

**Review article****A Perfect Storm: The Escalating Crisis of Antimicrobial Resistance in Surgical Wounds in Gaza***Abouelhag H. A.*

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The Gaza conflict has precipitated a catastrophic humanitarian crisis, creating an ideal environment for the emergence and spread of antimicrobial resistance (AMR). This review synthesizes evidence from humanitarian reports, medical testimonials, and preliminary data to analyze the multifactorial drivers of AMR in surgical wounds. The collapse of healthcare infrastructure, critical shortages of antibiotics and supplies, the impossibility of infection prevention and control (IPC), and the unique nature of war injuries converge into a perfect storm. With laboratories destroyed and antimicrobial stewardship abandoned, clinicians are forced into empirical, often ineffective antibiotic use, rapidly selecting for resistant pathogens like multidrug-resistant *Acinetobacter baumannii*. The consequences are increased morbidity, amputations, and mortality for patients, while posing a severe threat to global health security by creating reservoirs of untreatable infections. This review concludes that the situation in Gaza represents a profound failure of medical ethics and international law, demanding urgent, coordinated intervention to prevent a long-term AMR catastrophe.

Keywords: antimicrobial resistance, Gaza, surgical site infection, conflict medicine, war wounds, global health security, infection prevention and control, multidrug-resistant organisms

Introduction

Antimicrobial resistance (AMR) is a global health threat projected to cause 10 million deaths annually by 2050 if left unaddressed (O'Neill, 2016). Conflict zones are recognized as epicenters for its accelerated emergence, where fragmented health systems, population displacement, and destroyed sanitation infrastructure create fertile ground for resistant pathogens (Truppa *et al.*, 2019). The ongoing crisis in Gaza presents a particularly severe case study. Following the hostilities that began in October 2023, the healthcare system has been systematically degraded through the destruction of hospitals, a blockade on essential supplies, and the mass injury of over 80,000 people, overwhelming the remaining capacity (World Health Organization [WHO], 2024a).

Managing the vast number of complex surgical wounds under these conditions has become a near-impossible task. This review argues that the convergence of a collapsed health system, critical antibiotic shortages, suboptimal infection control, and population vulnerabilities in Gaza has created an unprecedented incubator for AMR in surgical wounds, with dire implications for both immediate patient survival and long-term global public health.

Methodology

This narrative review synthesizes information from a systematic search of electronic databases (PubMed, Google Scholar) for keywords including "antimicrobial resistance,"



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"Gaza," "surgical site infection," "conflict medicine," and "war wounds," from 2023 to the present. Given the scarcity of peer-reviewed literature from an active war zone, the search was expanded to include situation reports, press releases, and field analyses from international humanitarian and health organizations such as the World Health Organization (WHO), Médecins Sans Frontières (MSF), the International Committee of the Red Cross (ICRC), and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). Expert commentaries and journalist reports from within medical facilities were also included to provide contemporaneous, on-the-ground evidence.

The Perfect Storm: Multifactorial Drivers of AMR Overwhelmed and Collapsing Healthcare Infrastructure

The foundational driver of AMR in Gaza is the deliberate and systematic dismantling of the healthcare system. As of May 2024, only a fraction of hospitals remain partially functional, and these operate without reliable electricity, clean water, or anesthesia (WHO, 2024b). The destruction of key facilities like Al-Shifa Hospital has eliminated crucial tertiary care and laboratory services (ICRC, 2024). This collapse means that basic wound debridement is often performed without adequate analgesia, sterile gloves, or antiseptics, significantly increasing the risk of initial contamination with resistant bacteria.

The Crisis of Antibiotic Availability and Stewardship

Antimicrobial stewardship the systematic effort to optimize antibiotic use is a cornerstone of AMR containment. In Gaza, this concept has become irrelevant. A severe blockade has led to critical stock-outs of essential medicines, including first- and second-line antibiotics (MSF, 2024). With microbiological laboratories non-functional, clinicians are forced to prescribe empirically, often guessing which antibiotic might work. This leads to the widespread misuse of broad-spectrum agents as first-line therapy, a practice that powerfully selects for resistance (Llewelyn *et al.*, 2023). In desperate circumstances, patients may also self-medicate with incomplete courses of antibiotics obtained from non-official sources, further fueling the resistance cycle.

Suboptimal Infection Prevention and Control (IPC)

Infection prevention is impossible in the current environment. Overcrowded wards, with multiple patients sharing a single bed, make the isolation of infected individuals unfeasible, facilitating the rapid cross-transmission of resistant organisms (Quesada, 2024). The lack of fuel and water prevents the sterilization of surgical instruments and the implementation of basic hand hygiene. Healthcare workers, operating under extreme duress and without personal protective equipment, can become both vectors and victims of resistant infections.

The Nature of "Gaza War Wounds"

The injuries sustained are inherently high-risk. Modern explosive weapons cause extensive tissue damage, fragmentation, and contamination with soil, clothing, and other foreign bodies (Giannou and Hambridge, 2023). The overwhelming volume of casualties has necessitated a return to "open wound medicine," where primary closure is delayed for days or weeks. These large, contaminated wounds, managed in unsanitary conditions, are ideal niches for biofilm-forming, multidrug-resistant bacteria to establish themselves.

Population Vulnerability and Displacement

The population's resilience has been shattered. Widespread malnutrition, affecting a significant portion of the population, weakens immune responses, making individuals more susceptible to infection (UNICEF, 2024). The displacement of over 1.7 million people into overcrowded shelters with inadequate sanitation and limited access to clean water creates a



community-level reservoir for the spread of pathogens, complicating post-operative wound care and hygiene.

Documented Evidence and Emerging Pathogens

Direct evidence, while difficult to systematically collect, is alarming. Medical teams from MSF and the WHO have repeatedly reported outbreaks of untreatable infections in hospitals. One of the most frequently cited pathogens is multidrug-resistant *Acinetobacter baumannii*, a notorious "superbug" known for contaminating war wounds and causing outbreaks in intensive care units (Karruli *et al.*, 2023). Surgeons on the ground have provided harrowing testimonials. Dr. Thaer Ahmad, a volunteer physician, reported, "We're seeing bacteria that are resistant to every single antibiotic that we have... It's a devastating situation" (Ahmad, 2024, as cited in **The Guardian**). These anecdotes are the canaries in the coal mine, signaling a systemic AMR crisis that is currently unquantified but universally acknowledged by practitioners.

Consequences: A Local and Global Catastrophe

The consequences are stark. For patients, AMR turns a survivable injury into a death sentence or leads to life-altering complications like limb amputations that could have been avoided. The morale of the remaining healthcare workers, who must watch patients die from infections they cannot treat, is being crushed.

For global health, the implications are profound. Conflict zones like Gaza act as breeding grounds for resistant pathogens that do not respect borders. The emergence and amplification of pan-resistant bacteria in Gaza pose a direct threat to regional and global health security, potentially undermining decades of progress in infection control and modern medicine worldwide (Mendelson *et al.*, 2023).

Recommendations and a Call to Action

Addressing this crisis requires immediate and sustained action:

- **Immediate:** The international community must ensure an immediate and uninterrupted flow of humanitarian aid, including a full range of antibiotics, wound care materials, and fuel. The deployment of mobile field laboratories is critical to restore diagnostic capacity.
- **Long-Term:** A massive effort to rebuild Gaza's health system must integrate AMR containment as a core component, including robust surveillance, IPC programs, and antimicrobial stewardship. This must be supported by a political solution that upholds International Humanitarian Law to protect healthcare infrastructure.

Conclusion

The development of rampant antimicrobial resistance in surgical wounds in Gaza is not an accidental byproduct of war but a predictable and dire consequence of a targeted collapse of a healthcare system. The perfect storm of infrastructure destruction, supply shortages, and population vulnerability has created an unprecedented laboratory for the evolution of superbugs. The situation is a stark reminder that AMR is not only a biological phenomenon but also a political one. Failing to act decisively to support healthcare in Gaza condemns countless individuals to preventable deaths and recklessly undermines global health security for generations to come.

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