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War and Antimicrobial Resistance Spread

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ABSTRACT

Armed conflict significantly exacerbates the emergence and spread of antimicrobial resistance (AMR), compounding global public health challenges. Disruption of healthcare systems, population displacement, and unregulated antimicrobial use in crisis settings create conditions conducive to the proliferation of multidrug-resistant pathogens. Conflicts in Syria, Ukraine, Yemen, Afghanistan, and Iraq illustrate how war undermines infection prevention, surveillance, and stewardship, while amplifying transmission dynamics both within and across national borders. The combination of damaged infrastructure, inadequate pharmaceutical supply chains, and compromised governance hinders effective response, surveillance, and stewardship interventions. This review highlights the mechanisms linking conflict to AMR, explores public health and regional consequences, and underscores the ethical and policy dimensions of equitable antimicrobial allocation. Strengthening global health governance, implementing context-specific stewardship programs, and enhancing surveillance and supply chain resilience are essential strategies to mitigate AMR in conflict-affected settings. Coordinated international action, grounded in humanitarian law and public health principles, is crucial to prevent long-term global proliferation of resistant pathogens.

Keywords: Antimicrobial resistance (AMR), Armed conflict, Population displacement, Health systems disruption, and Global health governance.

INTRODUCTION

The development and deployment of antimicrobial agents was a breakthrough that saved millions of lives in the 20th century and allowed clinicians to better control host-pathogen interactions [1]. Despite the tremendous advances since 1945 in the discovery and development of antituberculosis, antimalarial, anti-HIV, antiviral, and antifungal agents, resistance to antimicrobials is increasing worldwide and is now threatening the control of tuberculosis, malaria, HIV, and multiple bacterial infections[2]. The factors contributing to the rising resistance to antimicrobials in the West and in developing countries are diverse, and include over-the-counter availability of antimicrobials, unnecessary use for viral infections, indiscriminate use in livestock (the use of antibiotics as growth promoters), and poorly managed processes in the pharmaceutical industry and the conservation of resources for vaccine development and people's awareness of vaccination in developing countries [3, 9]. Antimicrobial resistance occurs wherever antimicrobials are being used, including in the community, farms, and healthcare settings[4]. Overuse and misuse of antibiotics in humans and animals in the developing world have contributed to the emergence of resistant strains in the soil and surface water, seriously compromising efforts to control infectious diseases [1].

Theoretical Framework

Conflict can disrupt health systems, relieve pressure on infectious disease burdens, and increase vulnerability to the emergence and spread of AMR 1 -the complex interplay arises from context-specific variables, the characteristics of the substances involved, lifestyle practices, and socio-economic conditions specific to the human population in resistance dissemination and antimicrobial misuse [7]. The relationship often appears indirect and operates through a sequence of intertwined mechanisms [8]. First, a severe crisis leaves a population susceptible to infectious diseases, directs antimicrobial usage during a critical phase of the spectrum toward high-risk, often

unsuitable, drugs, and enhances antimicrobial misuse; maximum consumption must be evaluated cautiously to avoid misleading conclusions [8]. Second, the consequence of conflict exacerbates transmission dynamics among humans. Population displacement facilitates the rapid international spread of pathogens, sometimes together with falsified, counterfeit, or substandard drugs [3].

Mechanisms Linking Conflict to Antimicrobial Resistance

Disruption of public health infrastructure lacking resilience to disaster and conflict invariably leads to increased morbidity and mortality from infectious diseases, including those caused by multidrug-resistant pathogens [6]. In such crisis environments, the general population becomes exposed to a wide range of infectious diseases outside their normal ecosystem [4]. In turn, a high infectious disease burden, whether due to lack of access to antimicrobials and preventive health technologies or excessive use of antimicrobials without supervision, exacerbates the emergence and spread of AMR [7]. Moreover, mass displacement of vulnerable populations can alter standard pathogen transmission dynamics and further complicate AMR control [2]. In terrorism-afflicted Afghanistan, MDROs have emerged due to unregulated purchases of broad-spectrum antibiotics and a lack of standards in prescribing practices [5]. Multi-drug resistant Enterobacteriaceae, Acinetobacter baumannii, and Pseudomonas aeruginosa, as well as methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococcus (VRE), circulate freely among health facilities [3]. The spread of MDR and extensive use of antibiotics among livestock have similarly been reported in Syria, alongside widespread transmission of potentially zoonotic pathogens through the controlled movement of medical supplies from one country to another [8].

Disruption of Healthcare Systems

Antimicrobial resistance represents an urgent global health threat, causing an estimated 1.27 million deaths per year 4. Although many factors contribute to resistance emergence and spread, war and its immediate consequences are often overlooked [5]. Violent conflict not only increases the incidence of infectious diseases but also weakens humankind's capacity to contain their spread, making countries at war particularly vulnerable to resistance. Humanitarian crises exacerbate population mobility and introduce vast numbers of infectious agents into the environment [6]. Assessment of conflict zones indicates that population displacements function as amplifiers of resistance dissemination. Following the end of violent conflicts, the links between war and antimicrobial resistance remain evident; post-war countries experience greater rates of emergence than comparable ones that remained calm[8].

Increased Infectious Disease Burden

Hampered healthcare systems struggle to control the transmission of infectious agents due to the exodus of health workers, attacks against health infrastructure and personnel, shortages of medicines and vaccines, increased poverty, and the disruption of prevention, treatment, and education campaigns [2]. Consequently, war-expedient movements of displaced populations exacerbate the proliferation of infectious agents, revealing cross-border reappearances of epidemic diseases previously thought eliminated [3]. The upsurge of untreated infections, often with antimicrobial-resistant pathogens, transfers multidrug-resistant bacteria to the human population through other contending reservoirs [7]. Severe overcrowding in refugee camps, prisons, and urban settings further complicates the situation by facilitating transmission. A conflict-related onset of chronic infectious diseases leads to a drastic increase in demand for antimicrobials and abandonment of conventional clinical diagnostics. An infected individual is frequently the only source of guidance regarding infections and, consequently, the only source of treatment choices [5]. The indiscriminate input of outdated and unsuitable antimicrobial drugs to the black market and clinical case reports of prolonged post-infection-drug symptomatic aggressiveness-change, deemed absent in previous armed conflicts, contribute to substandard antimicrobial suitability [3].

Antimicrobial Usage and Misuse in Crisis Contexts

In conflict- and crisis-affected settings, AMR concerns and pressures intensify [4]. On one hand, to prevent, control, and treat trauma and infection, on the other, because of illegal imports and overcrowding conditions in shelters, antiseptics and antibiotics are both more used and misused. Also, save for humanitarian actors, essential AMR-surveillance systems either do not exist or rarely exist [14]. Fragile and conflict-affected settings often have dysfunctional health systems and rely on external support from humanitarian and development agents [16]. There has been increasing focus on delivering equitable healthcare in these settings, including child health, nutrition, sexual and reproductive health, and disease control programs. Antimicrobial resistance (AMR) has become a critical issue, but it has received little attention in conflict situations. Several factors in conflict-affected settings contribute to the emergence and spread of AMR [4, 18].

Population Displacement and Transmission Dynamics

Conflict-induced population displacement emerges as a critical enabler of AMR spread. Large-scale civilian movement enables the transference of resistant bacteria across regions and continents [6]. Refugees and forcibly displaced persons disproportionately affected by conflict often experience limited access to healthcare,

exacerbating exposure to resistant pathogens [8]. Human mobility significantly influences AMR transmission dynamics, warranting the prioritization of affected countries and population groups in surveillance efforts. Improving understanding of pre, peri, and post-displacement mobility patterns and their implications for pathogen transfer is therefore essential to inform targeted community screening and intervention strategies. Modelling approaches may further elucidate the impact of population displacement from conflict- and crisis-affected to outbreak-prone settings on the transmission of resistant organisms, including strain and resistance profile characterization [15].

Case Studies

Nicolle et al. (2022) underscore the potential for the spread of antimicrobial resistance (AMR) in conflict-affected regions and map the plausible channels for ongoing AMR dissemination in such settings [8]. AMR is a priority public health issue globally, and a major increase in AMR was recently documented in official reports from several institutions in countries where armed conflict is ongoing or has taken place [18]. Estimates of the AMR burden in these settings recently collapsed under two headings: an excess burden of AMR-associated infections and an increased risk of AMR transfer, reflected by a distinct set of AMR organisms resistant to widely used first-line antimicrobials [14]. Humanitarian emergencies were found to impact both burden and transfer [15]. Antimicrobial resistance patterns in war-wounded civilians in Yemen, Ukraine, and other areas from Syria to Iraq reveal the complex interactions between war and AMR. War has a multifaceted impact on the health sector, especially in low- and middle-income countries [7].

Historical Conflicts and AMR Patterns

Amplified by damage to public health infrastructure and acute surges in the burden of disease, the unpredictability of conflict can shift patterns of antimicrobial use and considerably increase the spread of resistance [7]. A review of the literature indicates that war situations are associated with episodic amplification of resistance, a trend that continues to date [8]. Major conflicts in the Middle East, such as those in Afghanistan and Iraq, have been linked to significant increases in resistance among healthcare-associated pathogens, particularly Acinetobacter baumannii and Klebsiella pneumoniae. Systems of disease surveillance and antimicrobial-stewardship programmes, already impeded in some countries by war, may become even more constrained during major conflicts [2].

Contemporary Conflict Zones

The emergence and spread of antimicrobial resistance (AMR) are shaped by the context in which antibiotic misuse and mismanagement occur [6]. Armed conflicts create exceptional conditions that can influence the selection, dissemination, and loss of antimicrobial drugs, as well as the capacity to monitor resistance. Scientific literature indicates that conflict-driven mass displacement creates risk conditions for AMR transmission [5]. Such challenges necessitate the formulation of an appropriate response strategy. Besides, conflict-affected regions remain difficult to reach, particularly for research teams monitoring AMR [9]. Direct evidence documenting AMR emergence and spread in war settings can be limited. Therefore, it is valuable for the scientific community to engage in thought experiments and elaborate on AMR vulnerability in ongoing conflicts, such as those in Syria and Ukraine [4]. High levels of human mobility, particularly among forcibly displaced persons, increase AMR exposure and transmission risks, serving as a transmission precursor. The magnitude of forced displacements associated with the Syrian civil war, now over a decade old, has reached an estimated 15 million people [7]. Four million of these have been displaced outside national borders, with a significant portion remaining in neighbouring countries [11]. Accordingly, a coordinated international effort is essential to address AMR spread in these areas.

Armed conflicts worsen already-prevalent medical evacuations (e.g., due to other outbreaks, war, natural disasters) and encourage international humanitarian corridors for medicines and supplies [12]. The Ukraine conflict raised fresh concerns over AMR emergence, monitoring, and control due to heightened access to unregulated medical products. Emerging data indicate high resistance rates for war injury-associated bacterial strains much more resistant or extensively resistant, further complicating trauma-associated infectious disease treatment [8]. Current strategic reflections on monitoring, preventing, and controlling war-driven AMR merit continued support [1].

Public Health Consequences

Fifty years ago, the World Health Organization declared that "the future of mankind is seriously threatened by the spread of multiresistant pathogens," and estimates now suggest that antimicrobial resistance (AMR) could cause 10 million deaths annually by 2050 if current trends continue [10]. By reducing the effectiveness of antimicrobial agents, AMR complicates the treatment of infections, increases morbidity and mortality, lengthens hospital stays and healthcare costs, and can compromise the success of surgery and cancer chemotherapy [8]. In parallel with these developments, the world is witnessing increasing violence, armed conflict, and civil disruption. As military engagement may serve to amplify the spread of AMR, humanitarian disease outbreaks may occur in war-torn countries (or in their proximate neighbors), underscoring the need for collaborative global responses to rapidly expanding AMR [7].

Regional Transmission Risks

Conflict-affected areas face heightened regional transmission risk owing to expanded connectivity, protracted population displacements, and resultant opportunities for pathogen movement across diverse and vulnerable hosts [23]. Armed violence typically escalates population displacements from affected areas toward urban centres and border zones where transmission rates frequently rise, and into peripheral settings and neighbouring countries where such environments may prevail [20]. During the Syrian crisis, war-related population displacements initially increased AMR-associated infection burden among host communities in neighbouring countries, notably Lebanon and Jordan [2]. The same occurred within Iraq amid intense conflict between Federally-recognised and Kurdistan-based armed groups. Indeed, even regions largely unaffected by war-related violence have reported increases in AMR-associated infections coinciding with asylum-seeker influxes from conflict zones [3]. Tankers convey oil and other commodities across conflict-affected territories, and industrial sites occasionally continue to function. The burgeoning development and wide distribution of mobile telecommunications networks have considerably amplified the volume of information and goods exchanged throughout the Middle East region [9]. Populations routinely straddle town and village boundaries to acquire quotidian goods amid ongoing armed confrontations [11]. Current estimated per capita processes of bacteria release to the environment are very similar within major cities across Syria, Libya, and Yemen, yet considerable diversity in the overall environmental bacterial load exists. Such interlinkages underscore potential regional spillover beyond national confines, whereby the war in one country engenders biogeographical wage differentials in others [12].

Global Implications

Antimicrobial resistance (AMR) has been included in the World Health Organization (WHO) list of the ten most important global health issues. The increase in resistance to medications is particularly critical in underdeveloped and developing countries, where medicines are already limited, and inadequate health systems favor the emergence of multi-resistant strains [6]. Antimicrobial resistance (AMR) is the capability of a microorganism to resist the effects of a medication to which it was previously sensitive [13]. Therefore, the spread of AMR is a significant public health problem that is increasingly seen as a global threat. War has a noticeable impact on economies, society, and the environment, and the effects can last for decades after fighting ceases. The rise of AMR and emerging infectious diseases (EIDs) are two prolonged effect of warfare [14]. The disruption caused by armed conflict hinders a country's capacity to combat infectious diseases and maintain regulation over antimicrobial substances, significantly favouring the emergence of AMR, as well as resistance to vaccines [10]. A recent example analysed was the Syrian civil war, which started in 2011[2]. The country has recorded high prevalence rates for some organisms, around two-thirds of which are multidrug-resistant. The absence of surveillance data indicates that AMR is likely to be underestimated during both pre-conflict and post-conflict times [8]. The degree of decline in the system of surveillance, detection, and monitoring activities, as well as the reports during these periods, paralleled Lebanon's civil war and the Georgian territorial dispute. War is a hazard for the aggravation of AMR even for countries that have not experienced the ongoing armed violence [15]. Central and South Asian nations have encountered a widespread overuse of antimicrobials, and a notable uptick of antimicrobial-resistant tuberculosis occurs immediately after major upheavals [5].

Surveillance, Stewardship, and Response Strategies

Internal displacement and refugee flows inevitably lead to increased pressure on already overstretched health systems, especially in locations with limited sanitary installations and no access to permanent water points [12]. In these crucial circumstances, the risk for the spread of a resistant micro-organism population grows, even for parameters without significant endemicity in the region [10]. Antimicrobial resistance (AMR) dramatically increases the risks of sepsis following severe trauma, the development of secondary pneumonia in burn patients, and superinfections after blunt and penetrating trauma. AMR accompanies the transmission of infectious diseases. Due to this phenomenon, sepsis remains the major cause of death in trauma patients recovering after the acute phase [8]. Rapid access to pharmaceutical products in conflict and post-conflict environments is essential in many emergencies [4]. Previous epidemiological analysis of armed conflict identified chloramphenicol and ampicillin resistance due to unrestricted availability and unsuitable and incorrect use of these two key medicines [5].

Surveillance Infrastructure in Conflict-Affected Areas

Surveillance of antimicrobial resistance is a public health priority across many contexts, yet effective systems targeting these pathogens are notably lacking in conflict-affected areas and among forcibly displaced people [5]. The situation is aggravated by the absence of comprehensive antimicrobial use data, which further hampers the development of targeted interventions [7]. Research from conflict zones, including Iraq and Somalia, shows increased demand for and inappropriate use of antibiotics during crises, highlighting the need for crisis-specific guidance [4]. Existing evidence indicates numerous risk factors favouring the emergence, transmission, and spread of antimicrobial-resistant (AMR) pathogens in crisis settings. Conflict and security conditions undermine

the routine collection of AMR data, including urgent epidemiological investigations, complicating national and international decision-making and preparedness [13]. War and disasters often lead to population movements; when coupled with the absence of surveillance, the potential for rapid cross-border dissemination of AMR increases substantially [5].

Antimicrobial Stewardship in Crises

Antimicrobial resistance disproportionately affects fragile and conflict-affected settings, where weak health policies, disrupted supply chains, and limited knowledge among healthcare providers and users prevail [4]. During crises, increased infectious disease incidence leads to heightened antimicrobial requirements. Yet supply chain disruptions, stock-outs, and altered clinical workflows intensify AMP misuse and overuse [14]. Crises also shift pathogens, vectors, and transmission dynamics, as populations relocate from rural to urban areas, cross porous borders, or remain displaced within conflict zones. These environmental and behavioural changes alter upstream risk factors, influencing AMR patterns [15]. Antimicrobial stewardship in primary health care warrants urgent attention in conflict settings, where the majority of antibiotics are prescribed. Current humanitarian discussions focus on multidrug-resistant infections and stewardship requirements at secondary and tertiary care facilities, due to strong epidemiological data from those levels [8]. Emphasizing sector-specific requirements enhances global AMR management strategies during crises, mitigating adverse long-term effects on both upstream and downstream determinants [9].

Infection Prevention and Control

Civil war in Syria has caused the collapse of the health system and a severe increase in the burden of infectious diseases. These observations are consistent with a historical analysis of each country in the 20th century [3]. The need for effective surveillance and appropriate antimicrobial use in humanitarian crises has been recognized in Iraq, Zanzibar, and Yemen [15]. Infection prevention and control measures also need to be implemented to mitigate the spread of AMR [16].

Pharmaceutical Supply Chain Resilience

In specific crisis contexts, either a versatile supply of pharmaceuticals or the availability of alternative molecules may be necessary [13]. Recent crises 17 have highlighted the extreme vulnerabilities of pharmaceutical supply chains, particularly due to those instabilities existing outside the health sector. During the COVID-19 pandemic, centralized production and supply chains led to abrupt disruptions and widespread stock shortages [11]. Lebanon exemplifies the risk of physical disruption, as instability over several decades devastated medical infrastructure and manufacturing [14]. Consequently, fragile supply chains persisted, maintained by institutions engaged in national health systems strengthening and stock management [10]. Crises influence the pharmaceutical supply chain in several ways: regulatory exemptions and substandard products may enter systems under pressure to dispense; leaked strategic planning may trigger preemptive stocking of antimicrobials; border closures cut imports; fuel scarcities disrupt power, transport, and handling; and staff shortages hinder distribution [4]. Access to antimicrobials subsequently dwindles, prompting inappropriate prescribing and self-medication with whatever remains available [5].

Policy and Ethical Considerations

Antimicrobial resistance (AMR) can be aggravated by warfare and disrupted healthcare systems, posing significant public health challenges [18]. The consequent ethical and policy implications are numerous. Preventing conflict-related AMR burdens calls for renewed political commitment to safeguard health in war-torn regions [19]. The notion of AMR as a serious threat under the 'one health' surveillance angle raises public health questions, e.g., prioritisation, resource allocation, and political stability [20]. The 'responsibility to protect' civilian populations vulnerable to political violence expected humanitarian assistance from war-afflicted nations. Addressing AMR demands urgent research into epidemic pandemic interactions, with emphasis on the historical role of warfare [17]. The immediate reinforcement of health systems by antimicrobial stewardship plans can foster existing health infrastructures and assist in post-crisis rebuilding [5]. Preventing, alleviating, and resolving armed conflict constitutes the priority. The recuperation of public health amidst instability still nuances intervention choice. Permits for re-establishment through others arise from fulfilling periodic gifting within health systems [14]. Occupiers are called to attend such requests if removal induces further deterioration. Suggesting prevention measures fails to accommodate every circumstance [15]. Formal power recognises no absolute prescription; moreover, the universality of every authority vis-à-vis AMR prevention remains unclear. Only consideration of worldwide concerns counteracts specificism; nonetheless, predominant health structures largely comply with the UN Sustainable Development Goals and 'systems approach' reinterpretation [15]. Political–epidemiological engagement and coordination beyond STAG–AMR illustrative of Arm-Tie/Cat-Bark bidirectionality could avert AMR aggravation [16]. Conflict can gravely impair health systems and render contextual remedies ineffectual, particularly with dormant patterns stabilising at different abrasive rates. Such scenarios dictate targeted intervention analyses and limit multi-contextual study; unchanged agents and modes preclude supplementary

options [17]. Post-consideration legislative exigencies still adhere broadly thanks to common epidemic topology. Within unambiguous policies, prescription becomes synonym to law, transposing from personal individual prohibition, through collective conjoint omission towards public maintaining capacity outline [11]. AMR awareness has risen and favours prioritisation within health sectors. Beyond prescriptions, societal freedom retains significance. Passive laws shielding frontline inputs while formal power maintains policy remain worthwhile. Amid condition-fired adherence propagation remains feasible via consistent passive laws while pre-existing collective commitment mitigates operational constraints [13]. Examples where health must remain sovereign indicate the core of conflict punishment. Immediate stewardship precludes pernicious long-term regimes incentivising withholding; nevertheless, priority continues to hinge upon armed-campaign prevention, justifying preservation of political epidemiological parallelism [9]. Policies voluntary with shareable values never constitute censorship [8].

Humanitarian Law and Health Obligations

The literature on antimicrobial resistance (AMR) suggests that the responsibility of states to provide adequate health care during conflicts or crises has become more tenuous and complicated due to the increasingly diverse and sophisticated nature of armed groups engaged in humanitarian law violations [11]. When AMR is viewed as a global public good, it strengthens the argument for collective-based approaches to combating AMR in fragile and crisis-affected countries [5]. Because entrants to global regulatory governance systems are socialized to comply with such systems as a condition for continued participation, increasing the role of the global health governance system enhanced by international law in combating AMR in fragile and crisis-affected countries is one viable approach [3]. Humanitarian law contains provisions regulating the provision of health care, including specifically the protection of health facilities and personnel, which increases the force of the obligation and renders a collective-based governance approach more tractable [10]. Safe, efficient, effective, and widely available vaccines to protect against AMR-associated pathogens are lacking in fragile and crisis-affected countries under the current dominant economic model [4]. The current rates of pathogen diversity in crisis-affected populations, coupled with near non-existent access to pathogenic organism control technologies such as vaccines, imply that both a theoretical mental model for AMR spread and a thorough situation analysis for the concerned country are required. The extant literature is insufficient to identify a workable economic solution [18].

Resource Allocation and Equity

The allocation of scarce resources during armed conflict raises fundamental questions of equity. Equality in resource allocation is widely acknowledged as a desirable principle [13]. However, the principle of fair allocation among people with different needs, levels of vulnerability, or other characteristics may arguably be preferable in the context of violent conflicts, given the disruption they cause to healthcare infrastructures and the consequent increases in mortality, morbidity, and hardship. The question remains unsettled, however, and perspectives among the international public health community differ [12]. Some advocate that responsibility for equity principles should reflect factors such as need or level of vulnerability, especially when the deterioration of services reaches extreme levels. Others suggest that the pursuit of an equitable principle must give way to more equal redistributions, where the destruction of public health capacity violates basic locus of control rights [20]. Humanitarian law requires states and armed non-state actors to take measures against disease proliferation; putting equity ahead of equality could violate such obligations. As military action in Ukraine increases, arguments intensifying for and against the prioritization of equity versus equality in health systems may gain momentum [21]. Experience reveals how and why particular equity principles can be invoked in wartime governance. Safety, security, and the avoidance of acute danger provide deep justifications for such approaches; yet humanitarian disaster and chronic generalized misery also create conditions justifying equity-based reallocation [23]. Today, Ukraine itself offers acute collective degree criteria relevant to violent conflict, while contemporaneous circumstances in Afghanistan demonstrate circumstances under which such allocation may not be considered applicable. Pressing issues thus emerge as arguments for and against competing principles intensify [17].

Global Health Governance

The interconnectedness of contemporary global society challenges the principles underpinning sovereign authority [6]. Limitations on one state's capability to enforce law, protect its citizens, or assure public order put people at risk of illness, violence, and poverty. As the submission of a state to aggressive takeover proceeds, the welfare of the population that remains within its borders declines significantly [20]. Health deterioration becomes evident in statutory reporting, where indicators in the parameters of life expectancy, infant mortality, and sanitation, active protection from disease, and access to medical services fall below levels satisfying humanitarian norms [18]. Yet other forms of measurement are set at far greater risk in such contexts than under conditions of "normal" state failure [19]. Antimicrobial resistance (AMR) ranks high on the international public health agenda, given the inevitable evolution of pathogens even in the most scrupulously undertaken chemotherapy regimens [3]. Transmission depends primarily on two factors: the potential for contagion embodied in the pathogen and its environment, combined with opportunities for or impediments to contact between host vectors [2]. Aggressive

armed conflict has marked effects on the epidemiology of infection and dissemination of AMR, correlated positively with governmental failure, while remaining agnostic on the relative merits of national or international authority to re-establish the public health order[20]. Certain standards of international humanitarian law delineate states' obligations to ensure the ongoing fulfillment of basic sanitation and public health needs in the wake of warfare [5]. Adhering to these regulations is bound to enhance public health wellbeing in multiple dimensions, including AMR. These systems are severely impacted by armed confrontation [23]. Once attacked, they can be monitored, and specific treatment regimens can be selected for acute needs. In agglomerations of conflicting parties, woe for one group amplifies the satisfactions of others via astray channels [26]. With shares of human populations already exceeding 30%, further escalation of services fractures mass dying, thus facilitating the establishment of ventilation gaps among protracted recovery phases [24]. Deterrents strengthen collection and resources reduce further during such cycles due to the sagging national economy, hence averting damp conditions [7]. Strengthening Global Health Governance is essential to ameliorate these connected dilemmas [25]. Effective mitigation of AMR accumulation and effective responses to emerging AMR threats demand renewed international efforts, including the development of new international legal frameworks to underpin collaborative, intergovernmental, and multi-sectoral responses [3]. Global health governance focuses on the governance of, and across governance systems for, cooperation to protect and promote health; this system also relates to interdependencies of countries connected with sickness, health, and wellbeing, an entry point or lever for engagement. Cooperation and action must therefore be broadened, both amongst global health governance actors and across multiple policy spheres. Global Public Health Governance remain underexploited domain to implement, operationalise, and diffuse these emerging international activities and business models [22].

Research Gaps and Future Directions

Complex challenges remain in addressing antimicrobial resistance in cases of armed conflict. Consistent, timely surveillance for all the necessary information cannot happen without some degree of peace established at a minimum [20]. Existence of AMR, reports of use or misuse of antimicrobials, changes in patterns of resistance, and emergence of new resistance mechanisms. Many of these reports come from a limited number of countries, mostly in Europe or North America [23]. Even if international conflict affects only a small portion of a country, when it comes to antimicrobial-resistant patterns, regulation and progress slow because crucial information and intelligence must remain concealed for security purposes [22-36]. The consideration of applying a research framework underlines the need for continual observation and understanding of AMR trends in scenarios of armed conflict 24. In each scenario of persistent unrest, whether localized or national, a thorough comprehension of the state of AMR can either already be underway or designed for future implementation [20].

CONCLUSION

Armed conflicts create unique and severe conditions that accelerate the emergence and spread of antimicrobial resistance, posing immediate and long-term threats to public health locally, regionally, and globally. Disrupted healthcare systems, mass displacement, unregulated antimicrobial use, and compromised infection prevention and control measures converge to amplify AMR transmission, while post-conflict settings often continue to experience heightened resistance burdens. Addressing conflict-driven AMR requires a multifaceted approach, integrating surveillance, stewardship, infection control, pharmaceutical supply resilience, and targeted public health interventions. Ethical and equitable resource allocation, guided by humanitarian law, remains critical to protecting vulnerable populations in crisis contexts. Strengthening global health governance and fostering coordinated international cooperation are necessary to implement sustainable strategies, prevent cross-border transmission, and support the rebuilding of resilient health systems. Ultimately, mitigating war-related AMR demands proactive policy planning, context-specific interventions, and robust international collaboration to safeguard public health and curb the global threat posed by resistant pathogens.

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