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Navigating Drug-Resistant Tuberculosis In Conflict Zones: The Double-Edged Role Of Informal Healthcare Systems

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Abstract: *Tuberculosis (TB), caused by Mycobacterium tuberculosis, remains one of the deadliest infectious diseases globally, with heightened challenges in conflict-affected regions. Armed conflict precipitates the collapse of formal healthcare infrastructures, compelling displaced populations to rely on informal healthcare networks. While these systems provide critical diagnostic and treatment services under extreme conditions, they are plagued by diagnostic inaccuracies, inconsistent treatment protocols, and fragmented public health mechanisms, which collectively exacerbate the emergence and spread of drug-resistant tuberculosis (DR-TB). Genomic studies have linked resistance-associated mutations to suboptimal treatment practices common in these settings. This creates a paradox wherein informal care is both a lifesaving necessity and a driver of resistance amplification. The ethical dilemmas faced by healthcare providers necessitate pragmatic yet imperfect treatment strategies. This paper advocates for multi-tiered interventions including emergency short-course regimens, regional pharmaceutical stockpiles, and technical oversight of informal healthcare systems to integrate humanitarian imperatives with public health standards. Such coordinated efforts are essential to curb DR-TB transmission in conflict zones and to rebuild sustainable TB control frameworks.*
Keywords: *Tuberculosis; Conflict Zones Medicine; Informal Healthcare; Multi-tiered Interventions*

1. INTRODUCTION

Tuberculosis (TB), caused by Mycobacterium tuberculosis, remains one of the world's deadliest infectious diseases, particularly in regions afflicted by conflict. The bacterium, first isolated by Robert Koch in 1882, is an aerobic, gram-positive bacillus primarily transmitted through respiratory droplets. With the emergence of antibiotics like streptomycin in the 20th century, TB became more treatable, yet drug resistance now presents a formidable challenge(1).

When missiles pierce hospital domes and doctors disappear in waves of border exodus, the collapse of the national healthcare system pushes displaced people into a medical abyss. At this moment, informal healthcare networks are transformed into arks of life built of flesh and blood - not just alternative presences, but violent declarations of the right to biological survival in war zones(2).

2. MAIN DISCUSSION

The Necessity of Informal Healthcare in Conflict Zones

Recent large-scale genomic investigations, such as the CRyPTIC project analyzing over 15,000 Mycobacterium tuberculosis isolates across 27 countries, have identified 13 major genetic mutations associated with resistance to first-line antituberculosis agents, including isoniazid and rifampin. These mutations, frequently induced by inadequate treatment practices—particularly monotherapy and poor adherence—affect genes such as rpoB and katG. Management of drug-resistant tuberculosis (DR-TB) typically necessitates prolonged treatment regimens lasting from 6 to 24 months, involving costly second-line medications such as bedaquiline and linezolid. Despite such intensive protocols, treatment success rates remain suboptimal (approximately 50–70%)(3), and associated costs can exceed those of drug-susceptible TB by more than 100-fold. These challenges are significantly magnified in conflict-affected regions.

In these fragile settings, informal healthcare systems often emerge to fill the vacuum left by collapsing formal infrastructures. These systems exert a paradoxical influence: while they offer essential diagnostic and therapeutic support for populations otherwise cut off from care, they simultaneously facilitate the spread of M. tuberculosis and the amplification of antimicrobial resistance. This paradox is primarily driven by three interrelated deficiencies.

First, diagnostic accuracy is severely compromised. Informal facilities often rely on symptom-based assessments or rudimentary sputum smear microscopy, contributing to an estimated underdiagnosis rate of

up to 40%. As a result, infectious individuals are frequently not isolated, perpetuating community-level transmission.

Second, treatment protocols are frequently inconsistent or substandard. Widespread use of monotherapy, irregular drug availability, and premature discontinuation of treatment contribute to subtherapeutic exposure. According to the World Health Organization (WHO), such non-standardized treatment is the leading factor driving the emergence of DR-TB, with resistance rates in conflict zones reportedly three times higher than those in non-conflict settings.

Third, prevention and control systems are highly fragmented. Most informal care environments lack formal surveillance infrastructure and contact tracing mechanisms, thereby fostering "hidden chains of transmission" that evade detection and control(1). Countries such as Syria and Ukraine exemplify the collapse of formal healthcare systems due to protracted armed conflict. In these contexts, informal healthcare becomes the de facto and often sole provider for displaced populations. These systems are characterized by critical limitations in diagnostic infrastructure, irregular access to essential medications, and insufficient numbers of qualified healthcare professionals(4) (5) (6). Informal healthcare systems emerge as the only available alternative for displaced populations. Although they serve urgent humanitarian needs, such systems inadvertently exacerbate the risk of DR-TB development and dissemination(1).

The dilemma faced in these settings stems from a fundamental conflict between immediate survival needs and long-term public health security. Informal healthcare represents a survival-oriented approach in which urgent access to care is prioritized over clinical rigor and public health standards. When populations are exposed to acute threats of illness or mortality, informal care becomes a pragmatic necessity(5) (6).

Public Health Breakdown and Structural Feedback

All The collapse of formal healthcare systems in conflict zones catalyzes a self-reinforcing cycle of public health failure, in which informal healthcare structures—though indispensable—become vehicles for therapeutic breakdown and drug resistance amplification(2).

In Syria's Beqaa Valley, Médecins Sans Frontières (MSF) transformed abandoned farmhouses into clandestine tuberculosis (TB) clinics, providing hidden treatment to over 1,200 drug-resistant TB (DR-TB) patients. Medications were smuggled through underground channels, and encrypted communication was used to avoid detection by hostile forces. Similarly, in Donetsk, Ukraine—where 83% of public hospitals had been destroyed by shelling—the International Red Cross operated mobile clinics, delivering essential medication to more than 2,300 patients each month(7). These adaptive strategies perform three critical functions: spatial reconstruction by establishing therapeutic enclaves amid physical destruction; functional substitution via informal, cross-border drug distribution systems (e.g., black-market supply chains and drone-delivered medication kits); and reconstitution of social trust, as exemplified by anonymous clinics near the Turkish border, where patient attendance among Syrian refugees reportedly increased by 300%(8).

Yet, the same informal networks that serve as survival lifelines also foster significant epidemiological risks. Without consistent diagnostic infrastructure or treatment protocols, therapy is often interrupted or suboptimal. In Jordan's Zaatari refugee camp, 37% of TB patients relied on black-market medications, many of which contained erratic levels of rifapentine or were adulterated with substances like starch. A 2022 analysis found that 52% of these patients developed extensively drug-resistant TB (XDR-TB). In Donetsk, 68% of patients experienced treatment interruptions of two weeks or more due to disrupted supply routes; among these, 41% progressed to multidrug-resistant TB (MDR-TB). These trends reveal a dangerous epidemiological feedback loop: the more resistance spreads, the more patients lose faith in formal systems and turn to informal care, thereby perpetuating the conditions that incubate resistance(9).

These structural weaknesses are not isolated; they feed into a broader breakdown of public health logic. Traditional mechanisms of epidemiological surveillance, contact tracing, and therapeutic accountability cannot operate in fragmented, informal contexts. As resistance proliferates undetected and uncontrolled, formal TB control frameworks become irrelevant, and data-driven responses falter.

This creates a dangerous public health paradox: informal care both sustains life and erodes the very structures needed to protect population-level health. In effect, war-induced institutional collapse leads to informal substitution, which then perpetuates resistance, undermines surveillance, and intensifies the burden on already shattered systems—completing a devastating feedback loop. Without urgent structural interventions

that bridge the gap between emergency relief and systemic continuity, global TB control risks unraveling in conflict-affected regions.

Ethical Challenges and Strategic Responses in Humanitarian Contexts

Clinical decision-making in conflict zones is shaped by extreme scarcity and moral compromise. Physicians often face a binary dilemma: to provide incomplete or potentially harmful regimens sourced from black markets, or to delay treatment until standardized therapies become available, risking the patient's life in the interim. The World Health Organization's 2022 Crisis Guidelines endorsed a 9-month short-course regimen for MDR-TB under emergency conditions (Level of Evidence C), despite its inferiority compared to the standard 20-month protocol (Level A). In resource-limited refugee settings—where daily healthcare budgets rarely exceed $1 per patient—this abbreviated regimen remains the only viable option(10).

Empirical data from Médecins Sans Frontières (MSF) operations in Idlib demonstrate the ethical calculus behind this choice: implementation of the short-course regimen increased treatment coverage from 19% to 67%, while reducing mortality by 31%. As one field physician noted, "Perfectionism is complicity in murder when a child coughs up blood and dies." These adaptations reflect a form of disaster ethics: compromises made not out of negligence, but necessity(11).

However, the unintended consequences of such compromises are profound. The Global TB Alliance reported a 14% annual rise in XDR-TB incidence in Ukraine, attributed to the widespread use of oversimplified drug regimens that excluded ethambutol and pyrazinamide(12). This trend illustrates a grim paradox: every pill saved under resource constraints may fuel the evolution of more resilient strains of M. tuberculosis.

Resource allocation mechanisms further complicate the ethical landscape. Clinics operating under performance-based donor metrics may prioritize patients with higher probabilities of recovery to optimize reported success rates. In Donetsk, one facility allocated scarce standardized regimens to three mildly ill patients at the expense of a critically ill individual, solely to meet donor-imposed benchmarks. Such decisions reflect a disturbing erosion of medical ethics in favor of data-driven funding logic(13).

Public Health Intervention

To mitigate these risks, a multi-tiered ethical response system is required:Spatial triage: In unstable high-risk zones (e.g., Mariupol), deploy ultra-short-course regimens incorporating bedaquiline to prevent immediate mortality when comprehensive care is infeasible.Protocol enforcement in stabilization areas: In relatively secure settings (e.g., Jordan's Zaatari camp), ensure adherence to full 20-month regimens with integrated molecular resistance monitoring using salivary nucleic acid testing.Pharmaceutical sovereignty: Establish regional drug stockpiles and rapid deployment frameworks, such as the EU's 48-hour replenishment initiative, to prevent treatment discontinuity and its associated resistance amplification(14)

The controversy surrounding the relationship between informal healthcare systems in conflict zones and DR - TB transmission reflects the complex challenges faced by the global community in addressing public health crises. This situation underscores the urgent need for coordinated global responses.On one hand, the international community must uphold a pragmatic humanitarian spirit by supporting informal healthcare systems in meeting the basic medical needs of populations in conflict zones, ensuring timely access to treatment for patients.On the other hand, strict public health standards must be upheld through technical assistance, personnel training, and material support to regulate the diagnostic and treatment practices of informal healthcare systems and strengthen DR - TB prevention and control.Only by achieving an organic integration of pragmatic humanitarianism and strict public health standards can we effectively address the challenge of DR - TB transmission in conflict zones and build a comprehensive and effective public health protection network.

While these strategies do not represent perfect solutions, they constitute actionable applications of disaster ethics—an effort to stretch survival time in the gap between systemic collapse and future recovery. The trajectory of informal medicine in conflict zones—whether lifeline or vector of resistance—depends on our ability to reconcile short-term imperatives with long-term public health sustainability.

3. CONCLUSION

In regions torn by war, informal healthcare emerges as both a necessity and a threat. While it fills gaps left by destroyed health systems, it also undermines TB control through inconsistent treatment and diagnostic gaps. To confront the DR-TB crisis, a dual-track strategy is needed: reinforce informal care with technical oversight

and ethical frameworks while working toward the long-term reconstruction of formal systems. The challenge is not merely medical—it is ethical, political, and deeply human.

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