachers of schools (6-8%) and teachers of higher education institutions (8-9%). The other categories are nurses – up to 12%, physicians – 15-20%, security guards – up to 13%, police officers – 14-15%, fighters of territorial defense – 12-13% and military – 18-23%. The results indicate a critically low level of awareness among the Ukrainian population about the specifics of nuclear weaponry use, the risk of human damage, and the basic algorithm of action. However, medical workers and military and territorial defense soldiers are somewhat more competent in the stated issues.

The analysis of the data indicates the urgent need for raising awareness among civilians against the use of nuclear and biological weapons, as well as providing first aid and self-help in cases of these



types of injuries. In this regard, the authors have made recommendations to increase public awareness of the provision of premedical or first aid: i) carrying out information and educational activities on the stated issue; ii) conducting special activities by medical representatives aimed at raising the level of knowledge among participants on providing proper assistance to victims and self-help - the program of such events should include simulations of certain situations (explosions, NPP accidents, use of projectiles with hazardous biological components), during which participants will be able to work out an algorithm of actions to provide self-help as well as assistance to victims and others; iii) preparation and dissemination of special guides or methodological instructions, which will clearly describe actions to assist in specific situations against different types of weapons or projectiles; iv) introduction of the lectures and practical classes) according to the declared topics in the educational program of school students and students of higher educational institutions (medical and non-medical); v) conducting and broadcasting special reports in the media, which will address theoretical issues (including the use of drug therapy) and practical aspects of the application of basic algorithms for emergencies (in this case, radiation and bacteriological hazards).

The implementation of the stated recommendations will contribute to a significant increase in the level of knowledge and skills in providing premedical and first aid for various types of injuries, which will significantly reduce the scale of consequences and the number of victims during military operations in Ukraine. However, some researchers, for example, Tekin and Aslan,<sup>16</sup> note that failure to provide first aid to victims of radiation or bacteriological injuries or render poor-quality service may come directly from fear of performing the wrong actions. According to the authors, about 78% of the civilian population would not use medicines because they were afraid of harming themselves or other people.

There are organisations and institutions in Ukraine that deal with radiation safety and radiation risk management. They work on monitoring the radiation situation, developing strategies to ensure public safety, and conducting research and educational activities on this topic. In Table 1, the authors considered the leading Ukrainian organisations in this field.

Radioprotectors are chemical drugs whose action is aimed at reducing damage due to ionising radiation by increasing radioresistance or reducing radiosensitivity of tissues and cells in the body.<sup>17</sup> They are advisable to use in cases where there is a high risk of radiation damage. There are radioprotectors of short-term (the anti-radiation effect is observed from half an hour to 4 hours) and prolonged (effective from 1 to several days) action.<sup>18</sup> Some of the short-term radioprotectors are reducing agents (like cysteine, mercaptoethylamine, gammaphos, and others), antioxidants (like ascorbic acid, vitamin E, and tocopherol), and agents that cause tissues and cells to lose oxygen (like methemoglobin-forming agents, cyanides, and nitrites).<sup>19-21</sup> It should be noted that cystamine is a standard remedy that should be used 40-50 minutes before irradiation, but if the received dose is 1 Gy or more, the injured person should take 6 tablets at a time; repeated intake of the drug is carried out during the next three days, 2-3 times a day, but no more than twelve tablets at a daily dose.

Long-acting drugs should include drugs with anabolic effects (estrogens) as well as polymers of polyanionic action (heparin, polysaccharides, polynucleotides, and nucleic acids). The most common is RTD-77, which suppresses the function of the thyroid gland and, at the same time, activates the internal secretory function of the adrenal glands. In addition, it inhibits the processes of post-radiation catabolism, increasing the repair of radiosensitive tissues. The dosage of the drug is 50 mg, and the efficacy is in radiation doses up to 6 Gy. It should also be mentioned as B-190, which shows its instant effectiveness in radiation exposure, reducing the severity of radiation damage to 70-80%. It would be advisable to use it for NPP employees since the effect of the drug would secure the personnel to perform all necessary actions, disable the necessary equipment, and prevent further release of radioactive particles, if possible. Therefore, it would reduce the scope of the disaster and downscale the radiation impact on Ukrainians and residents of other countries. The optimal dose of radioprotector is 3 tablets (0.45 mg).

However, the Code of Civil Protection of Ukraine<sup>22</sup> envisions only iodine prophylaxis aimed at preventing the ingestion of radioactive iodine. Iodine prophylaxis involves the use of potassium

iodide in cases of official notification of a radiation threat. The dose for people aged 13 to 40 is 125 mg. The drug's intended use is 6 hours or less before radiation exposure. Currently, not a single radioprotective drug is registered in Ukraine, so this issue requires a more detailed study.

In this regard, it would be advisable to introduce radioprotectors as an official means of protecting the population from radiation exposure. At the moment, though, the biggest problem is that people don't know the basic steps that should be taken to provide pre-medical care in cases of reported injuries because they aren't ready for radiation or bacterial hazards.<sup>23,24</sup> Because of this, the authors of the study managed to formulate a basic algorithm of action against the threat of nuclear and bacteriological weapons. The algorithm of actions for premedication aids in cases of radiation hazards: i) turn on official mass notification sources and listen carefully to the instructions of the authorities; ii) close windows and doors tightly, and turn off ventilation systems; iii) if the media reports an official warning about the threat of radiation hazards, it is advisable to take iodine prophylaxis (potassium iodide or iodine in a dosage of 20 drops for children or 44 drops for adults of 5% iodine solution per glass of water); iv) provide yourself with personal respiratory protection, which can be a respirator, a mask with a filter valve, a medical mask, or a cotton gauze bandage; v) in the event of a nuclear threat, it is very important to have a comprehensive first aid kit containing the necessary means to address various medical needs - Table 2 shows a list of essential components that should be in such a first-aid kit.

It should be noted that some premedical or first aid courses do not consider the aspect of the use of medicines at all, and this fact may be a significant reason why people are afraid of using any medicines. Previous researchers did not consider this fact, but it has a significant impact on the level of awareness and knowledge of the population. Algorithm of actions for premedical aid in cases of bacteriological hazards: i) turn on the media and listen carefully to the instructions of the authorities; ii) leave the infected area - if possible, stay in shelters or rooms with tightly closed windows and doors; iii) protect yourself with additional clothing, rubber gloves, and boots; iv) provide yourself with personal respiratory protection equipment - if possible, wear protective

goggles; v) collect a first aid kit, which should contain everything listed in paragraph v of the algorithm of actions for premedical assistance in case of a radiation hazard, as well as at least 3-5 interchangeable medical masks and personal protective equipment. Also included are doxycycline hydrochloride (a broad-spectrum antibiotic), which is administered half an hour before entering the affected area, and antimicrobial drugs.

In summary, the study delves into the pressing issues surrounding the potential use of biological and nuclear weapons, recognising their grave threat to humanity. The complexity of identifying and responding to biological hazards underscores the need for improved surveillance and diagnostic capabilities. Furthermore, the alarming lack of awareness among the Ukrainian population regarding the specifics of nuclear weaponry and appropriate response measures highlights a critical gap in public knowledge. Recommendations to address this include educational campaigns, specialised training, and the integration of relevant topics into educational curricula. By adhering to these rules, it will be possible to prevent large-scale consequences as well as significantly reduce the number of victims from the possible use of declared weapons.

## **Discussion**

The study of literature on public knowledge in providing premedical or first aid in cases of radiation or bacteriological hazards helps us to state the fact that the Ukrainian civilian population is almost unaware of the declared issues. In the course of the study, the authors found out that this fact pertains to Ukrainians' unpreparedness and ignorance regarding the nature of combat operations and the use of various types of weapons. In addition, even governing bodies are not able to convey the importance of awareness of the stated issues to citizens. Therefore, it is necessary to implement the recommendations proposed in this study to have a considerable effect on the situation and conduct further research aimed at solving the problem. It should be given particular attention to the consideration of medical drug therapy in cases of nuclear hazards and at least ensure a clear understanding of the “radioprotector” concept. Hayoun *et al.*<sup>25</sup> note that doxycycline is a highly

effective agent in the case of plague, which is advisable to use as prophylaxis. However, ciprofloxacin, chloramphenicol, and cotrimoxazole can also be effective during preventive measures. The authors mention that the duration of prophylaxis should be 1-2 weeks, but the course of taking drugs against *Yersinia pestis* and *Francisella tularensis* is currently unknown.

According to these claims, the health authorities should make sure they have enough of certain medicines and vaccines on hand to deal with bacterial threats. This will stop the disease from spreading and at least lessen the damage that could be caused by this kind of weapon.<sup>26-28</sup> It should be noted that, currently, the most important problem in Ukraine is the early identification of the pathogen, quick and accurate diagnosis, and the early creation of medical reserves (in the case of the potential use of bacteriological weapons). However, it should also evaluate the risk of microorganisms becoming resistant to antibiotics.<sup>29</sup> In this case, WHO and the Ministry of Health should draw up certain protocols and regulations, as well as implement appropriate solutions that will determine the algorithm of action.<sup>30</sup> Zekioglu and Parlar<sup>31</sup> note that despite the simplicity of the list of necessary drugs, the medical staff of many countries, as well as the civilian population, are completely unaware of the issues of providing pharmacological assistance in the event of a bacteriological attack. The list contains only a few drugs, including doxycycline or quinolone for *Bacillus anthracis*, streptomycin or gentamicin for tularemia and plague, and ciprofloxacin for anthrax. The dosage of drugs depends on the purpose (*i.e.*, prophylaxis or treatment) and continues before or after contact with the pathogen for 7 to 60 days (we should note that taking drugs for 60 days is advisable only for anthrax).

Therefore, if the health authorities comply with all the above factors, it would be possible to report a sufficient level of awareness and reliability of protection for the population from the damaging effects of pathogenic agents in cases of biological hazards. The American authorities abandoned the use of biological weapons, and all arsenals of biological weapons were eliminated in 1973.<sup>11</sup> Despite this, they have thoroughly studied the mechanisms of action of the offensive biological

weapons of various types and have never stopped developing vaccines and antiserums for their army and civilians.

However, other opinions determine the importance of further research on the stated issues. Currently, the main problem is the development of high-quality and safe radioprotective agents for use by people of all ages because of ambiguity or a lack of clear provisions on the use of radioprotectors or other protective means.<sup>32</sup> The authors note that for the development of effective drugs, it is most necessary to study the toxicity of the active substance and its effect on internal organs, as well as to determine the minimum effective dose and the maximum permissible dose. The authors agree with these claims, but they would also look at other factors that would help them decide if the agent is safe to use and if it is right for certain groups of people, such as those with serious illnesses, liver or kidney failure, or digestive system diseases. These criteria should include the dosage form (capsule, tablet, or liquid), particle size, homogeneity, color, smell, and taste, solubility, release time from the body, and shelf life.<sup>33</sup>

In addition, the low level of public awareness and critical thinking about the consequences of radiation and bacteriological damage to animals is also a significant problem. In the use of bacteriological weapons, animals can generally be the only vectors of the disease, since pathogenic agents often produce effects that are particularly targeted at infecting animals. The plague is an example of the use of infectious agents on animals, followed by transmission to humans through the bites of infected fleas.<sup>34</sup> It should be noted that unprotected animals could suffer serious consequences or even die in case of radiation exposure or become a danger to their owners (especially pets in private houses or cottage cooperatives, where animals walk freely outside). According to the International Atomic Energy Agency, iodine prophylaxis has many consequences for pets, including anorexia, vomiting, diarrhoea, suffocation, cardiomyopathy, hyperthermia, cough, and weight loss.<sup>35</sup> Therefore, it would be advisable to take a closer look at this issue and make a decision on the most reliable and safest protection of animals from biological or nuclear

damage. In this case, it will be possible to prevent the spread of diseases and reduce the level of radiation hazards for a large number of people.

## **Conclusions**

It was established that the urgency of the problem of protecting the civilian population from radiation and the effects of bacteriological weapons is due to the poor knowledge of citizens in the provision of premedical and first aid. It was determined that low awareness rates come from public ignorance about the criticality of the damage consequences as well as the fear of using medications. Therefore, recommendations were made, which should serve as long-term indicators of public awareness, significantly increasing the number of people who understand the issues of assisting in cases of radiation hazards or the use of biological weapons. Conducting awareness-raising activities and special events by healthcare professionals, introducing class hours or separate lessons in the curriculum dedicated to the issues of assistance to victims and self-help in various emergencies, creating and disseminating relevant guides, and broadcasting special reports on the discussion of the stated issues will significantly increase the awareness and consciousness of the population.

The problems of medical protection for the population of Ukraine in areas of increased radiation and bacteriological hazards are still relevant. During the writing of this research paper, the authors found that the issue of the use of radioprotectors needs to be clarified by the authorities and the WHO since there is currently no single solution or official regulation that would help the population freely use radioprotectors of different categories in cases of radiation hazards. In addition, the authors established that the issues of premedical and first aid require further study, as new hypotheses arise in the process of research and writing research papers that significantly affect the situation but have never been considered in previous studies. It would be advisable to conduct further research to identify effective methods for raising awareness among the civilian population that would contribute to the rapid achievement of results in the structure of raising the level of self-education of citizens. It would also help to identify additional issues and factors that affect the

situation regarding the protection and pharmaceutical supply of the population in the event of radiation or bacteriological hazards.

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**Table 1.** Organizations in Ukraine dealing with radiation safety and risk management.

| <b>Organisation</b>  | <b>Description</b>  |
|--|---|
| G.M. Doletsky State Scientific and Applied Institute of Nuclear Energy | Engaged in research in nuclear power, radiation safety, and nuclear medicine. Provides education and training for specialists.                            |
| Ukrainian State Emergency Service                                      | Manages radiation emergencies and protects the public during radiation accidents. Monitors radiation levels and conducts drills/exercises.                |
| National Centre for Radiation Medicine                                 | Specialises in medical radiology and radiation medicine. Focuses on the diagnosis and treatment of radiation diseases and conducts research in this area. |
| Ukrainian Association of Environmentalists                             | It comprises ecologists and environmentalists working on radiation ecology and assessing radiation's impact on the environment.                           |

**Table 2.** Nuclear threat first aid kit essentials.

| <b>Item</b>   | <b>Purpose</b>                                    |
|---|---|
| Antiseptics   | Clean and disinfect wounds                        |
| Alcohol   | Disinfect equipment and surfaces                  |
| Sterile bandage   | Dress wounds and prevent infections               |
| Broad-spectrum antibiotics (Augmentin 1000)             | Treat bacterial infections                        |
| Nitroglycerin   | Treat chest pain associated with heart conditions |
| Antiemetics (ondansetron, metoclopramide hydrochloride) | Reduce nausea and vomiting                        |
| Analgesics (nimesulide)                                 | Relieve pain and inflammation                     |
| Antipyretic (paracetamol, ibuprofen)                    | Reduce fever and alleviate pain                   |
| Antidiarrheals (loperamide, bisoprolol)                 | Treat diarrhoea and related symptoms              |
| Immunostimulants (methyluracil, decaris, dibazole)      | Boost immune response                             |
| Potassium iodide or manganese solution                  | Water disinfection to prevent infections          |

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