

# Potential and real dangers of the chemical warfare agents use during the full-scale invasion into Ukraine

Nataliia D. Kozak, Oleh V. Rudynskiy, Andriy V. Verba, Alla A. Asaulenko, Dmytro O. Kozak

UKRAINIAN MILITARY MEDICAL ACADEMY, KYIV, UKRAINE

## ABSTRACT

**Aim:** To analyze modern threats of the use of chemical warfare agents on the line of contact during the full-scale invasion into Ukraine.

**Materials and Methods:** The study was carried out with the use of theoretical methods (information retrieval, analytical, descriptive, generalization, system analysis and information synthesis) and the construction of trends with the identification of the coefficient of determination.

**Results:** Most of damage cases of the military men of the Armed Forces of Ukraine were caused by the enemy's use of such groups of chemical warfare agents with an irritating effect as lacrimators and sternites, more specifically K-51 grenades with chloropicrin (PS) and 2-chlorobenzalmalononitrile (CS), RGR grenade with 2-chlorobenzalmalononitrile (CS) and RG-Vo (862-3-23) grenades with chloroacetophenone (CN).

**Conclusions:** 2698 cases of damage by chemical warfare agents of irritant action were detected among the military men of the Armed Forces of Ukraine, and every month during 2024, more and more injuries were detected among the military men of the Armed Forces of Ukraine (715 cases in May 2024 compared to 444 cases in April 2024), which indicates that a stable upward trend towards a wider trend is emerging deliberate use of chemical warfare agents, the coefficient of determination of R<sup>2</sup> of which was high and amounted to 0,9577, and which continues to grow steadily.

**KEY WORDS:** chemical warfare agents, military men, Armed Forces of Ukraine, full-scale invasion

Wiad Lek. 2024;77(11):2186-2192. doi: 10.36740/WLek/197094 

## INTRODUCTION

Chemical warfare agents (CWA) with asphyxiating and irritating effects, such as chemical weapons, were first used during the First World War. In total, from April 1915 to November 1918 inclusive, more than 50 German gas attacks were carried out. During the same period, in opposition to the German troops, 150 British and 20 French gas launches were carried out. On May 15, 1916, French troops resorted to the use of artillery with a mixture of phosgene with tin tetrachloride and arsenic trichloride, chloropicrin, as well as a mixture of hydrocyanic acid with arsenic trichloride, tin tetrachloride in chloroform (a form of vensenite). Mustard gas was first used as a cutaneous blister chemical agent by Germany on July 12, 1917 near Ypres (Belgium) [1].

Chemical warfare agents were regularly used in the 1980s during the Iran-Iraq war. According to various estimates, 5% of Iran's total losses, which amounted to approximately 45 000 people, can be classified as chemical weapons. Libya was suspected of involving chemicals during the invasion of Chad in 1986.

On January 16, 2015, during the anti-terrorist opera-

tion in eastern Ukraine, illegal armed groups used tear gas and chemical grenades against the defenders of the Donetsk airport.

The use of chemical weapons by the Syrian Armed Forces on April 4, 2017, when an air strike was carried out on the city of Khan Sheikhoun (Idlib province, Syria) caused a significant resonance in the world. The ammunition contained a nerve agent (most likely sarin). About 100 people died (including 20 children and 17 women), and more than 300 people were poisoned of varying degrees of severity [2].

According to the most common toxicological classification, according to the nature of their effect on the human body, CWA are divided into nerve agents (sarin, soman, VX gases, etc.), cutaneous abscesses (mustard gas, nitrogenous mustard gas, lewisite, etc.), general poisonous (hydrocyanic acid, chlorocyanin), asphyxiating (phosgene, diphosgene, etc.), irritant (chloroacetophenone (CN), 2-chlorobenzalmalononitrile (CS), dibenzoxazepine (CR), adamsite (DM)), psychotomimetic (psychochemical) (Bi-Z (BZ), lysergic acid diethylamide) [3].

## AIM

Analysis of modern threats of the use of chemical warfare agents on the line of contact during the full-scale invasion into Ukraine.

## MATERIALS AND METHODS

The study was carried out with the use of theoretical methods (information retrieval, analytical, descriptive, generalization, system analysis and information synthesis) and the construction of trends with the estimation of the determination coefficient.

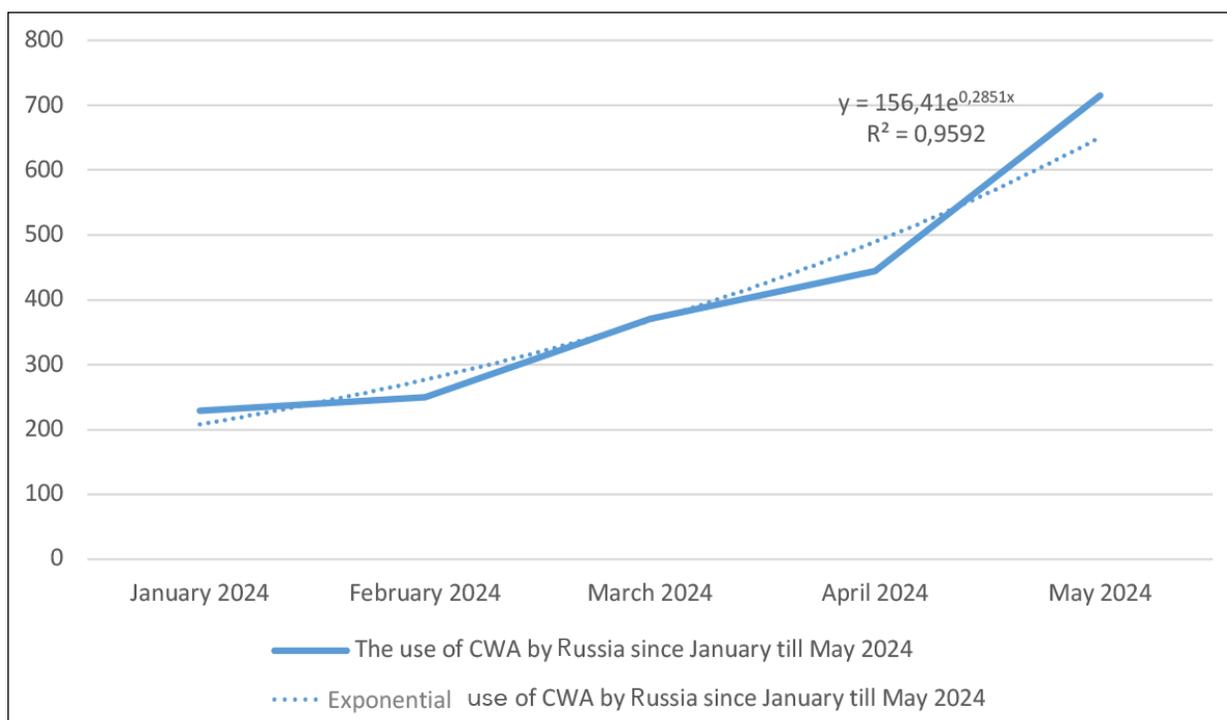
The study was carried out in accordance with the principles of bioethics and legislative norms and requirements for biomedical research, namely: the Helsinki Declaration (2000), the Constitution of Ukraine (1996), the Fundamentals of the Legislation of Ukraine on Health Care (1992), as well as the Law of Ukraine "On Information" (1992) (as amended as of 21.03.2023).

## RESULTS

As of the beginning of large-scale aggression against Ukraine on February 24, 2022 until January 2024, according to the General Staff of the Armed Forces of Ukraine, more than 626 cases of the use of ammunition with toxic chemicals by the invaders were recorded [4]. In addition, such cases are becoming more and more frequent. Thus, during January 2024, the defense

forces of Ukraine recorded 229 cases [5], and during February 2024 – 250 cases of the use of poisonous substances by the invaders, of which 244 cases of the use of aerosol grenades containing irritating CWA, that is, the vast majority of them [6]. During March 2024, 371 cases of the use of chemical munitions were recorded [7]. During April 2024, 444 cases were recorded. And already in May 2024, 715 cases of the use of ammunition containing dangerous chemicals were documented, which was 271 cases more than in April. From the above data, it follows that there is a clear trend towards an increase in the number of cases of the use of CWA. After calculating the trend and estimating the determination coefficient, it was found that the trend is reliable, since the coefficient of determination  $R^2$  is in the range from 0,8 to 1,0 and is 0,9577, which is a very high value (Fig. 1). In total, from February 2022 to May 24, 2024, 2698 cases of the use of toxic chemicals by the enemy were recorded in Ukraine [8]. During this period, 1385 cases of appeals of servicemen of the Armed Forces of Ukraine to medical institutions with symptoms of chemical damage of varying degrees of severity were recorded, of which only in May – 21 cases [8].

From December 2022 to May 2024, there were repeatedly used chemical grenades K-51, RGR and RG-VO chemical grenades (862-3-23) against the positions of our troops (Fig. 2) in the areas of deployment of units of troops (forces) of the Armed Forces of Ukraine near



**Fig. 1.** The trend of the use of chemical warfare agents against military men of the Armed Forces of Ukraine for the period January-May 2024, line, trend equation and coefficient of determination.



**Fig. 2.** Grenades K-51 (A), RGR (B) and RG-Vo (C).



**Fig. 3.** Erythematous spots on the surface of the skin of affected military men.

and in settlements, including Mariupol, Klishchiivka, Kurdyumivka, Avdiivka, Novokalynove, Lastochkyne, Pervomaiske, Maryinka [9].

The body of the K-51 grenade is made of hard plastic, the bottom is metal. After inflammation, a reaction occurs, as a result of which the pressure inside the case increases and the bottom is squeezed out, spraying the chemical. As for the content of K-51 grenades, there are two versions of them: garnets containing chloropicrin and 2-chlorobenzalmalonitrile (CS), as well as indoors the effect of the grenade extends to an area of up to 400 square meters. [9].

An irritant hand grenade (RGR) is a 60 mm aerosol hand grenade containing chlorobenzalmalonitrile (CS) [10].

It is reported that in December 2023, the enemy's use of a new type of special RG-VO gas grenades containing CWA chloroacetophenone (CN) was detected for the first time. The substance chloroacetophenone (CN) is prohibited for use as a chemical warfare agent in accordance with the Geneva Protocol, approved by

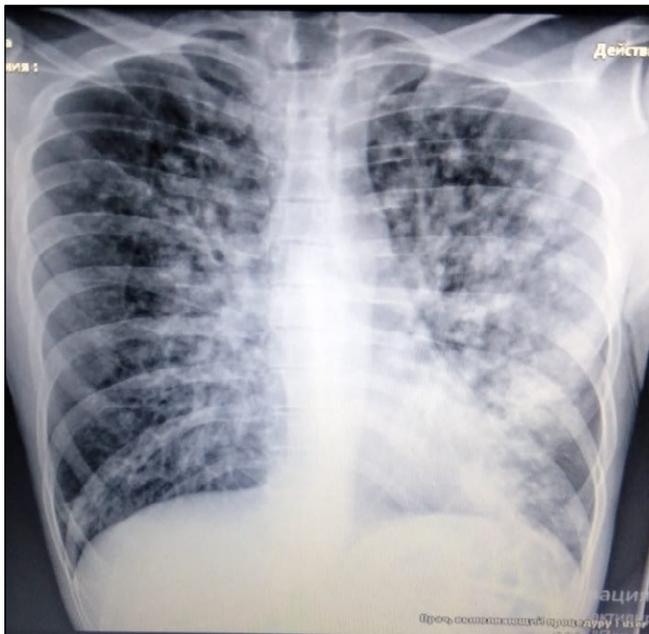
the UN General Assembly in 1969, based on the results of its use during the Vietnam War [11].

Thus, most of the cases of damage to the military men of the Armed Forces of Ukraine were caused by the enemy's use of irritating weapons such as lacrimators and sternites.

Delivery to the contact line and drops of K-51 and RG-VO chemical grenades were carried out mainly by enemy unmanned aerial vehicles.

Conventionally, gas grenades K-51, RGR and RG-VO are non-lethal means. At the same time, chloroacetophenone (CN) at a concentration of 0,85 mg/l and exposure for 10 minutes leads to the development of toxic pulmonary edema with fatal outcome.

The use of chemical grenades by the enemy, which leads to the release of CWA, temporarily deprives military men of the opportunity to return fire, forces them to leave shelter and move to open "smoke-free" areas of the terrain, which makes them easy targets for enemy lethal weapons. After contact with gas, a person begins to have watery eyes, shortness of breath,



**Fig. 4.** Patient Sh., 46 y.o. Subtotal pulmonary edema, pulmonary failure II.



**Fig. 5.** Patient R., 31 y.o. Total pulmonary edema, pulmonary failure III.

cough, sinuses fill with mucus, vomiting is possible, etc. The effect intensifies with every minute a person stays in the toxic cloud.

The clinical picture of sternite lesions in military personnel was differentiated by three degrees of severity of the lesion. In the case of mild damage, the following manifestations were observed: slight irritation of the mucous membrane of the upper respiratory tract, moderate cough, burning pain in the nasal passages, pharynx, symptoms of tracheal irritation, pain behind the sternum, feeling of tightness in the chest, hyperemia of the mucous membranes. During the moderate degree of damage, severe symptoms of irritation of the mucous membranes, involvement of the middle parts of the respiratory tract in the process, headache, earache, excessive rhinorrhea, dry cough, sneezing, salivation, nausea, vomiting were observed. With a severe degree of damage, there were such symptoms as damage to all parts of the respiratory tract, unbearable pain behind the sternum, reflex violation of the mechanics and rhythm of breathing, cardiac disorders (bradycardia, increased blood pressure, slowing and pathological rhythms of breathing, up to its stop – apnea).

The clinical picture of lesions with lacrimators was manifested in all patients by sharp irritation of the conjunctiva and cornea of the eyes, 5-10 seconds after the lesion, severe pain and heartburn in the eyes, lacrimation, photophobia and headache began. Also, lacrimator injuries were classified according to three degrees of lesion severity. With a mild degree of damage, the following manifestations were

observed: slight burning pain in the eyes, moderate lacrimation, slight conjunctival hyperemia, and no irritation of the respiratory tract. During the moderate degree of damage, conjunctivitis and spasm of the eyelids, photophobia, excessive lacrimation, pain in the orbits were sharply expressed. During the severe degree of damage, symptoms of general toxicity increased, heartburn in the throat, rhinorrhea and wet cough, severe headaches, dizziness, nausea, vomiting, and general weakness appeared. As a rule, the effect of irritating warfare agents was short-lived. When exiting the “wave of poisonous smoke”, the phenomena of irritation in the first 15-20 minutes persisted or even increased, and then gradually decreased over the course of 1-2 hours and disappeared altogether.

The clinical picture in CS lesions was manifested by severe inflammation of the conjunctiva, eye pain, excessive lacrimation, and blepharospasm. Affected military men complained of a burning sore throat, severe cough, respiratory contamination, tightness, tenderness, and then chest pain. Breathing became arrhythmic, the victims became anxious, irritable, intimidated, prone to panic, itching of the skin, burning pains, erythematous spots on the surface of the skin, there could be chemical burns of the skin of the second degree. The action of CN caused severe irritation of the nerve endings of the mucous membranes of the eyes, skin, mucous membranes of the mouth and nose, intense blepharospasm; eye pain with lacrimation (temporary blindness may be observed), difficulty breathing; redness of the skin, burning pain

of the affected area. Affected military men also report heartburn and pain in the mouth and throat. Short-term reflex bradycardia was observed.

When CS came into contact with the skin in military personnel, skin reactions were noted: mainly erythema of the skin of the face and hands with an edematous component, cases of allergic contact sensitization with erythematous spots and vesicular skin rashes were also noted (Fig. 3).

It should be noted that high concentrations of CS and/or CN can cause serious respiratory symptoms such as reactive airway dysfunction syndrome (compromised lung syndrome). Affected military men experienced cough, chest pain, sputum secretion, and in some cases, hemoptysis, difficulty breathing, and nasal discharge, sometimes lasting weeks after the injury. X-ray examination of the lungs revealed the following radiological signs: infiltration of lung tissue, consolidated rounded foci (destruction cannot be ruled out), decreased pneumatization due to infiltrative changes, etc. X-ray of the chest organs of the affected military men is shown in Fig. 4 and Fig. 5.

## DISCUSSION

The cardiovascular response of the patients affected by CS and CN was characterized, as a rule, by a change in heart rhythm and an increase in systolic and diastolic blood pressure. In addition to the direct impact of CWA, significant neuropsychic overload of frontline fighters during hostilities can cause not only a significant increase in the incidence of arterial hypertension, but also lead to a significant "rejuvenation" of this disease in the future [12].

The basic level of medical care includes limiting contact with the CWA as soon as possible (putting on a gas mask, leaving the affected area), using a smoke mixture (ficillin) (an ampoule of the drug in a braid is opened and placed under the mask of the gas mask). The smoke mixture has the following composition: chloroform – 40,0; ethyl alcohol – 40,0; ether – 20,0; ammonia – 5 drops. Available in ampoules in a braid of 1,0 [13]. Outside the lesion, rinse the mouth, nose, throat, rinse the eyes and exposed skin with clean water, saline, or 2% sodium bicarbonate solution outside the lesion. The main thing in providing assistance to victims is self-help and mutual aid, as well as the provision of first aid by combat medics of the units, which requires careful training of personnel [14].

As a rule, with mild and moderate injuries, military personnel are not subject to evacuation outside the military area. Most of the victims can be returned to combat capability in a short time – within 1-2 days.

At the same time, in case of severe lesions of the eyes and respiratory tract, evacuation is carried out first [15].

When providing first aid, the gas mask is removed, the smoke mixture is reused (if necessary), in case of severe pain, analgesics are administered, the eyes, oral cavity, and skin are washed with plenty of warm running water (with the exception of capsaicin lesions), saline, 2% sodium bicarbonate solution.

The first level of medical care (first aid) includes the administration of metamizole sodium 50% – 2,0 ml, ketorolac 30 mg – 1,0 ml, butorphanol tartrate 0,2% – 1,0 ml intramuscularly; rinsing the eyes, mouth, skin with 2% sodium bicarbonate solution, dripping with 2% novocaine, 1% atropine or 0,5% dicaine for eye pain, applying antibacterial ointment behind the eyelid, gastric lavage and prescribing antacids (if necessary).

All victims of irritants, in the absence of other signs of damage, are classified as lightly affected and, as a rule, do not need to be evacuated to the next stage.

The second level of medical care (qualified medical care) involves complete sanitization with a change of uniforms, pathogenetic and symptomatic therapy. Treatment of bronchospasm, acute respiratory distress syndrome and pneumonia is carried out according to general principles.

The third level of medical care (specialized medical care) consists in the continuation of previous measures, prevention and treatment of complications. Bronchospasm, pneumonia, and, in severe cases, pulmonary edema and acute distress syndrome are treated [16].

## CONCLUSIONS

1. As a result of the full-scale armed aggression against Ukraine, 2698 cases of damage by chemical warfare agents of irritant action were detected among the military men of the Armed Forces of Ukraine, and every month during 2024, more and more injuries were detected among the military men of the Armed Forces of Ukraine (715 cases in May 2024 compared to 444 cases in April 2024), which indicates that a stable upward trend towards a wider trend is emerging deliberate use of chemical warfare agents, the coefficient of determination of  $R^2$  of which was high and amounted to 0,9577, and which continues to grow steadily.
2. Injuries to military men of the Armed Forces of Ukraine by chemical warfare agents of irritating effect, in most cases, were of mild and moderate severity. Medical care was provided, in most cases, on the spot, as a rule, they did not need to be evacuated to higher stages of medical evacuation.

## REFERENCES

1. Arustamian AN, Tkachishin VS. Istoriiia zastosuvannia boiovykh otruinykh rehovyn u roky Pershoi svitovoi viiny [The history of the use of chemical warfare agents during the World War I]. EMERG MED. 2017;(4):100-4. doi:10.22141/2224-0586.4.83.2017.107430. (Ukrainian) [DOI](#)
2. Khan Shaykhun Sarin Attack. <https://crd.org/wp-content/uploads/2021/04/KHAN-SHAYKHUN-SUMMARY-EN-final.pdf> [Accessed 08 September 2024]
3. Encyclopedia of Modern Ukraine. Boiovi otruini rehovyny (BOR) [Chemical warfare agents (CWA)]. <https://esu.com.ua/article-36158> [Accessed 08 September 2024] (Ukrainian)
4. Skaletskyi YuM. Viiskova toksykolohiia, radiolohiia ta medychnyi zakhyst [Military toxicology, radiology, and medical defense]. Ternopil: Ukrmedknyha, 2003, pp.165-329. (Ukrainian)
5. ArmyInform. U ZSU rozpovily, skilky khimichnykh atak zdiisnyla rosiia z pochatku shyrokomasshtabnoi viiny [The Armed Forces of Ukraine told how many chemical attacks Russia has carried out since the beginning of the large-scale war]. <https://armyinform.com.ua/2024/02/09/u-zsu-rozpovily-skilky-himichnyh-atak-zdiisnyla-rosiya-z-pochatku-shyrokomasshtabnoyi-viiny/> [Accessed 08 September 2024] (Ukrainian)
6. Defense Express. Skilky khimichnykh hranat rashysty skynuly v liutomu, i na shcho zvernuty uvahu [How many chemical grenades did the ruscists drop in February, and what to look for]. [https://defence-ua.com/news/skilki\\_himichnih\\_granat\\_rashisti\\_skinuli\\_v\\_liutomu\\_i\\_na\\_scho\\_zvernuti\\_uvagu-14667.html](https://defence-ua.com/news/skilki_himichnih_granat_rashisti_skinuli_v_liutomu_i_na_scho_zvernuti_uvagu-14667.html) [Accessed 08 September 2024] (Ukrainian)
7. Ukrinform. Henshtab: Rosiia zbilshyla zastosuvannia khimichnykh boieprypasiv - ponad 370 udariv za misiats [General Staff: Russia has increased the use of chemical munitions - more than 370 strikes in a month]. <https://www.ukrinform.ua/rubric-ato/3848942-genstab-rosia-zbilshyla-zastosuvanna-himichnih-boeprypasiv-ponad-370-udariv-za-misac.html> [Accessed 08 September 2024] (Ukrainian)
8. Espresso.Tv. rf U travni 715 raziv zastosuvala khimichni boieprypasy v Ukraini [In May, the Russian Federation used chemical munitions 715 times in Ukraine]. <https://espresso.tv/viyna-z-rosiyeyu-rosiyani-u-travni-715-raziv-zastosuvali-khimichni-boeprypasi-proti-zsu> [Accessed 08 September 2024] (Ukrainian)
9. Radio Liberty. Rosiia vse chastishe vykorystovuie khimichnu hranatu K-51 v Ukraini: shcho tse take [Russia is increasingly using the K-51 chemical grenade in Ukraine: what it is]. <https://www.radiosvoboda.org/a/k-51-Russia-war/32341755.html> [Accessed 08 September 2024] (Ukrainian)
10. Tkachuk P.P., Chumakevych V.O., Droban O.M., Fedor B.S., Yevdokimov P.M. Boyeprypasy: pidruchnyk. [Ammunition: manual]. Kyiv : Vyd. dim «SKIF». 2023, p.266. (Ukrainian)
11. Public Association "Ukrainian Military Center". V Ukraini doslidyly novu rosiisku hranatu iz otruinoiu rehovynoiu [A new Russian grenade with a poisonous substance was investigated in Ukraine]. <https://mil.in.ua/uk/news/v-ukrayini-doslidyly-novu-rosijsku-granatu-iz-otrujnoyu-rehovynoyu/> [Accessed 08 September 2024] (Ukrainian)
12. Kravchenko AM. Arterialna hipertenziia i viina, choho ochikuvaty? [Arterial hypertension and war, what to expect?]. Klinichna ta profilaktychna medytsyna. 2023;3(25):93-9. doi:10.31612/2616-4868.3(25).2023.13. (Ukrainian) [DOI](#)
13. Parashchuk LD. Territorial Defense Forces of the Armed Forces of Ukraine. Ekstrena ta nevidkladna medychna dopomoha pry urazhenniakh boiovykh i synodiichymy otruinymy rehovynamy [Emergency and emergency medical care for injuries with combat and potent toxic substances]. [https://sprotyvg7.com.ua/wp-content/uploads/2023/03/ekstrena\\_ta\\_nevidkladna\\_medychna\\_dopomoga\\_pry\\_urazhennyax\\_bojovymy.pdf](https://sprotyvg7.com.ua/wp-content/uploads/2023/03/ekstrena_ta_nevidkladna_medychna_dopomoga_pry_urazhennyax_bojovymy.pdf) [Accessed 08 September 2024] (Ukrainian)
14. Order of the Commander of the Medical Forces of the Armed Forces of Ukraine No. 4. Metodychni rekomendatsii «Metodychni aspekty upravlinnia sytuatsiiamy kryzovykh podii ta masovykh sanitarnykh vtrah» [Methodical recommendations «Methodical aspects of managing situations of crisis events and mass sanitary losses»]. Kyiv: CMF of the Armed Forces of Ukraine. 2021. (Ukrainian)
15. Radchenko OM, Stadnik SM, Komarytsya OJ, Fedyk OV. Uroky povnomasshtabnoho vtorhnennia Rosii: urazhennia boiovykh otruinymy rehovynamy podrazniuvalno-zadushlyvoi dii (vlasne klinichne sposterezhenia) [Lessons of Russia's Full-Scale Invasion: Exposure to Chemical Warfare Agents of Irritating and Asphyxiating Effects (Own Clinical Observation)]. Ukr J Mil Med. 2024;5(1):141-7. (Ukrainian)
16. Osyodlo H, Verba A, Kozachok M et al. Voinno-polova terapiia: pidruchnyk [Military field therapy: textbook]. Osyodlo H, Verba A, editors. Kyiv: SPD Chalchynska N. V.; 2017, p.613. (Ukrainian)

## CONFLICT OF INTEREST

The Authors declare no conflict of interest

## CORRESPONDING AUTHOR

**Nataliia D. Kozak**

Ukrainian Military Medical Academy

45/1, Kniaziv Ostrozkykh St., 01015 Kyiv, Ukraine

e-mail: kozaknd@ukr.net

### ORCID AND CONTRIBUTIONSHIP

Nataliia D. Kozak: 0000-0001-9407-9634 **A** **E** **F**  
Oleh V. Rudynskiy: 0009-0006-8391-0561 **B** **C** **D** **E**  
Andriy V. Verba: 0000-0002-9661-3084 **A** **B** **E**  
Alla A. Asaulenko: 0009-0004-2580-4782 **B** **E**  
Dmytro O. Kozak: 0000-0001-7007-4687 **C** **D** **E**

---

**A** – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article

**RECEIVED:** 29.07.2024

**ACCEPTED:** 27.10.2024

