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MULTIDRUG-RESISTANT PATHOGENS IN CRISIS-AFFECTED HOSPITALS

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Background. Multidrug-resistant organisms (MDROs) have become a major global public health challenge, particularly in healthcare settings where they are associated with increased morbidity, mortality, and healthcare costs [1 - 4]. Healthcare-associated infections (HAIs) caused by MDROs are difficult to treat and contribute significantly to adverse patient outcomes worldwide. Recent surveillance data demonstrate alarmingly high rates of antimicrobial resistance among clinical isolates in hospital environments, with resistance to multiple antibiotic classes becoming increasingly common in both Gram-positive and Gram-negative pathogens. Resistance to β-lactams, carbapenems, and other last-resort antimicrobials has been documented in diverse bacterial species, reflecting the rapid evolution and dissemination of resistance mechanisms across clinical settings [5-7].

Armed conflicts significantly contribute to the rise of antibiotic resistance, primarily due to the breakdown of healthcare infrastructure, increased use of antibiotics in austere settings, and the spread of infectious diseases in crowded and unsanitary conditions [8 - 10]. The disruption of medical supply chains often leads to the misuse and overuse of antibiotics, fostering the emergence of resistant strains [11 - 12]. Additionally, conflict zones frequently witness the proliferation of multidrug-resistant bacteria, which pose a global health threat because they can easily spread across borders via displaced populations and contaminated environments [13-15].

In Ukraine, longstanding challenges in infection prevention and control have been exacerbated by ongoing military conflict, leading to disruptions in healthcare delivery, increased patient displacement, and strained hospital resources. Studies have reported high prevalence of MDROs among patients in Ukrainian hospitals, with a significant proportion of isolates exhibiting resistance to third-generation cephalosporins, carbapenems, and other critical antibiotics [2, 8, 16 - 19]. War-related injuries and repeated hospitalizations abroad have further heightened the risk of colonization and infection with resistant pathogens, highlighting the impact of conflict environments on antimicrobial resistance dynamics [20 – 21].

The combined effects of healthcare system disruption and increased exposure to broad-spectrum antibiotics in crisis-affected regions may foster the emergence and spread of MDROs. Understanding the prevalence, resistance profiles, and transmission patterns of these organisms in conflict-affected hospitals is essential for guiding infection control policies and antibiotic stewardship strategies. Yet, comprehensive microbiological surveillance in such settings remains limited. This study aims to characterize the multidrug resistance phenotypes of clinical isolates from hospitals in a crisis-affected area during 2024–2025, thereby contributing critical data on the burden and trends of antimicrobial resistance in resource-strained healthcare environments.

Objectives. The primary objective of this study is to assess the prevalence and antimicrobial resistance profiles of multidrug-resistant bacterial isolates obtained from patients in Kharkiv hospitals affected by the ongoing conflict in Ukraine during 2024–2025. Secondary objectives include:

1. Identifying the most common species of MDROs in these hospital settings.
2. Characterizing resistance patterns to critical antibiotic classes, including β-lactams, carbapenems, and aminoglycosides.
3. Evaluating potential risk factors associated with the acquisition of MDROs in crisis-affected healthcare facilities.
4. Providing evidence to inform infection prevention and antimicrobial stewardship strategies under resource-limited, conflict-affected conditions.

Methods

Study design and setting

This observational study was conducted across five hospitals in Kharkiv, a region of Ukraine affected by ongoing conflict, from January 2024 to December 2025. Hospitals included both tertiary care centers and district-level facilities providing acute care to patients with trauma, infectious diseases, and medical comorbidities.

Sample collection: Clinical isolates were obtained from patients with suspected healthcare-associated infections, including bloodstream, urinary tract, respiratory, and surgical site infections. Standard microbiological techniques were used for specimen collection, transport, and processing in accordance with WHO guidelines [22].

Microbiological analysis

Bacterial identification was performed using conventional culture methods. Antimicrobial susceptibility testing was conducted using the disk diffusion method and interpreted according to the EUCAST standard. Automated systems (BD Phoenix M 50 and VITEK 2) were used where available. Multidrug resistance was defined as non-susceptibility to at least one agent in three or more antibiotic classes.

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Data collection and analysis

Demographic, clinical, and epidemiological data were collected from hospital records. Statistical analyses included descriptive statistics for prevalence and resistance patterns. Trends in resistance patterns were analyzed across the two-year study period.

Ethical considerations: The study protocol was approved by the Bioethics Commission of Kharkiv National Medical University. Informed consent was obtained from patients or their legal guardians where required. Data were anonymized to ensure confidentiality.

Results

Between February 2024 and December 2025, a total of 1313 MDRO isolates were collected from five healthcare facilities in Kharkiv across various hospital departments. Isolates were recovered from both pediatric and adult patients, with ages ranging from 1 month to 88 years. Male patients accounted for the majority of MDRO isolates (69%), whereas female patients accounted for 31%.

A total of 25 pathogenic species were identified (tabl. 1). The most frequently detected MDRO included *Klebsiella pneumoniae* (583 isolates, 44.4%), *Acinetobacter baumannii* (261 isolates, 19.9%), *Pseudomonas aeruginosa* (178 isolates, 13.6%), and *Proteus mirabilis* (68 isolates, 5.2%).

Table 1. Distribution of MDR Isolates by Bacterial Species (n = 1,313)

Bacterial species	Number of isolates	Percentage (%)
Klebsiella pneumoniae	583	44.4
Acinetobacter baumannii	261	19.9
Pseudomonas aeruginosa	178	13.6
Proteus mirabilis	68	5.2
Other species (21 species)	223	17.0
Total	1,313	100

Analysis of clinical specimen types showed that MDRO isolates were most commonly obtained from wound exudates (394 isolates, 30.0%), followed by bronchoalveolar lavage fluid (208 isolates, 15.8%), urine (189 isolates, 14.4%), blood (127 isolates, 9.7%), sputum (73 isolates, 5.6%), throat swabs (79 isolates, 6.0%), and feces (41 isolates, 3.1%) (tabl.2).

Table 2. Distribution of MDR Isolates by Clinical Specimen (n = 1,313)

Specimen type	Number of isolates	Percentage (%)
Wound exudate	394	30.0
Bronchoalveolar lavage fluid	208	15.8
Urine	189	14.4
Blood	127	9.7
Sputum	73	5.6
Throat swab	79	6.0
Feces	41	3.1
Other/unspecified	202	15.4
Total	1,313	100

All isolates exhibited resistance to multiple classes of antimicrobial agents, including carbapenems, although specific resistance profiles varied by species. The predominance of Gram-negative pathogens, particularly Klebsiella pneumonia and Acinetobacter baumannii, reflects the high burden of MDRO in hospitalized patients in these facilities.

Discussion

The present study provides a comprehensive overview of MDRO pathogens in crisis-affected hospital settings in Kharkiv during 2024–2026.

Research on antimicrobial resistance in Kharkiv offers significant advantages for assessing the impact of military conflicts by providing a localized, detailed understanding of how such crises influence bacterial resistance patterns. Kharkiv, as a major city affected by conflict, exemplifies how disruptions to healthcare systems, increased

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antibiotic misuse, and population displacement contribute to the development and spread of resistant microorganisms. Studying this specific context allows researchers to identify unique challenges and adaptive responses, thereby generating valuable insights that can inform public health strategies both regionally and globally. Additionally, data from Kharkiv can serve as a case study to understand the broader effects of war on infectious disease dynamics, helping improve preparedness and response efforts in other conflict-affected areas.

The predominance of Gram-negative bacteria, including *Klebsiella pneumonia* and *Acinetobacter baumannii*, is consistent with reports from other conflict-affected regions, where disruptions in healthcare delivery and infection control contribute to the proliferation of resistant organisms [8, 10-15].

The observed male predominance among MDRO isolates may reflect higher exposure to healthcare interventions, occupational factors, or behavioral risks, although further investigation is required to clarify these associations. The wide age range of affected patients underscores that MDRO infections are not confined to any single demographic and can impact both vulnerable pediatric populations and older adults.

The distribution of clinical specimens highlights that wounds are a major reservoir for MDRO pathogens, likely due to trauma-related injuries and post-surgical infections, particularly in conflict-affected environments. Respiratory and urinary tracts were also important reservoir of MDRO, emphasizing the need for vigilance in Intensive Care Units (ICU) and high-dependency units.

These findings underscore the critical need for targeted antimicrobial stewardship and infection-prevention measures, including enhanced hand hygiene, environmental cleaning, and careful monitoring of antimicrobial use. The ongoing conflict context likely exacerbates MDRO emergence by limiting resources, increasing patient displacement, and interrupting routine surveillance and infection control activities.

Conclusions

1. The study reveals a high prevalence of multidrug-resistant organisms, primarily *Klebsiella pneumoniae, Acinetobacter baumannii* and *Pseudomonas aeruginosa,* in hospitals affected by ongoing armed conflict in Kharkiv during 2024–2025.
2. Wound exudates, bronchoalveolar lavage fluid, and urine are the most common reservoirs of MDRO isolates, reflecting the impact of trauma, respiratory infections, and urinary tract infections in this setting.
3. Resistance to multiple antibiotic classes is widespread among the isolates, highlighting the critical challenge of antimicrobial resistance in resource-limited, crisis-affected healthcare environments.
4. The findings underscore the urgent need to strengthen infection prevention measures, including strict hygiene practices and environmental cleaning, alongside optimized antimicrobial stewardship programs.
5. Continuous microbiological surveillance is essential to monitor resistance trends, guide empirical therapy, and prevent the further spread of resistant pathogens in conflict-affected healthcare settings.
6. The data provide a vital baseline for developing targeted policies and interventions aimed at reducing the burden of MDROs and improving patient outcomes in war-affected regions.
7. Additionally, there is an imperative to enhance the capacity of the epidemiological surveillance system through integration of advanced diagnostic technologies and comprehensive information management platforms, to facilitate timely detection, reporting, and response to antimicrobial resistance threats in these vulnerable settings.

Perspectives for Future Research. Building on the findings of this study, future research should focus on expanding the surveillance of antimicrobial resistance patterns in conflict-affected regions, such as Ukraine. Longitudinal studies are needed to monitor the evolution of resistance over time and assess the impact of ongoing military conflicts on the spread of MDROs. Additionally, investigating the effectiveness of infection prevention and control measures in resource-limited and war-torn healthcare settings could provide valuable insights for improving patient outcomes. Further research into the molecular mechanisms underlying resistance in predominant pathogens like *Klebsiella pneumoniae* and *Acinetobacter baumannii* is also crucial for developing targeted therapies. Ultimately, multidisciplinary approaches integrating microbiology, epidemiology, and public health are essential to combat the growing threat of antimicrobial resistance in conflict zones and to develop sustainable strategies for managing infections under challenging conditions.

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Conflicts of Interest. The authors declare no conflicts of interest.

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Multidrug-resistant pathogens in crisis-affected hospitals

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Aim. This study aims to evaluate the prevalence, species distribution, and antimicrobial resistance profiles of multidrug-resistant organisms (MDROs) in hospitals affected by ongoing conflict in Kharkiv, Ukraine, during 2024–2025. The goal is to generate data to support infection control and antimicrobial stewardship in resource-limited, crisis-affected settings. **Materials and Methods.** An observational study was conducted across five Kharkiv hospitals from January 2024 to December 2025. Clinical isolates were collected from patients with suspected healthcare-associated infections, including bloodstream, urinary, respiratory, and surgical site infections. Bacterial identification was performed using conventional culture methods, and antimicrobial susceptibility testing was performed in accordance with EUCAST standards. Patient demographic and clinical data were analyzed to assess resistance patterns and prevalence. **Results**. A total of 1313 MDRO isolates were collected, mainly from wound exudates, bronchoalveolar lavage, and urine samples. The most common species were *Klebsiella pneumoniae* (44.4%), *Acinetobacter baumannii* (19.9%), and *Pseudomonas aeruginosa* (13.6%). Resistance to multiple antibiotic classes was widespread, especially among Gram-negative bacteria. The isolates affected a broad age range (1 month to 88 years), with males accounting for 69%. The findings highlight the significant burden of resistant bacteria in conflict-affected hospitals, driven by healthcare disruptions, increased antibiotic use, and compromised infection control. **Conclusions.** The study demonstrates a high prevalence of MDROs, predominantly *Klebsiella pneumoniae, Acinetobacter baumannii*, and *Pseudomonas aeruginosa*. Wound, respiratory, and urinary tracts are major reservoirs. These results emphasize the urgent need for enhanced infection prevention, antimicrobial stewardship, and ongoing microbiological surveillance to limit the spread of resistant pathogens. The data provide a crucial baseline for developing policies to combat antimicrobial resistance in conflict-affected healthcare environments. There is an imperative to enhance the capacity of the epidemiological surveillance system through integration of advanced diagnostic technologies and comprehensive information management platforms, to facilitate timely detection, reporting, and response to antimicrobial resistance threats in these vulnerable settings.

Keywords: Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, antimicrobial resistance, antimicrobial stewardship, surveillance, armed conflict.

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