THE THREAT OF WEAPONS OF MASS DESTRUCTION IN THE CONTEXT OF THE CONFLICT IN UKRAINE AND ITS IMPACT ON BATTLEFIELD MEDICINE

Zagrożenie bronią masowego rażenia w kontekście konfliktu na Ukrainie i jego wpływ na medycynę pola walki

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Abstract

The modern battlefield encompasses not only conventional operations but also the potential use of chemical, biological, radiological, and nuclear (CBRN) agents. This article focuses on two key aspects: the identification and analysis of CBRN-related threats in the context of the armed conflict in Ukraine, and the assessment of their impact on the functioning of battlefield medicine. The first part discusses possible scenarios involving the use of radiological weapons, including so-called "dirty bombs" (radiological dispersal devices, RDDs), and their potential consequences for civilian populations and the natural environment. It also outlines strategies to mitigate the effects of such attacks, including preventive measures, early warning systems, and decontamination procedures. The second part examines the challenges faced by medical personnel operating under CBRN threat conditions. Emphasis is placed on the need for rapid identification, accurate diagnosis, and effective treatment of victims of chemical, biological, or radiological attacks. The importance of adequate training for medical teams, the availability of specialized equipment, and access to personal protective gear is also highlighted. In conclusion, the article underscores the importance of an integrated approach to crisis management and medical practice as essential components of an effective response to CBRN-related threats.

Streszczenie

Współczesne pole walki obejmuje nie tylko działania konwencjonalne, lecz także potencjalne użycie broni masowego rażenia (BMR). Artykuł koncentruje się na dwóch kluczowych aspektach: identyfikacji oraz analizie zagrożeń związanych z BMR w kontekście konfliktu zbrojnego w Ukrainie, a także ocenie ich wpływu na funkcjonowanie medycyny pola walki. W pierwszej części omówiono możliwe scenariusze użycia broni radiologicznej, w tym tzw. „brudnych bomb" (radiological dispersal devices, RDD), oraz ich potencjalne skutki dla ludności cywilnej i środowiska naturalnego. Zidentyfikowano również strategie przeciwdziałania skutkom takiego ataku, obejmujące działania prewencyjne, systemy ostrzegania i procedury dekontaminacyjne. W drugiej części przeanalizowano wyzwania stojące przed personelem medycznym w warunkach zagrożenia BMR. Podkreślono konieczność szybkiej identyfikacji, trafnej diagnostyki oraz skutecznego leczenia ofiar ataków z użyciem broni chemicznej, biologicznej lub radiologicznej. Zwrócono uwagę na znaczenie odpowiedniego przeszkolenia zespołów medycznych, dostępności specjalistycznego sprzętu oraz środków ochrony osobistej. W podsumowaniu zaakcentowano rolę zintegrowanego podejścia do zarządzania kryzysowego i praktyki medycznej, jako kluczowych elementów skutecznej reakcji na zagrożenia związane z bronią masowego rażenia.

Keywords: civil protection; weapons of mass destruction; military health service

Słowa kluczowe: ochrona ludności; broń masowego rażenia; wojskowa służba zdrowia

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Introduction

The modern battlefield extends beyond conventional warfare and may involve evolving and escalating threats posed by Weapons of Mass Destruction (WMD), also known as Chemical, Biological, Radiological, and Nuclear (CBRN) weapons. They prompt modifications in tactics, strategy, and approaches to counteracting potential threats, ranging from terrorist chemical attacks to accidental radioactive leaks, the consequences of which are highly diverse and difficult to predict [1, 2]. Considerations related to the prevention, diagnosis, and treatment of the consequences of CBRN weapon use constitute a vital component of preparing all armed forces for operations in modern battlefield conditions. However, in the case of the Armed Forces of Ukraine, they take on particular significance due to the real threat of CBRN weapon deployment and the intensity of the ongoing conflict [3, 4]. The implementation of new technologies, procedures, and protocols is intended not only to minimize human casualties, but also to maintain the operational effectiveness of the armed forces and civilian emergency services. Exploring these issues will clarify the challenges of battlefield medicine in the context of rising CBRN threats and support the creation of effective countermeasures.

CBRN weapons on the modern battlefield

The classification of CBRN weapons constitutes a key element of international security strategy, enabling the identification of different types of weapons of mass destruction – namely chemical, biological, radiological, and nuclear weapons – as well as a better understanding of the consequences of their potential use. Each of these categories is associated with distinct mechanisms of action, varying degrees of destruction, and specific challenges for emergency response systems and medical services. Precise categorization allows not only for the development of appropriate countermeasure and protection procedures, but also for the adaptation of military and civilian training in responding to mass-casualty threats. Contemporary armed conflicts – such as the ongoing war in Ukraine – clearly demonstrate that the threat of CBRN weapon use is not merely theoretical, but constitutes a real challenge for national defense structures and entire international alliances. Consequently, a deeper understanding of CBRN weapon classification and its operational, logistical, and medical implications is essential, and will be discussed in the following sections of this chapter.

The concept of CBRN comprises several major threat categories:

- **chemical weapons –** toxic agents intentionally employed to contaminate large areas and target civilian populations;
- **biological weapons –** pathogenic microorganisms or toxins used to induce infectious diseases, potentially causing epidemics or pandemics;
- **radiological weapons** – improvised devices that utilize radioactive materials or isotopes; they do not cause a nuclear explosion, but disperse radioactive substances over a wide area, contaminating the environment and populations;
- **nuclear weapons** – a weapon based on an explosive nuclear reaction capable of causing massive destruction and long-lasting radioactive effects on both the environment and human populations [2].

The potential use of CBRN weapons by the Russian Federation on Ukrainian territory represents one of the most serious contemporary threats to both regional and international security. CBRN defense specialists face numerous challenges, including the ongoing identification of emerging threats and the development of effective strategies to mitigate their consequences. Among all types of weapons of mass destruction, radiological weapons draw particular attention, as their potential use is considered one of the most plausible and destabilizing scenarios in the ongoing conflict. The magnitude of possible consequences – both in terms of public health and environmental impact – demands heightened vigilance and preparedness on the part of military, medical, and civilian structures [5, 6].

Radiological weapons include, among others, the so-called "dirty bombs". A dirty bomb is an improvised explosive device designed to disperse radioactive isotopes, causing contamination of the surrounding area. During the explosion, a conventional charge detonates, while the radioactive substance itself does not undergo nuclear transformation. Radioactive isotopes can also be dispersed without the use of explosives, e.g. by means of aerosols, dropping from an aircraft or water contamination. Sources of radioactive isotopes may include nuclear power plants, radioactive waste storage facilities, and other institutions that utilize these agents for routine research and diagnostic purposes. Hazardous isotopes are characterized by a long half-life and high radioactivity. Even small amounts, e.g. 30 grams of ^{137}Cs, can cause large area contamination [5]. An attack with radiological exposure devices (RED) not only disrupts entire urban areas and critical infrastructure, but also generates enormous cleanup costs and long-term health consequences for the population.

The effectiveness of REDs depends on many factors, including:

- the force of the conventional explosive, which determines the extent of radioactive isotope dispersion;
- the type of radioactive isotopes, including their radioactive activity and half-life;
- weather conditions that influence the dispersion of isotopes following the explosion.
- The greatest threat posed by radiological weapons is their potential to contaminate vast areas and cause lasting changes to the natural environment. The use of such devices can lead to the destruction of housing, energy, and communication infrastructure, resulting in significant social, economic, and political consequences, including the evacuation and relocation of populations from affected areas.

Radiological weapons exert a profound psychological impact, often inducing panic and social chaos that surpass the immediate physical effects of the explosion. Such an attack generates fear with lasting consequences. The number of victims may increase over time due to the development of radiation sickness of varying severity and cancer among individuals exposed to contaminated areas [2, 5, 7].

The war in Ukraine has led to the loss of control over substantial amounts of radioactive materials. The location and quantity of these substances, both prior to and during the ongoing conflict, remain unknown. International organizations, including the International Atomic Energy Agency (IAEA), have documented many cases of attempted illicit trafficking of radioactive materials [5].

During the conflict in Ukraine, the Zaporizhzhia Nuclear Power Plant attracted increased attention from both the aggressor and international organizations [8, 9]. Russian troops occupying the Zaporizhzhia Nuclear Power Plant have used the threat of its potential destruction as a means of blackmail, raising fears of a nuclear catastrophe in the region. The facility is currently under the control of the Russian state-owned company Rosatom, further intensifying concerns about nuclear safety [10]. Meanwhile, international organizations are working to ensure its security, prevent a potential catastrophe, and establish protective zones around the plant.

The radiation situation in Poland is currently stable, posing no threat to public health or the environment. The National Atomic Energy Agency conducts continuous 24-hour monitoring using nearly 90 measuring devices, most of which are positioned along the country's eastern border [9].

Potential deployment of a nuclear bomb is another threat related to the Russia's use of CBRN weapons in Ukraine. Russia possesses a substantial nuclear arsenal and is the world's most powerful nuclear state alongside the United States.

European Commission representatives Hans Das and Marc Fiedrich presented an analysis of the escalating CBRN threats and the European Union's response to these challenges to a European Parliament Subcommittee. Hans Das stressed that Russia's stance on the use of nuclear weapons remains ambiguous. Earlier remarks by Russian Foreign Minister Sergey Lavrov hinted at the possibility of nuclear weapon use, although more recent statements suggest a softening of these aggressive positions [10, 11]. Nevertheless, periodic threats of tactical nuclear weapon use, voiced by Russian politicians at various levels [6], are taken seriously by the international community. These threats are closely monitored by the United Nations and the International Atomic Energy Agency, with efforts focused on dialogue, diplomacy, and peaceful negotiations to prevent escalation that could result in human tragedy and regional destabilization.

The military conflict in Ukraine has escalated to a level raising reasonable suspicion of the Russian army's use of chemical weapons, phosphorus bombs in particular [12]. Reports indicate that white phosphorus may have been used in certain engagements, notably during the battles for the city of Bakhmut in 2023. Some international organizations and eyewitnesses have reported observing the use of white phosphorus munitions by Russian forces or Russian-backed separatists. However, it should be emphasized that confirming the use of white phosphorus as a weapon in Ukraine is challenging due to limited access to conflict-affected areas and the absence of independent investigations [13]. Nevertheless, reports of the possible use of this substance are deeply concerning, as white phosphorus is highly toxic; the lethal dose for humans ranges from 50 to 100 mg. Burns caused by exposure are typically deep, affect multiple sites, and vary in size. Because elemental phosphorus reacts with skin lipids and subcutaneous fat, it penetrates deeply and can delay wound healing. Dispersed phosphorus particles are neutralized only by self-ignition, which continues until they are completely consumed. During this process, phosphorus generates temperatures of approximately 1000°C, intensifying thermal damage. As it burns, it also absorbs moisture from the tissue and produces phosphoric acid [14].

Reports related to the conflict in Ukraine have also raised concerns about the possible use of biological weapons [15]. Despite the lack of official confirmation regarding their use in combat, the Russian Defence Ministry has claimed to have found evidence that Kyiv is conducting research on components of biological weapons "with the direct involvement of the Pentagon" [16]. Russia's accusations may be intended to divert attention from its own actions against Ukraine. As with radiological weapons, the primary concern surrounding biological weapons lies in their profound psychological impact. Richard Guthrie, a British expert on chemical and biological weapons, notes that while Russia has submitted an inquiry to the UN Security Council, it has not filed a formal complaint under Article 6 of the Biological Weapons Convention. Russia has recently made similar accusations against Georgia, where the U.S. government funds the Lugar Research Center in Tbilisi. In 2018, the Georgian government invited international experts, including Russian representatives, to inspect the facility; however, Moscow declined the invitation. Following the inspection, it was confirmed that the laboratory complies with the Biological Weapons Convention. Experts recommend that Ukraine undertake similar measures; however, this would be challenging amid the ongoing conflict [17].

A new report by the Atlantic Council and the Scowcroft Center for Strategy and Security highlights the ongoing threat posed by Russian chemical weapons. The authors emphasize Russia's disregard for international arms control norms, citing, among other things, the use of Novichok in the UK in 2018. The report suggests that Moscow may resort to CBRN weapons to pursue its objectives in the conflict with Ukraine, even without large-scale deployment. Russia's military doctrine and limited conventional capabilities indicate that CBRN weapons are likely to play an increasingly important role in its defence strategy [18].

Civil-military cooperation in critical infrastructure, such as power grids and public healthcare systems, is essential for countering potential CBRN attacks. The report also recommends enhanced integration of operational planning between the United States and its European allies. At the same time, the advances in biological and chemical technologies, including genetically modified organisms, intensify the threat of highly infectious biological weapons, presenting significant challenges for societies [18].

NATO Allies have long regarded the threat posed by CBRN weapons with utmost seriousness, placing strong emphasis on preparing their armed forces to effectively respond to such challenges. This approach is driven primarily by concerns over the potential use of CBRN agents by terrorist organizations. At the same time, it is essential to closely monitor countries such as Russia and their stance on WMDs, as reflected in the largest Allied exercises in years, conducted in 2024 to enhance preparedness for CBRN threats [19].

Effective management of these threats in the context of the conflict in Ukraine requires coordinated international action. Joint efforts are essential to control, monitor, and prevent the illegal proliferation of such threats. Such actions may include information exchange, joint operational activities and the development of preventive and crisis response strategies. Support from international partners may be crucial to effectively manage the situation and minimise the risk. Poland, like many other countries, requires a comprehensive security strategy, particularly regarding threats to energy infrastructure and other critical sectors. Sharing information with international partners and drawing on the experiences of other nations can be highly valuable in shaping such a strategy.

Threats posed by weapons of mass destruction and the challenges of battlefield medicine

The growing risk of CBRN weapon use compels healthcare systems to implement comprehensive response strategies. A key priority is the establishment of interdisciplinary teams composed not only of medical personnel, but also of experts in radiobiology, toxicology, and epidemiology. Such collaboration enables faster threat assessment, more accurate clinical decision-making, and more effective preventive actions. On the battlefield – where response time is critical – integrated efforts can significantly improve casualty survival rates and help mitigate the long-term health consequences resulting from exposure to weapons of mass destruction.

Integrated medical response, supported by specialized expertise, constitutes the foundation of an effective reaction to CBRN threats. Nevertheless, even the most well-prepared healthcare system may become overwhelmed in the event of large-scale deployment of such weapons.

WMDs may impose a significant burden on healthcare systems for several reasons:

- **Mass casualties:** an attack involving WMDs may result in a large number of fatalities and injuries, necessitating the rapid mobilization of medical services and hospitals to provide urgent care to those affected.
- **Complexity of care:** victims may need specialized medical treatment due to the diverse injuries and effects caused by chemical, biological, or nuclear weapons; managing such attacks demands specialized equipment, medications, and trained medical personnel. The need for psychological support must also be taken into account, as exposure to weapons of mass destruction can lead to severe war-related trauma, manifesting as post-traumatic stress disorder (PTSD), anxiety, or adjustment disorders.
- **Risk of contamination:** Attacks involving WMDs may lead to contamination of both population and the environment; medical services are forced to operate under high-risk conditions due to exposure to toxic substances, pathogens, or radiation.
- **Pressure on the healthcare system:** A sudden influx of casualties can overwhelm hospitals and healthcare services, compromising timely care for all patients. This may necessitate difficult decisions regarding prioritization and resource allocation.

It is therefore crucial for healthcare services to be adequately prepared to respond to such situations through thorough planning, training, access to necessary equipment, and close cooperation with crisis management agencies [3, 4, 20].

Conclusions

The threat posed by WMDs significantly affects the operational capacity of battlefield medical services. The need for rapid identification, diagnosis, and treatment of CBRN victims poses major challenges for medical personnel. In battlefield conditions, where situations are dynamic and require rapid response, trained medical personnel and access to specialized equipment and personal protective gear are essential for effective treatment and minimizing adverse outcomes. Educating medical personnel on the effects of CBRN agents and the appropriate countermeasures is essential to ensuring an effective response [20]. Such training should encompass hazard identification, crisis management, the use of specialized equipment, and procedures for personal protection and evacuation. It is essential to establish appropriate procedures for responding to radiological weapon threats and cases of acute radiation syndrome (ARS). Proper preparation of medical personnel enhances response effectiveness and ensures timely, efficient medical care for both military personnel and civilians.

In the context of an armed conflict where there is a real threat of weapons of mass destruction being used, their profound psychological impact cannot be overlooked, as it may significantly exacerbate war-related trauma and intensify symptoms of combat stress. In response to these challenges, the Military Institute of Medicine – National Research Institute (WIM-PIB) has launched a project to facilitate the exchange of experiences between Polish and Ukrainian medical professionals. WIM-PIB is currently implementing the latest edition of this project, which includes training in casualty rehabilitation as well as the diagnosis and treatment of individuals affected by war trauma [21].

Creating a medical forces component will ensure coordinated action by military medical services, critical for the swift and effective care of the wounded. These initiatives are intended to enhance the country's defence capabilities and protect the lives and health of both soldiers and civilians in the event of CBRN weapon deployment on the battlefield.

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