

## Multidrug-resistant organisms in combat-related injuries: comparative insights from Iraq, Afghanistan, and Ukraine and implications for large-scale combat operations

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**Background:** Armed conflict is a significant driver of antimicrobial resistance (AMR). As advances in personal protective equipment and combat casualty care have improved survival among wounded service members, trauma-related infections have become increasingly prevalent. Combat wounds caused by blasts, gunfire, and shrapnel are frequently contaminated and difficult to manage in austere environments. Across recent conflicts in Iraq, Afghanistan, and Ukraine, multidrug-resistant organisms (MDROs) have emerged as a major threat to both military readiness and global public health. Common combat-related infections include skin and soft tissue infections (41%), pneumonia (13%), bloodstream infections (13%), osteomyelitis (6%), and sepsis (4%). Evidence demonstrates a progression from MDR pathogens to extensively drug-resistant (XDR) and pan-drug-resistant (PDR) organisms.

**Aim:** This literature review compared the epidemiology, predominant pathogens, and antimicrobial resistance patterns associated with combat-related infections in Iraq, Afghanistan, and Ukraine. The objective was to identify trends that may inform future military medical operations and infection prevention strategies.

**Methods:** A review of the literature was conducted using the MEDLINE and PubMed databases. Search terms included “war,” “armed conflict,” “Iraq,” “Afghanistan,” “Ukraine,” and “antibiotic resistance.” Publications from January 2008 through August 2025 were included to capture data from the Iraq and Afghanistan conflicts and the ongoing war in Ukraine. MDR was defined as non-susceptibility to at least one agent in three or more antimicrobial categories, XDR as susceptibility to only one or two categories, and PDR as non-susceptibility to all antimicrobial categories.

**Results:** Combat-related infections were predominantly caused by Gram-negative organisms, including *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and extended-spectrum  $\beta$ -lactamase-producing Enterobacterales. Approximately one-third of combat casualties developed infections during initial hospitalization. Risk factors included severe injury, traumatic amputation, multiple surgical procedures, and intensive care unit admission. Across all conflicts, resistance patterns demonstrated an increasing prevalence of MDR, XDR, and PDR organisms, with particularly high resistance to carbapenems, fluoroquinolones, and aminoglycosides.

**Conclusion:** Combat trauma remains a major contributor to the emergence and spread of antimicrobial resistance. The increasing prevalence of MDR, XDR, and PDR pathogens threatens military medical operations and civilian healthcare systems. Strengthening infection prevention and control practices, antimicrobial stewardship, surveillance, rapid diagnostics, and pre-deployment training is essential to mitigate transmission and improve outcomes during future large-scale combat operations.