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## **EPIDEMIOLOGICAL MONITORING OF TUBERCULOSIS AMONG MILITARY PERSONNEL IN UKRAINE: THE IMPACT OF THE WAR AND KEY PRIORITIES FOR THE DEVELOPMENT OF THE NATIONAL TUBERCULOSIS PREVENTION PROGRAM**

**Introduction.** *The war in Ukraine has exacerbated the humanitarian crisis and severely damaged the healthcare infrastructure, which had already been weakened in recent years by the COVID-19 pandemic, creating a new threat to the fight against tuberculosis. The incidence of tuberculosis within the Armed Forces has increased, mirroring the broader trends of rising tuberculosis rates across Ukraine.*

**Problem Statement.** *In light of the difficult epidemic situation with tuberculosis globally, in Ukraine, and within its Armed Forces, the issues of diagnosis, treatment, and prevention of tuberculosis have become extremely urgent.*

**Purpose.** *The aim of this study is to analyze the specific developments in tuberculosis infection among military personnel and the need for the implementation of innovative measures for its prevention, early diagnosis, and treatment.*

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**Materials and Methods.** The materials for this study included reports on tuberculosis incidence from 2017 to 2023 among servicemen within the administrative territorial zones of responsibility, as determined by the Regional Sanitary and Epidemiological Department of the Command of the Medical Forces of the Armed Forces of Ukraine. Analytical and epidemiological methods, as well as mathematical modeling techniques, have been applied.

**Results.** The relationship between the increase in tuberculosis incidence among the servicemen of the Armed Forces of Ukraine and the armed aggression by the Russian Federation was highlighted. From 2021 to 2023, a sharp increase in military personnel illness rates was observed, rising from 0.2‰ to 1.82‰. The morbidity ratio in 2023 compared to 2022 was 170.09%. The predicted incidence rate for 2024 is 1.42‰ (unfavorable).

**Conclusions.** Ensuring effective treatment for tuberculosis, particularly multi-drug resistant forms, through the use of innovative early diagnosis methods, is one of the primary objectives for domestic medicine. Additionally, identifying cofactors contributing to tuberculosis development remains a crucial task.

**Keywords:** tuberculosis, multidrug-resistant (MDR) tuberculosis, screening, military servants, sanitary and epidemiological surveillance, prevention.

Tuberculosis (TB), a disease caused by the microorganism *Mycobacterium tuberculosis*, remains one of the most dangerous infectious diseases in the world after HIV/AIDS [1]. Each year, 10 million new cases of TB are recorded globally, affecting all age groups, along with 1.3 million deaths [2]. According to the latest estimates, approximately 25% of the world's population is infected with *Mycobacterium tuberculosis* but without clinical symptoms of active tuberculosis (TB), a condition known as latent tuberculosis infection (LTBI) [3]. According to the World Health Organization (WHO), the peak of tuberculosis incidence occurred between 2003 and 2019, with a slow decline thereafter, although in 2019 alone, 1.6 million people worldwide died from tuberculosis [4].

In recent years, the fight against tuberculosis has been complicated by the increase and spread of multidrug-resistant tuberculosis (MDR-TB) and extensively drug-resistant tuberculosis (XDR-TB) [5].

In Ukraine, approximately 32,000 people are infected with active tuberculosis each year [6]. It is believed that the actual number of individuals with tuberculosis in Ukraine has already exceeded 0.5% of the country's population [6]. Furthermore, according to Merker et al. (2020) [7], Ukraine has the highest prevalence of multidrug-resistant tuberculosis (MDR-TB) in Europe and ranks third in the world for the prevalence of extensively drug-resistant tuberculosis (XDR-TB). In 2020, Ukraine registered 4,257 cases of MDR-TB. In com-

parison, the European Union/European Economic Area registered only 566 cases [6].

Multidrug-resistant tuberculosis (MDR-TB) is defined as resistance of *Mycobacterium tuberculosis* (Mtb) to at least two of the most potent anti-tuberculosis drugs, rifampicin (RIF) and isoniazid (INH) [5]. Drug resistance in tuberculosis can have various causes, with irregular drug use and interruptions in treatment contributing to the rapid development of resistance to the medication.

At least 23.0% of new TB cases detected in Ukraine are resistant to standard anti-tuberculosis drugs, meaning they are resistant to treatment, and over 40.0% of these new cases already exhibit destructive forms. According to other data [6], multidrug-resistant TB accounts for 33% of all individuals diagnosed with TB in Ukraine, which is 30 times more common than, for example, in Poland.

Among newly diagnosed tuberculosis (TB) patients, approximately 65.0% belong to socially disadvantaged groups, including low-income individuals, unemployed persons of working age, migrants, former inmates, and those without a permanent place of residence. This significantly complicates the detection of TB cases in these populations and the organization of their treatment [8, 9].

At the same time, no more than 60.0% of patients with newly diagnosed bacteriologically confirmed TB in Ukraine achieve successful treatment outcomes each year. A portion of patients succumb to the disease, while over 20.0% of those with inef-

fective or interrupted treatment contribute to the ongoing transmission of infection within the population. These TB treatment outcomes are among the poorest in Eastern Europe [10, 11]. According to expert assessments by specialists from the F. G. Yanovsky National Institute of Phthisiology and Pulmonology, the current TB epidemic situation in Ukraine is expected to result in a further increase in incidence, primarily driven by multi-drug-resistant tuberculosis (MDR-TB) [10–12].

Ukraine ranks among the ten countries with the highest incidence rates of MDR-TB worldwide. Despite the country's extensive experience in implementing international best practices and services within the framework of TB epidemic control, an analysis of the situation reveals significant functional shortcomings in the national system for providing TB medical care [8, 13, 14].

Findings from epidemiological modeling conducted by the *Stop TB Partnership* Global Initiative underscore the urgent need for a comprehensive approach to TB diagnosis, treatment, and prevention. Ensuring early TB diagnosis requires proactive case detection, systematic screening of all household contacts, and substantial expansion of access to TB preventive therapy [15].

One of the key factors contributing to the ongoing TB crisis in Ukraine is the low treatment success rate. This challenge stems from deficiencies in the organization of early TB detection, gaps in diagnosing *Mycobacterium tuberculosis* drug resistance, and weaknesses in ensuring adherence to prevention, early detection, and treatment protocols among the civilian population [16].

### THE IMPACT OF THE WAR IN UKRAINE ON TUBERCULOSIS TRANSMISSION

The ongoing war in Ukraine has had a multidimensional impact on global public health, which had already been weakened in recent years by the COVID-19 pandemic and ongoing climate change [17–20], thereby creating a new threat to tuberculosis (TB) control efforts across Europe [6, 21]. The disruption of healthcare services, destructi-

on of critical infrastructure, displacement of millions of civilians, overcrowded living conditions, and prolonged stays in shelters pose a significant threat to public health. The high prevalence of chronic infections such as TB and HIV/AIDS in Ukraine, compared to the WHO European Region, is also linked to low COVID-19 vaccination rates [22].

As anticipated, during the years of full-scale military aggression by the Russian Federation, a sharp increase in TB incidence has been observed particularly among military personnel mobilized for service. The war in Ukraine has escalated the humanitarian crisis, significantly impacting progress toward achieving regional TB control targets. The conflict exerts both direct and indirect devastating effects on human lives, health, and the functioning of the healthcare system.

Infectious diseases caused by mycobacteria differ from most other bacterial infections due to the need for prolonged treatment to achieve relapse-free recovery with currently available therapeutic approaches. This is especially relevant for TB, where *Mycobacterium tuberculosis* exhibits multi-drug resistance.

Interruptions in treatment and healthcare services due to disruptions in medical infrastructure, shortages of essential medicines, and limited access to medical supplies pose a serious risk of increased morbidity and mortality from infectious diseases such as HIV and TB. The negative impact of the conflict on the provision of long-term treatment and care services further exacerbates these risks. Addressing urgent healthcare challenges in Ukraine, ensuring the continuity of TB treatment – including multidrug-resistant (MDR) forms – remains one of the top-priority tasks of the national healthcare system [3, 8, 9, 15].

The WHO End TB Strategy emphasizes systematic TB screening as a central component of primary healthcare, aimed at ensuring early diagnosis for all TB patients [2, 4, 8, 10].

In accordance with the objectives of the WHO Strategy, countries should achieve at least 90% coverage of systematic tuberculosis (TB) screen-

ing among individuals from identified risk groups. The Global Plan to End TB for 2023–2030, developed by the Global Stop TB Partnership, includes recommendations for critical programmatic interventions aimed at combating TB. These include expanding active case-finding strategies, such as contact investigation, which requires additional investment, as well as improving the quality of existing measures for testing latent TB infections and ensuring their effective treatment [7, 8, 14, 15].

TB incidence within the Armed Forces of Ukraine has also increased, reflecting the overall rise in TB cases nationwide [6, 7, 13, 14]. Given the complex epidemiological situation regarding TB worldwide, in Ukraine, and within its military forces, TB prevention remains a highly relevant issue [4, 6, 10, 13, 23].

The health of military personnel significantly impacts the outcome of any military mission; therefore, infectious diseases, along with strategies for their prevention, early detection, and rapid management, constitute one of the most critical areas in military medicine. A distinctive feature of military medicine as a specialty is the need for advanced research and innovation.

TB has a well-established association with military personnel, though the link between armed conflict and increased TB risk is less evident [23–25]. For instance, TB risk in the U.S. military has largely mirrored the risk observed in the general U.S. population. However, certain high-risk groups within the military, such as prisoners of war, exhibit elevated TB incidence. Although TB control principles in the armed forces align with those applied to civilian populations, military personnel require additional screening, monitoring, and control measures both in peacetime and during wartime [23, 24].

The objective of Ukraine's Military Medical Doctrine is to preserve the lives and health of military personnel by maximizing the effectiveness of their medical support. This is achieved through the integration of capabilities and efforts between military medical services and the civilian healthcare system, as well as by preparing the national

healthcare system to provide medical care to service members during special periods, states of emergency, and other crisis situations.

Ensuring the epidemiological well-being of military personnel is therefore one of the key factors in national security and the combat readiness of the Armed Forces. Given the significant socioeconomic impact of tuberculosis (TB), a comprehensive scientific analysis of the epidemic process and the factors contributing to the spread of this infectious disease among service members, as well as the effectiveness of the existing epidemiological surveillance system, is crucial for the Armed Forces of Ukraine [7–9, 14–16].

The primary objective of this study was to examine the characteristics of TB epidemic development and progression among military personnel of the Armed Forces under the conditions of armed aggression by the Russian Federation, as well as to improve preventive measures.

The materials used for analyzing the development and progression of the TB epidemic among military personnel included TB morbidity reports from 2017–2023, annual TB incidence dynamics reports for 2023, and sputum sample test results from military personnel in 2023 within the administrative territorial area of responsibility of a designated Regional Sanitary and Epidemiological Unit (RSEU) of the Ministry of Defense of Ukraine. In 2023, systematic screening among military personnel included radiological examinations of 16,884 service members, of whom 707 exhibited a cough symptom. A total of 705 sputum samples were collected for further bacteriological analysis. Based on the results, 228 service members were referred for additional examinations, and 91 tested positive for TB. To forecast TB incidence rates, Microsoft Excel software was utilized. The results guided the development of management strategies aimed at preventing further increases in TB cases and enabling the proactive and rational planning of preventive and anti-epidemic measures. The forecasted values were calculated using TB incidence rates per 1,000,000 military personnel over the past seven years.

## THE STRUCTURE OF MULTIANNUAL AND ANNUAL DYNAMICS OF TUBERCULOSIS MORBIDITY AMONG MILITARY PERSONNEL

The analysis of the long-term dynamics of tuberculosis incidence among military personnel was conducted to assess the epidemiological situation over a period significantly preceding the study (2017–2023). This analysis aimed to enhance preventive and anti-epidemic measures and to forecast the epidemiological trends (Table 1).

The data presented in Table 1 indicate a consistent fivefold increase in the incidence rate over seven years – from 0.34% to 1.82%.

In 2017, among 44,213 military personnel, the tuberculosis incidence rate was 0.34%, whereas in 2023, among 73,117 personnel, it reached 1.82%. Accordingly, the incidence intensity indicators were 0.47‰, in 2017, and 2.065‰, in 2023.

The use of Microsoft Excel, with the activation of its data analysis functions, enabled us to calculate growth indicators and their values, construct an incidence graph reflecting the seven-year trend along with a linear trendline, and generate tables displaying the results of regression analysis and a forecast for tuberculosis incidence in the following year.

According to the data in Table 2, the projected tuberculosis incidence rate for 2024 is 1.42‰ ± ± 0.28‰. The incidence ratio for 2023 compared to 2022 was 170.09%, indicating a 70.09% increase in incidence over the reporting year compared to the previous year.

Analyzing the monthly tuberculosis incidence from 2018 to 2023, isolated cases were observed. However, following the onset of the Russian Federation's military aggression (specifically from

March 2022), tuberculosis incidence among military personnel began to rise steadily. By 2023, starting in June, the number of reported cases exceeded 20 per month in certain instances (Table 3).

The annual dynamics of tuberculosis incidence among mobilized military personnel in 2023 are illustrated in Fig. 2, which tracks the cyclic pattern of the process. Throughout 2023, a seasonal peak in incidence was observed in February, with an intensity rate of 0.23‰, and in March, with 0.21‰. A subsequent increase in tuberculosis incidence was recorded in July (0.33‰) and August (0.29‰). The periods of incidence rise and decline exhibited a wave-like pattern.

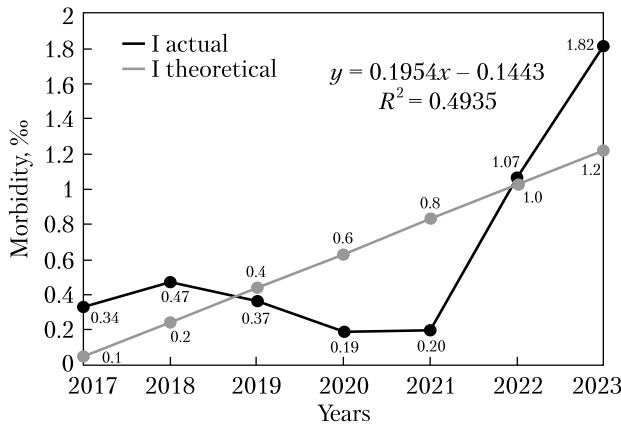
As anticipated, during the years of full-scale aggression by the Russian Federation, a sharp increase in tuberculosis incidence has been observed among the category of military personnel mobilized for service (Fig. 3).

In 2022, out of 68 tuberculosis cases, 66 (97%) were among mobilized personnel. In 2023, out of 151 reported cases of pulmonary tuberculosis, 144 (95%) were identified within the mobilized contingent. No tuberculosis cases were registered among officers during 2022–2023. The incidence among conscripts and contract military personnel remained minimal, with conscripts accounting for one case in 2022 and two cases in 2023, while contract servicemen recorded one case in 2022 and five cases in 2023.

The obtained results on tuberculosis incidence among military personnel generally align with data presented in the literature. However, interpreting these findings requires considering various factors that may have influenced the incidence trends within the studied group.

**Table 1. Overall Tuberculosis Morbidity Among Military Personnel for 2017–2023 within the Administrative Territorial Zone of Responsibility of the Designated RSEU**

Index	Year						
	2017	2018	2019	2020	2021	2022	2023
Tuberculosis morbidity rate, %	0.34	0.47	0.37	0.19	0.2	1.07	1.82
Personnel count, individuals	44213	45118	48311	48300	48908	63580	73117



**Fig. 1.** Dynamics of morbidity among military personnel within the administrative territorial zone of responsibility of the designated RSEU and the morbidity forecast for the next year

**Table 2. Growth Indices, Forecast for 2024**

No.	Index	Value
1	Average multiannual growth rate, %	69.78
2	Absolute growth, %	0.75
3	Growth rate, %	170.09
4	Increase rate, %	70.09
5	Unit of increase, ‰	0.01
6	Average morbidity rate of previous years, ‰	0.44
7	Difference between the reporting year's level and the multiannual average	75.82
8	Student's t-test value for significance	8.51
9	Forecast for 2024, ‰	1.42 ± 0.28

**Table 3. Monthly Tuberculosis Morbidity Among Military Personnel in 2023, individuals**

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2018	1	1	3	1	1	0	2	0	3	1	4	4
2019	0	2	4	1	0	0	4	2	2	2	2	1
2020	0	0	0	1	0	1	1	2	2	1	0	3
2021	0	1	0	1	2	2	1	2	1	0	0	0
2022	0	0	4	13	11	18	7	7	5	4	1	14
2023	9	17	15	12	10	5	24	21	11	7	5	15

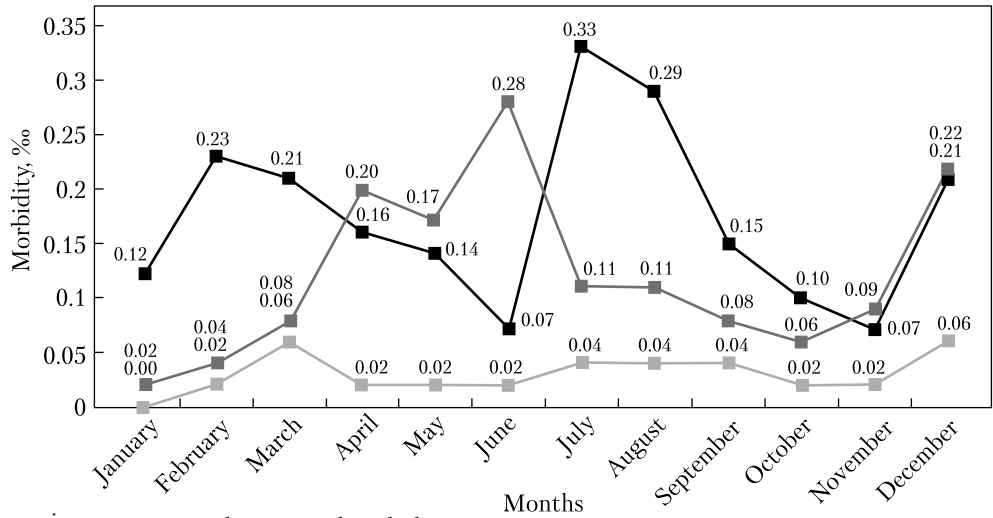
Throughout the screening period, an increase in tuberculosis incidence was observed primarily among mobilized servicemen. This trend may indicate that other population categories were not adequately covered by tuberculosis surveillance and monitoring. Notably, the rise in tuberculosis incidence in Ukraine from 2017 to 2023 contrasts with the global decline observed over the same period. Documented data from 2020 show a 20% reduction in tuberculosis diagnoses, likely attributable to multiple factors, including restricted access to diagnostic, treatment, and preventive services, misdiagnoses due to the COVID-19 pandemic, as well as increased mask-wearing and social distancing measures [26].

It is well established that crises triggered by armed conflicts, forced displacement, or natural disasters lead to heightened morbidity and mortality from infectious diseases, including tuberculosis [27].

The predominant *M. tuberculosis* Beijing strain (MDR-TB) in Ukraine is associated with higher virulence and increased transmissibility [6].

It is important to recognize that developing a national tuberculosis control program is a multifaceted challenge. First and foremost, it is necessary to assess the prevalence and risk factors associated with tuberculosis (TB) among individuals infected with the human immunodeficiency virus (HIV) or those diagnosed with acquired immunodeficiency syndrome (AIDS) [28]. According to the latest WHO data [29], tuberculosis accounts for approximately 30% of the 690,000 AIDS-related deaths worldwide.

According to McKee and Nagyova (2022) [30], following the conclusion of the war in Ukraine, months and years of resource shortages will create conditions for the emergence and exacerbation of serious health issues. This will hinder efforts to prevent the transmission and mortality of HIV, hepatitis C, tuberculosis, and other related diseases. Consequently, Ukraine's healthcare system must act proactively by developing a national tuberculosis control program, targeting one of the most severe infectious diseases, through



**Fig. 2.** Annual morbidity dynamics (2023) of tuberculosis among mobilized military personnel, % — 2023 — dynamics of morbidity — Me + 0.95 — median level and its confidence interval — Me — median level

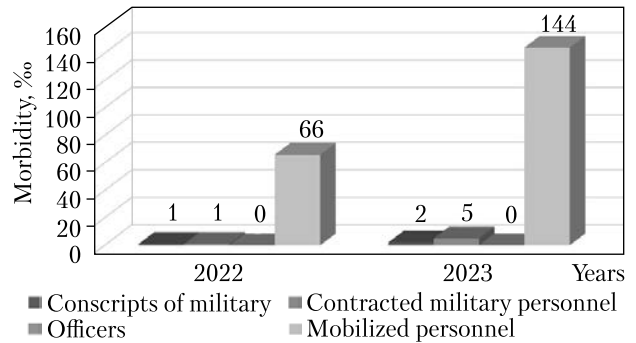
innovative approaches ensuring early diagnosis and effective treatment. Many people in Ukraine have missed recommended screenings and vaccinations due to the war [30]. In 2022, the BCG vaccination coverage rate was only 77%.

This factor may also explain the increased tuberculosis incidence among military personnel in Ukraine.

The specific conditions in which Ukrainian citizens have found themselves for an extended period contribute to the rising number of tuberculosis cases. It is well established that weakened immune defense significantly increases susceptibility to tuberculosis infection and progression. Prolonged physical and psychological stress, including chronic stress, inadequate nutrition, and prolonged stays in crowded environments — such as bomb shelters with limited ventilation — compromise immunity, potentially facilitating the spread and progression of tuberculosis and other infectious diseases.

Additional challenges to tuberculosis control in Ukraine include the prevalence of various infectious diseases (e.g., measles, diphtheria) that have been largely eradicated or effectively controlled in other European countries.

Social and medical surveillance systems will be essential both for detecting new outbreaks of in-



**Fig. 3.** Overall tuberculosis morbidity among the personnel of military units within the administrative territorial zone of responsibility of the designated RSEU, in 2023

fectious diseases and for predicting and understanding the emergence of high-risk networks and behaviors.

A key requirement for pulmonary tuberculosis diagnosis is the identification of *M. tuberculosis* in tissue samples. Between 2000 and 2020, timely tuberculosis diagnosis and treatment saved approximately 66 million lives worldwide [31]. There are several diagnostic methods, each with its own advantages and limitations. In most countries, active tuberculosis is still diagnosed through sputum smear microscopy (SSM). This remains one of the most accessible diagnostic tools and is of-

ten the only available method in low-income countries. While it is fast and inexpensive, its primary limitation is low sensitivity (40–60%), particularly among individuals co-infected with HIV [32]. The low sensitivity and high rate of false-negative results can lead to misdiagnosis and delayed treatment initiation. Some recent modifications to this technique, incorporating fluorescent antibodies, may help overcome some of these limitations, though they also increase costs, making them impractical for use in resource-limited settings [33].

Another modern “gold standard” for tuberculosis detection is *M. tuberculosis* culture on specialized nutrient media, which can also facilitate antibiotic susceptibility testing [34].

Drug susceptibility testing (DST) based on traditional culture remains the primary diagnostic platform in most developing countries. However, delayed diagnosis remains a major factor in the escalation of tuberculosis incidence. Early detection and treatment are crucial to preventing further transmission [32]. Nonetheless, this method requires up to four weeks, necessitating skilled personnel and well-equipped laboratories.

In recent years, new and highly sensitive molecular genetic methods have been developed worldwide, offering promising advancements in the rapid detection of active tuberculosis [36]. Specifically, modern molecular-biological diagnostic techniques for TB include the Xpert MTB/RIF — an automated molecular-genetic test that detects *Mycobacterium tuberculosis* DNA and the gene responsible for rifampicin resistance, which serves as a marker for multidrug-resistant tuberculosis (MDR-TB) in 97% of cases [34, 37].

Significant progress has been made in the rapid identification of MDR/XDR-TB cases, but these technologies are not yet widely accessible, and advancements in diagnostics have not kept pace with developments in treatment or prevention strategies [34].

These molecular methods drastically reduce the time required for TB diagnosis while improving sensitivity. However, their availability remains li-

imited in developing countries or war-affected regions such as Ukraine.

Modern TB drug delivery systems require advancements in nanotechnology, a rapidly evolving scientific field that integrates chemistry, physics, and biology to develop nanostructured therapeutic solutions for pharmacology and biomedical applications [34].

That said, new technologies alone cannot solve the tuberculosis epidemic. Innovative, integrated, community-centered solutions — emphasizing primary healthcare approaches rather than relying solely on technological innovations — are necessary to curb TB resistance [38].

The incidence of pulmonary tuberculosis among military personnel conscripted under mobilization has become a distinct issue. This fact raises concerns that recruitment may have occurred without thorough medical record evaluations or proper fluorographic screening at enlistment centers. As a result, a significant number of individuals already infected with tuberculosis — or with latent infections — may have entered the Armed Forces of Ukraine.

Moreover, epidemiological surveillance of tuberculosis among military personnel is a critical component of military healthcare. Enhancing TB surveillance systems contributes to maintaining and improving service members’ overall health, sustaining high combat readiness, and reducing government expenditures on treatment and epidemic control measures within affected units.

## CONCLUSIONS

1. Long-term Trends (2017–2023): Tuberculosis exhibited a statistically significant upward trend over this period, with an average annual growth rate of 2.09%. Notably, from 2021 to 2023, there was a sharp increase in TB incidence among military personnel — from 0.2‰ to 1.82‰, primarily due to the mobilization of individuals already infected with *Mycobacterium tuberculosis*.

2. Stable Increase in Incidence Rates: Between 2017 and 2023, TB incidence among military per-

sonnel steadily increased from 0.34% (2017) to 1.82% (2023). The intensive incidence rate per 1,000 personnel rose from 0.47‰ in 2017 to 2.065‰ in 2023.

3. Military TB Incidence Mirrors National Trends: The incidence of respiratory tuberculosis in the Armed Forces of Ukraine closely follows the general epidemiological patterns observed in the civilian population. The ongoing socio-economic crisis and adverse epidemiological situation

in Ukraine have had a direct impact on the military, leading to similar TB trends. The increase in TB cases is a direct consequence of deficiencies in medical screening during mobilization.

4. Strategic Response to TB in the Armed Forces: Ukraine's National TB Strategy must focus on innovative diagnostic and treatment approaches, including the integration of nanotechnology, to enhance early detection and improve therapeutic outcomes.

## REFERENCES

- Kia, P., Ruman, U., Pratiwi, A. R., Hussein, M. Z. (2023). Innovative Therapeutic Approaches Based on Nanotechnology for the Treatment and Management of Tuberculosis. *International Journal of Nanomedicine*, 18, 1159–1191. <https://doi.org/10.2147/IJN.S364634>
- World Health Organization (WHO) (2021). Global Tuberculosis Report 2021. Geneva, WHO, 2021. URL: [apps.who.int/iris/bitstream/handle/10665/336069/9789240013131-eng.pdf/](https://apps.who.int/iris/bitstream/handle/10665/336069/9789240013131-eng.pdf/) (Last accessed: 23.07.2024).
- Kiazzyk, S., Ball, T. (2017). Latent tuberculosis infection: an overview. *Can. Commun. Dis. Rep.*, 43, 62–66. <https://doi.org/10.14745/ccdr.v43i34a01>
- World Health Organization (WHO) (2022). Rapid Communication: Key Changes to the Treatment of Drug-Resistant Tuberculosis. World Health Organization; 2022. URL: <https://www.who.int/publications/i/item/WHO-UCN-TB-2022-2> (Last accessed: 23.07.2024).
- World Health Organization. (2015). Global tuberculosis report 2015, 20th, Ed. World Health Organization. URL: <https://iris.who.int/handle/10665/191102> (Last accessed: 23.07.2024).
- Wilczek, N. A., Brzyska, A., Bogucka, J., Sielwanowska, W. E., Żybowska, M., Pieciewicz-Szczęśna, H., Smoleń, A. (2023). The Impact of the War in Ukraine on the Epidemiological Situation of Tuberculosis in Europe. *Journal of Clinical Medicine*, 12(20), 6554. <https://doi.org/10.3390/jcm12206554>
- Merker, M., Nikolaevskaya, E., Kohl, T. A., Molina-Moya, B., Pavlovska, O., Brannberg, P., ..., Niemann, S. (2020). Multidrug- and extensively drug-resistant Mycobacterium tuberculosis Beijing Clades, Ukraine, 2015. *Emerg. Infect. Dis.*, 26(3), 481–490. <https://doi.org/10.3201/eid2603.190525>
- Tuberculosis, analytical and statistical guide for 2022 in Ukraine. (2023). State University «Public Health Center of the Ministry of Health of Ukraine». Kyiv. URL: [https://phc.org.ua/sites/default/files/users/user90/TB\\_surveillance\\_statistical-information\\_2022\\_dovidnyk.pdf](https://phc.org.ua/sites/default/files/users/user90/TB_surveillance_statistical-information_2022_dovidnyk.pdf) (Last accessed: 23.07.2024) [in Ukrainian].
- Khomenko, I. P., Lurin, I. A., Tsybalyuk, V. I. (2020). *Medical support of the Armed Forces of Ukraine*. Kyiv [in Ukrainian].
- Toman's tuberculosis. Case detection, treatment, and monitoring – question and answers* (2004) (Ed. T. Frieden). 2nd ed. World Health Organization, Geneva.
- Feshchenko, Yu. I., Petrenko, V. M., Cherenko, S. O., Bialik, Y. B., Lytvynenko, N. A., Tsygankova, L. M., ..., Davydenko, V. V. (2007). New cases of pulmonary tuberculosis: results of treatment, causes of insufficient effectiveness. *Journal of the Academy of Medical Sciences of Ukraine*, 13(3), 567–578 [in Ukrainian].
- Feshchenko, Yu. I., Melnyk, V. M., Opanasenko, M. S. (2019). *Ineffective treatment of patients with pulmonary tuberculosis and its prevention*. Kyiv [in Ukrainian].
- Spasenko, O., Kholodna, L. (2006). Characteristic features of biological properties of tuberculosis causative agent. *Visnyk of the National Academy of Sciences of Ukraine*, 8, 13–16. URL: <http://dspace.nbuv.gov.ua/handle/123456789/1954> (Last accessed: 23.07.2024) [in Ukrainian].
- State strategy for the development of the system of anti-tuberculosis medical care for the population [Order N 1414-p, Approved by the Decree of the Cabinet of Ministers of Ukraine of November 27, 2019 No. 1414-p.] (2020). *Tuberculosis, lung diseases, HIV infection*, 1(40), 18–24 [in Ukrainian].
- Recommendations “Strategic directions for the implementation of measures to improve tracking, examination and preventive treatment of contact persons with an index case of tuberculosis”/ State University “Public Health Center of the Ministry of Health of Ukraine”. Kyiv, 2023 [in Ukrainian].
- Terleeva, Ya. S., Goncharova, M. I., Kuzin, I. V., Sereda, Yu. V. (2020). Barriers to tuberculosis treatment in Ukraine. *Tuberculosis, lung diseases, HIV infection*, 3(42), 7–16. <https://doi.org/10.30978/TB2020-3-7> [in Ukrainian].

17. Pareek, M., Greenaway, C., Noori, T., Munoz, J., Zenner, D. (2016). The impact of migration on tuberculosis epidemiology and control in high-income countries: a review. *BMC Med.*, 14, 48. <https://doi.org/10.1186/s12916-016-0595-5>
18. Dahl, V. N., Tiberi, S., Goletti, D., Wejse, C. (2022). Armed conflict and human displacement may lead to an increase in the burden of tuberculosis in Europe. *Int. J. Infect. Dis.*, 124, 104–106. <https://doi.org/10.1016/j.ijid.2022.03.040>
19. Fatyga, E., Dzięgielewska-Gęsiak, S., Muc-Wierzgoń, M. (2022). Organization of Medical Assistance in Poland for Ukrainian Citizens during the Russia-Ukraine War. *Front. Public Health*, 10, 904588. <https://doi.org/10.3389/fpubh.2022.904588>
20. Roberts, L. (2022). Surge of HIV, tuberculosis and COVID feared amid war in Ukraine. *Nature*, 603, 557–558. <https://doi.org/10.1038/d41586-022-00748-6>
21. Hauer, B., Kröger, S., Haas, W., Brodhun, B. (2023). Tuberculosis in times of war and crisis: Epidemiological trends and characteristics of patients born in Ukraine, Germany, 2022. *EuroSurveillance*, 28(24), 2300284. <https://doi.org/10.2807/1560-7917.ES.2023.28.24.2300284>
22. Essar, M. Y., Rezayee, K. J., Ahmad, S., Kamal, M.A., Nasery, R., Danishmand, T.J., ..., Nemat, A. (2022). Knowledge, Attitude, and Practices Toward Tuberculosis Among Hospital Outpatients in Kabul, Afghanistan. *Front Public Health*, 10, 933005. <https://doi.org/10.3389/fpubh.2022.933005>
23. Mancuso, J. D., Aaron, C. L. (2013). Tuberculosis trends in the U.S. Armed Forces, active component, 1998–2012. *MSMR*, 20(5), 4–8. PMID: 23731007.
24. Mancuso, J. D. (2017). Tuberculosis Screening and Control in the US Military in War and Peace. *Am. J. Public. Health*, 107(1), 60–67. <https://doi.org/10.2105/AJPH.2016.303502>
25. Dzhus, M., Golovach, I. (2022). Impact of Ukrainian-Russian War on Healthcare and Humanitarian Crisis. *Disaster Med. Public Health Prep.*, 17, e340. <https://doi.org/10.1017/dmp.2022.265>
26. Luke, E., Swafford, K., Shirazi, G., Venketaraman, V. (2022). TB and COVID-19: An Exploration of the Characteristics and Resulting Complications of Co-infection. *Front Biosci. (Schol Ed.)*, 14(1), 6. <https://doi.org/10.31083/j.fbs1401006>
27. Kimbrough, W., Saliba, V., Dahab, M., Haskew, C., Checchi, F. (2012). The burden of tuberculosis in crisis-affected populations: a systematic review. *Lancet Infect. Dis.*, 12, 950–965. [https://doi.org/10.1016/S1473-3099\(12\)70225-6](https://doi.org/10.1016/S1473-3099(12)70225-6)
28. Qi, M., Zhang, L., Gan, W., Xu, Y., Wei, J., Fu, X., Li, X. (2023). The Imaging Features and Diagnostic Value of Computerized Tomography in Seminal Duct Tuberculosis. *Journal of Multidisciplinary Healthcare*, 16, 1395–1402. <https://doi.org/10.2147/JMDH.S401660>
29. WHO G. Global tuberculosis report 2020. (2020). *Glob. Tuberc. Rep.*, S7–S12.
30. McKee, M., Nagyova, I. (2022). When the guns fall silent... Priorities for health in post-war Ukraine. *European Journal of Public Health*, 32(4), 517–518. <https://doi.org/10.1093/eurpub/ckac090>
31. Verma, N., Arora, V., Awasthi, R., Chan, Y., Jha, N. K., Thapa, K., ..., Dua, K. (2022). Recent developments, challenges and future prospects in advanced drug delivery systems in the management of tuberculosis. *Journal of Drug Delivery Science and Technology*, 75, 103690. <https://doi.org/10.1016/j.jddst.2022.103690>
32. Steingart, K. R., Ng, V., Henry, M., Hopewell, P. C., Ramsay, A., Cunningham, J., ..., Pai, M. (2006). Sputum processing methods to improve the sensitivity of smear microscopy for tuberculosis: A systematic review. *Lancet Infect. Dis.*, 6, 664–674. [https://doi.org/10.1016/S1473-3099\(06\)70602-8](https://doi.org/10.1016/S1473-3099(06)70602-8)
33. Kumar, M., Virmani, T., Kumar, G., Deshmukh, R., Sharma, A., Duarte, S., ..., Fonte, P. (2023). Nanocarriers in Tuberculosis Treatment: Challenges and Delivery Strategies. *Pharmaceuticals*, 16(10), 1360. <https://doi.org/10.3390/ph16101360>
34. Hsu, D., Irfan, M., Jabeen, K., Iqbal, N., Hasan, R., Migliori, G. B., ..., Tiberi, S. (2020). Post Tuberculosis Treatment Infectious Complications. *Int. J. Infect. Dis.*, 92, 41–45. <https://doi.org/10.1016/j.ijid.2020.02.032>
35. Kamphée, H., Chairprasert, A., Prammananan, T., Wiriyachaiyorn, N., Kanchanatavee, A., Dharakul, T. (2015). Rapid Molecular Detection of Multidrug-Resistant Tuberculosis by PCR-Nucleic Acid Lateral Flow Immunoassay. *PLoS One*, 10(9), e0137791. <https://doi.org/10.1371/journal.pone.0137791>
36. Orenstein, E. W., Basu, S., Shah, N. S., Andrews, J. R., Friedland, G. H., Moll, A. P., ..., Galvani, A. P. (2009). Treatment outcomes among patients with multidrug-resistant tuberculosis: systematic review and meta-analysis. *Lancet Infect. Dis.*, 9(3), 153–161. [https://doi.org/10.1016/S1473-3099\(09\)70041-6](https://doi.org/10.1016/S1473-3099(09)70041-6)
37. Protocol of a study in the field of anti-tuberculosis: causes of late detection of multidrug-resistant tuberculosis (MDR-TB) and planning interventions to reduce the spread of generalized forms of tuberculosis. (2018). The Center of social expertises named after Yuri Saenko. Kyiv [in Ukrainian].
38. Mason, P. H., Oni, T., van Herpen, M. M., Coussens, A. K. (2016). Tuberculosis prevention must integrate technological and basic care innovation. *European Respiratory Journal*, 48, 1529–1531. <https://doi.org/10.1183/13993003.01449-2016>

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## ЕПІДЕМІОЛОГІЧНИЙ НАГЛЯД ЗА ТУБЕРКУЛЬОЗОМ СЕРЕД ВІЙСЬКОВОСЛУЖБОВЦІВ В УКРАЇНІ: НАСЛІДКИ ВІЙНИ ТА ОСНОВНІ ПРІОРИТЕТИ ДЛЯ РОЗРОБКИ НАЦІОНАЛЬНОЇ ПРОГРАМИ ПРОТИДІЇ ТУБЕРКУЛЬОЗУ

**Вступ.** Війна в Україні спричинила ескалацію гуманітарної кризи та руйнування інфраструктури системи охорони здоров'я, яка вже була ослаблена в останні роки через пандемію COVID-19, створюючи нову загрозу для боротьби з туберкульозом. Захворюваність на туберкульоз у Збройних Силах зросла, наслідуючи загальні тенденції до зростання туберкульозу в Україні.

**Проблематика.** В умовах складної епідситуації з туберкульозу в світі, Україні та в її Збройних Силах питання діагностування, лікування та профілактики туберкульозу є вкрай актуальним.

**Мета.** Проаналізувати особливості розвитку туберкульозної інфекції серед військовослужбовців та потребу впровадження інноваційних заходів її профілактики, ранньої діагностики й лікування.

**Матеріали й методи.** Матеріалами слугували звіти захворюваності на туберкульоз за 2017–2023 роки серед військовослужбовців адміністративно-територіальної зони відповідальності, визначеної Регіональним санітарно-епідеміологічним управлінням Командування медичних сил Збройних сил України; застосовано аналітичний, епідеміологічний методи та метод математичного моделювання.

**Результати.** Встановлено зв'язок між зростанням захворюваності на туберкульоз серед військовослужбовців ЗСУ та збройною агресією РФ. У багаторічній динаміці туберкульоз мав статистично достовірну тенденцію до зростання із багаторічним середнім темпом приросту 2,09 %. З 2021 по до 2023 роки року мала місце тенденція до різкого зростання рівня захворюваності військовослужбовців — з 0,2 до 1,82 %. Співвідношення показників захворюваності у 2023 році до показників 2022 року становить 170,09 %. Прогнозований рівень захворюваності на 2024 рік — 1,42 % (несприятливий).

**Висновки.** Забезпечення ефективного лікування туберкульозу, зокрема й мультирезистентних форм, із застосуванням інноваційних засобів ранньої діагностики інфекції, входить до першочергових завдань вітчизняної медицини. Необхідним є з'ясування і кофакторів розвитку туберкульозу.

**Ключові слова:** туберкульоз, мультирезистентний туберкульоз, скринінг, військовослужбовці, санітарно-епідеміологічний нагляд, профілактика.