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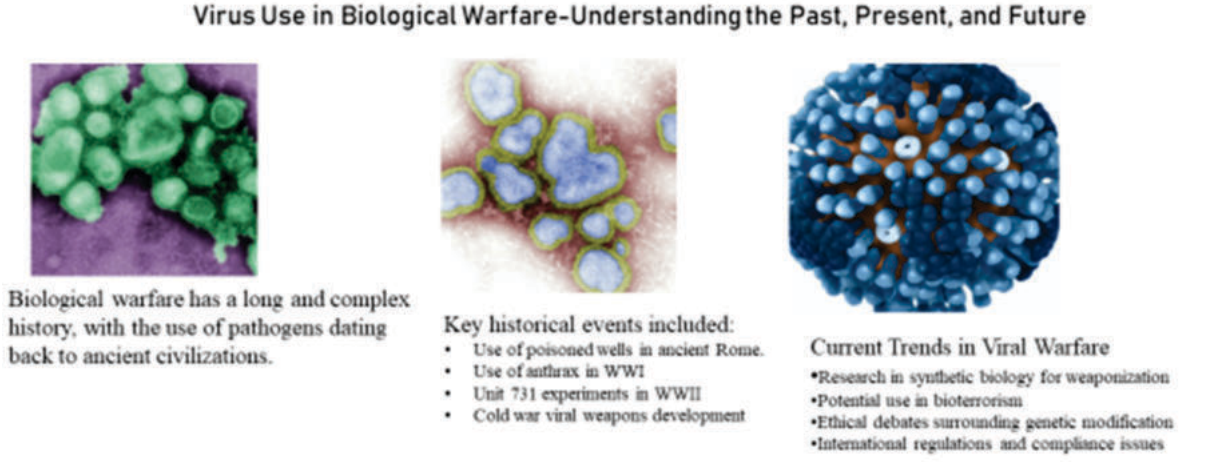
VIRUS USE IN BIOLOGICAL WARFARE - A REVIEW OF THE PAST, PRESENT AND FUTURE

Public Health

Dr. Aditi Munmun Sengupta Eastern Michigan University (Department of Chemistry), Harvard Medical School Post Graduate Assocition Member, University of Calcutta, India

ABSTRACT

The utilization of viruses in biological warfare represents a complex and increasingly relevant concern in global security and public health domains. This review explores the history, mechanisms, and potential consequences of deploying viral agents as weapons. Historically, the use of biological agents dates back centuries, but the modern understanding of virology has enabled the development of increasingly sophisticated strategies for warfare. Viruses, due to their stealthy nature and ability to replicate within host organisms, pose unique challenges in detection and containment. This review examines key viral agents historically associated with biological warfare, including their transmission dynamics and potential for causing large-scale outbreaks. The implications of viral warfare extend beyond immediate health risks; they encompass ethical, legal, and psychological dimensions. The potential for widespread panic, disruption of societal functions, and international conflict necessitates robust frameworks for prevention, response, and ethical considerations in the face of these threats. In conclusion, as the landscape of biological warfare evolves with advancements in biotechnology, the implications of virus use become increasingly pronounced. It is crucial for policymakers, scientists, and military strategists to engage in informed discussions to mitigate risks associated with viral agents in warfare, ensuring that preparedness and response mechanisms can effectively address potential threats. This review serves as a foundational piece for further exploration of the intricate relationship between viruses and biological warfare, highlighting the urgent need for collaborative efforts in research, policy development, and public health preparedness.



KEYWORDS

Virus, Biological Warfare, Ethics, Biosafety, Public Policy

INTRODUCTION

The exploration of viruses as instruments of biological warfare has been a topic of considerable ethical, military, and scientific debate for many years (1). This review seeks to illuminate the historical context of viral agents employed in warfare, tracing the development of biological weapons programs from their inception to the present day and the vulnerabilities in the future. The use of biological agents, including viruses, can be traced back to ancient civilizations, where tactics such as contaminating water supplies with pathogens were employed to weaken enemy forces (2). As scientific understanding of microbiology advanced, particularly in the 20th century, nations began to formalize their biological warfare programs, leading to the development of more sophisticated viral agents designed for specific military objectives (1). This historical perspective is crucial for understanding how past practices have shaped current policies and attitudes toward biological warfare.

In addition to examining historical precedents, this review will also delve into the broader implications of these practices for contemporary society. The potential risks associated with the use of viral agents in conflict are manifold, ranging from the unintended consequences of widespread outbreaks to the ethical dilemmas posed by targeting civilian populations. The dual-use nature of biological research—where scientific advancements can be applied for both beneficial and harmful purposes—raises significant concerns about the regulation and oversight of such research. As nations grapple with the realities of modern warfare, the ethical considerations surrounding the deployment of biological agents become increasingly pressing, necessitating a careful evaluation of the moral responsibilities of scientists and military leaders alike (3).

By analyzing past instances and current trends, this overview aims to foster a deeper understanding of the complexities surrounding the intersection of virology and warfare (4). The historical context provides valuable lessons that can inform contemporary discussions about the responsible use of biological research in military applications. As we navigate an era marked by rapid advancements in biotechnology and an evolving landscape of global conflict, it is imperative to engage in thoughtful discourse about the implications of utilizing viral agents as weapons. Ultimately, this review seeks to

contribute to the ongoing dialogue on how to balance national security interests with ethical considerations, ensuring that the lessons of the past guide us toward a more responsible and humane approach to biological research and its potential military applications (5).

Historical Context

The utilization of viruses in biological warfare has a complex history that spans from early instances to contemporary concerns. Historically, various nations have explored the potential of viral agents as tools for warfare, recognizing their ability to cause widespread illness and disruption (6). In recent years, advancements in biotechnology and an increased understanding of viral mechanisms have raised alarms about the potential for engineered viruses to be weaponized (7). The current analysis of the development of viral applications within military settings is crucial, as it underscores both historical examples and contemporary ramifications. This examination must also stress the importance of implementing strict regulations and ethical guidelines to address the potential risks posed by emerging biological threats.

Early Instances

In ancient Rome, the strategic use of poisoned wells emerged as a particularly insidious form of bioterrorism, reflecting the darker aspects of warfare and political intrigue that characterized the era. This method involved the deliberate contamination of water sources, a tactic designed to incapacitate or eliminate adversaries without the need for direct confrontation. By targeting a fundamental resource like water, which was essential for survival, the perpetrators showcased a calculated approach to undermining enemy forces. The act of poisoning wells was not merely a physical assault; it was a psychological weapon that instilled fear and uncertainty among populations. The knowledge that their very lifeblood could be tainted by an unseen enemy created an atmosphere of paranoia and distrust, eroding the social fabric of communities and destabilizing political structures. In this way, poisoned wells became a symbol of the ruthless strategies employed in the relentless quest for power, highlighting the intersection of fear, control, and the darker impulses of human nature in the annals of history (2).

Historical accounts from the Middle Ages reveal a grim and strategic aspect of warfare: the use of biological tactics to weaken enemy forces. During sieges, besieging armies would often resort to launching corpses infected with diseases over the walls of cities under siege. This macabre practice was rooted in the understanding that contagion could spread through the air and water, and the hope was that the introduction of decaying bodies would instill fear and panic among the inhabitants while simultaneously propagating illness within their ranks. The psychological impact of such tactics was profound; not only did it serve to demoralize the defenders, but it also created an atmosphere of dread and uncertainty. As the bodies decomposed, the stench would permeate the air, further exacerbating the already dire conditions within the besieged city. Food and water supplies would become contaminated, leading to a rapid decline in the health of the population. This strategy highlights the lengths to which medieval armies would go to achieve victory, often prioritizing the spread of disease over direct confrontation. Moreover, these accounts underscore a broader understanding of warfare during this period, where the lines between military strategy and biological warfare were blurred. The use of infected corpses was not merely a tactic of desperation; it was a calculated move that reflected a sophisticated grasp of the interplay between health, morale, and military effectiveness. As such, these historical practices serve as a chilling reminder of the brutal realities of medieval conflict and the lengths to which humans have gone in the pursuit of power and control (8).

The utilization of viruses in biological warfare can be traced back to several early instances that highlight the strategic application of pathogens as weapons. One notable example occurred during World War I, when German forces allegedly employed anthrax and slanders to infect livestock, thereby crippling the food supply of their adversaries. This tactic underscored the potential of biological agents to disrupt not only military operations but also civilian life by targeting agricultural resources. By infecting animals that were crucial for food production, the German military aimed to weaken the morale and resilience of enemy populations, illustrating a calculated approach to warfare that extended beyond conventional combat. The implications of such actions were profound, as they revealed how biological agents could be wielded to create chaos and suffering, affecting not just soldiers on the battlefield but also innocent civilians reliant on those agricultural systems (9).

The historical precedents set by these instances serve as a stark reminder of the lethal potential inherent in biological warfare, prompting ongoing debates about regulation and the moral implications of employing viruses as instruments of war. As nations grapple with the advancements in biotechnology and the potential for misuse, the lessons learned from past conflicts underscore the urgent need for international agreements and ethical frameworks to govern the use of biological agents. The haunting legacy of these early instances of biological warfare not only informs current military strategies but also compels society to confront the darker aspects of human ingenuity and the responsibilities that come with it. In an age where the threat of bioweapons looms larger than ever, the historical context of their use serves as both a warning and a call to action for global cooperation in preventing future atrocities (1,10).

World War II and Beyond

During World War II, numerous countries undertook significant research initiatives focused on biological warfare, particularly in the realm of viral agents. The war catalyzed a surge in interest surrounding the potential use of biological weapons, as nations sought to gain any possible advantage over their adversaries. A particularly notorious example of this dark chapter in history was Japan's Unit 731, a covert biological and chemical warfare research facility that operated under the guise of a medical unit. This unit conducted inhumane experiments on human subjects, including prisoners of war and civilians, to explore the potential of biological weapons. The horrific experiments included exposure to deadly pathogens, such as those responsible for the plague and anthrax, as researchers sought to weaponize these viruses. The actions of Unit 731 not only highlighted the extreme lengths to which nations would go in their pursuit of biological superiority but also raised profound ethical questions that resonate to this day regarding the limits of scientific inquiry in times of conflict (11).

In the aftermath of World War II, the onset of the Cold War marked a further intensification of biological weapons programs, as both the United States and the Soviet Union allocated considerable resources to research and development in this field. The geopolitical landscape of the time fostered an environment of suspicion and competition, leading to a race to enhance capabilities in biological warfare. Both superpowers invested heavily in the study of various viruses, seeking to understand their potential for use as weapons (12). This period was characterized by a relentless pursuit of knowledge and technological advancement, with scientists working under the pressure of national security concerns. The implications of this research were profound, as it not only reflected the broader geopolitical tensions of the time but also raised significant ethical dilemmas regarding the use of science for destructive purposes (13). The legacy of these initiatives continues to influence contemporary discussions about bioethics, international law, and the need for stringent regulations to prevent the misuse of biological research (14).

Modern Developments

Biological warfare has historically employed various viruses as agents of infection and disease. Notable examples include the use of the smallpox virus(15), which was deliberately spread among indigenous populations during colonial conflicts, and the Ebola virus (16), which has been speculated to be weaponized in certain geopolitical contexts. Additionally, the manipulation of the influenza virus (17) has raised concerns regarding its potential use in bioterrorism (10). These instances highlight the ethical and humanitarian implications of utilizing viral agents in warfare, underscoring the need for stringent regulations and international cooperation to prevent such practices (18).

In recent years, the landscape of biological warfare has evolved in an ultramodern way. The emergence of synthetic biology raises new concerns regarding the potential creation of novel viral agents that could be used with malicious intent. Advances in genetic engineering have made it easier to manipulate viruses, which not only heightens the risk of their use in warfare but also complicates detection and prevention efforts (19).

The Dilemma of Covid-19

The intersection of the COVID-19 pandemic and the concept of biological warfare presents a complex and multifaceted dilemma that has garnered significant attention from scholars, policymakers, and the public alike. As the world grappled with the unprecedented challenges posed by the virus, questions arose regarding its origins, with some speculating about the potential for it to be a product of deliberate

manipulation or release as a bioweapon (20). This speculation has not only fueled debates about the virus's origins but has also ignited discussions surrounding global biosecurity. The notion that a pathogen could be engineered or weaponized raises critical ethical implications regarding scientific research and the responsibilities of nations to prevent the misuse of biological agents. Scholars and ethicists are now calling for a reevaluation of existing frameworks governing biological research, emphasizing the need for stringent oversight and transparency to mitigate the risks associated with dual-use research—where scientific advancements can be applied for both beneficial and harmful purposes (18).

Moreover, the pandemic has starkly highlighted vulnerabilities in public health systems worldwide, revealing gaps in preparedness and response capabilities that have left many nations ill-equipped to handle such crises. The rapid spread of COVID-19 underscored the interconnectedness of global health, as the virus transcended borders and overwhelmed healthcare infrastructures. In this context, the need for robust international cooperation has never been more apparent. Countries must work collaboratively to strengthen their public health systems, share critical data, and develop coordinated response strategies that address not only natural outbreaks but also the looming threats posed by bioterrorism. The lessons learned from the COVID-19 experience may serve as a critical foundation for future preparedness, prompting nations to invest in research, surveillance, and rapid response mechanisms that can effectively counter both natural and engineered biological threats (21).

As nations strive to enhance their preparedness and response capabilities, the COVID-19 pandemic has catalyzed a broader discourse on the ethical and strategic dimensions of biological research and warfare. Policymakers are increasingly recognizing the importance of establishing comprehensive strategies that encompass not only immediate health responses but also long-term biosecurity measures. This includes fostering international agreements that regulate the development and use of biological agents, ensuring that scientific advancements are harnessed for the greater good rather than for malicious purposes. Ultimately, the intersection of the pandemic and biological warfare challenges us to rethink our approach to global health security, urging a proactive stance that prioritizes collaboration, ethical research practices, and a commitment to safeguarding humanity against both natural and engineered biological threats in the future (22).

The Future of Bioterrorism

The potential use of viruses in biological warfare raises significant concerns for the future, as the implications of such actions could be catastrophic on multiple levels. With the rapid advancements in biotechnology, the ability to engineer pathogens has transitioned from the realm of science fiction to a tangible reality. This evolution not only enhances our understanding of viruses but also increases the risk that these engineered agents could be weaponized. The prospect of intentionally released viral agents poses a dual threat: it jeopardizes national security by creating new avenues for conflict and aggression, while simultaneously challenging global health systems that may be ill-prepared to respond to such unprecedented outbreaks (19,22)

The rapid spread of engineered viruses could lead to widespread devastation, overwhelming healthcare infrastructures and causing significant loss of life. In a world that is already grappling with the effects of natural pandemics, the introduction of a deliberately released pathogen could exacerbate existing vulnerabilities, leading to chaos and panic. The interconnectedness of our global society means that a viral outbreak in one region can quickly escalate into a worldwide crisis, highlighting the urgent need for comprehensive preparedness and response strategies (22).

CRISPR and gene editing technologies represent a dual-edged sword in the realm of bioterrorism, particularly when their potential applications with viruses are considered. On one hand, these groundbreaking advancements hold the promise of remarkable medical breakthroughs, including the rapid development of vaccines and targeted treatments for a wide array of diseases. For instance, CRISPR has already been instrumental in accelerating research into genetic disorders and infectious diseases, allowing scientists to create more effective therapies and preventive measures. The ability to edit genes with unprecedented precision opens new avenues for combating health crises, potentially saving countless lives and improving global health outcomes. Conversely, the very tools that empower researchers to make these life-saving advancements can also be misappropriated to engineer harmful pathogens. The prospect of creating virulent strains of viruses or bacteria poses significant ethical and security concerns, as the misuse of such technologies could lead to catastrophic consequences. The potential for bioterrorism is heightened by the accessibility of CRISPR technology; it is no longer confined to well-funded laboratories but is increasingly available to individuals and groups with malicious intent. This democratization of powerful genetic tools amplifies the urgency for stringent regulations and oversight to mitigate the risks associated with their misuse (23).

To navigate this complex landscape, it is essential to strike a balance between fostering responsible scientific innovation and implementing robust safeguards against bioterrorism. Policymakers, scientists, and ethicists must collaborate to establish comprehensive frameworks that govern the use of gene editing technologies. These frameworks should include rigorous screening processes for research proposals, enhanced security measures for laboratories, and international agreements to prevent the proliferation of dangerous genetic engineering techniques (19). By prioritizing ethical considerations and security protocols, society can harness the transformative potential of CRISPR and gene editing while minimizing the risks associated with their misuse. Ultimately, the goal should be to ensure that these powerful tools are used to enhance human health and well-being, rather than to threaten it (24).

The integration of artificial intelligence in the realm of bioterrorism, particularly concerning viral agents, presents both significant challenges and opportunities. AI technologies can enhance the detection and analysis of viral threats, enabling rapid identification of potential bioterrorism incidents. By leveraging machine learning algorithms, researchers can analyze vast datasets to predict viral mutations and assess their potential for weaponization. Furthermore, AI can aid in the development of countermeasures, such as vaccines and antiviral drugs, by simulating interactions between pathogens and human biology. However, the same technologies that bolster defense mechanisms can also be exploited by malicious actors to design more effective biological weapons, underscoring the need for robust ethical guidelines and regulatory frameworks to mitigate risks associated with AI in this sensitive area (25).

Bioweapons Treaties and Global Responses

Bioweapons treaties play a crucial role in shaping global responses to the ever-looming threat of biological warfare. These agreements, such as the Biological Weapons Convention (BWC) in 1972, are designed to prevent the development, production, and stockpiling of biological weapons, thereby fostering a framework of international cooperation and accountability. By establishing clear norms and expectations, these treaties not only deter nations from engaging in bioweapons programs but also promote a culture of transparency and trust among signatory states. This collaborative spirit is essential, as the potential for biological agents to cause widespread harm transcends national borders, necessitating a unified global response (26).

Countries participating in these treaties are encouraged to enhance their surveillance and response capabilities to biological threats, which is vital for ensuring a collective approach to public health and security. This includes investing in research and development of rapid detection technologies, improving laboratory capacities, and establishing effective communication channels for sharing information about potential biological threats. By strengthening these capabilities, nations can better prepare for and respond to outbreaks, whether they arise naturally or as a result of malicious intent. Furthermore, the emphasis on collaboration extends to sharing best practices and resources, which can significantly bolster the global health infrastructure (27).

The effectiveness of these treaties, however, relies heavily on robust verification mechanisms and the unwavering commitment of nations to uphold their obligations. Verification processes, such as regular inspections and reporting requirements, are essential for ensuring compliance and building confidence among states. Without these mechanisms, the risk of non-compliance increases, potentially undermining the entire framework of the treaty. Therefore, it is imperative that nations not only commit to the principles outlined in these agreements but also actively engage in efforts to strengthen and refine verification processes. By doing so, they contribute to a safer global environment, where the threat of biological warfare is significantly diminished, and public health is prioritized. Ultimately,

the success of bioweapons treaties hinges on the collective will of the international community to work together in safeguarding humanity from the devastating consequences of biological conflict. By fostering a culture of responsibility and vigilance, we can work towards mitigating the risks associated with viral warfare and safeguarding the future of global health and security (28).

Ethical Considerations

The use of viruses in military operations presents profound ethical challenges that warrant careful consideration and debate. At the core of this issue lies the potential for significant harm to civilian populations, as the deployment of biological agents can lead to uncontrollable outbreaks and unintended consequences. Unlike conventional weapons, which are designed to target specific military objectives, viruses can spread indiscriminately, affecting not only enemy combatants but also innocent bystanders, including vulnerable groups such as children and the elderly. This raises critical questions about the moral responsibility of military leaders and governments in ensuring that their actions do not violate the principles of proportionality and distinction, which are fundamental to international humanitarian law (29).

Moreover, the use of viruses in warfare can lead to long-term ecological and health repercussions that extend far beyond the immediate conflict. The introduction of a virus into a population can disrupt local ecosystems, lead to the emergence of new pathogens, and create a public health crisis that may persist for generations. This potential for collateral damage complicates the ethical landscape, as military strategists must weigh the short-term tactical advantages against the long-term consequences for both the environment and human health. Additionally, the possibility of bioweapons falling into the hands of rogue states or non-state actors further exacerbates these ethical dilemmas, as it raises concerns about accountability and the potential for misuse.

Furthermore, the psychological impact on both military personnel and civilian populations cannot be overlooked. The knowledge that a virus could be used as a weapon may instill fear and anxiety, leading to a breakdown of trust within communities and between nations. This fear can have a destabilizing effect, potentially inciting panic and social unrest, which can hinder humanitarian efforts and exacerbate the suffering of those caught in the crossfire. As such, the ethical implications of using viruses in military operations extend beyond the battlefield, influencing societal dynamics and international relations in profound ways (30).

In light of these complexities, it is essential for policymakers, military leaders, and ethicists to engage in open dialogue about the implications of bioweapons. Establishing clear guidelines and international agreements regarding the use of viruses in warfare is crucial to prevent their misuse and to protect human rights. Ultimately, the ethical challenges posed by the use of viruses in military operations demand a nuanced approach that prioritizes the preservation of life and the promotion of peace, ensuring that the lessons of history are not forgotten in the pursuit of military objectives (31).

The potential utilization of viruses in warfare raises significant ethical dilemmas. The indiscriminate nature of viral infections, which can affect both combatants and civilians, necessitates urgent dialogue regarding the morality of such weapons. Furthermore, the possibility of accidental releases during warfare or research highlights the need for stringent safety measures and international cooperation (32).

CONCLUSION

The examination of both historical and contemporary applications of viruses in biological warfare highlights the ongoing danger these agents represent. As advancements in scientific research continue to unfold, it is crucial for the international community to maintain a proactive stance in overseeing progress within the field of biological studies. This vigilance is essential not only for understanding the potential implications of emerging viral technologies but also for reinforcing global commitments to international agreements designed to prevent the misuse of such agents. By fostering collaboration and transparency among nations, the global community can better safeguard against the threats posed by biological warfare, ensuring that scientific innovation is directed towards beneficial outcomes rather than destructive applications (33).

Future initiatives should not only concentrate on the enforcement of the Biological Weapons Convention (BWC) but also emphasize the importance of advancing research that prioritizes public health and safety over military uses. This dual approach is essential, as it allows for the development of scientific knowledge and technologies that can effectively address health crises without contributing to the potential for biological warfare. By fostering a collaborative environment among nations, researchers, and public health organizations, we can work together to reduce the threats posed by viruses and other pathogens that could be weaponized. Collective action is crucial in this endeavor, as it enables the sharing of resources, expertise, and best practices, ultimately leading to a more robust global response to the challenges posed by biological threats (26,33)

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REFERENCES

1. Riedel S. (2004). Biological warfare and bioterrorism: a historical review. Proceedings (Baylor University. Medical Center), 17(4), 400–406. https://doi.org/10.1080/08998280.2004.11928002
2. Rathish B, Pillay R, Wilson A, et al. Comprehensive Review of Bioterrorism. [Updated 2023 Mar 27]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK570614/
3. NATIONAL ETHICAL GUIDELINES FOR RESEARCH INVOLVING HUMAN PARTICIPANTS. PHREB Resolution No. 002 Series of 2022. URL: https://www.pchrd.dost.gov.ph/wp-content/uploads/2023/05/2022-NEGRIHP_Official-Gazatte_Ver-5-1.pdf (accessed 05.09.2025)
4. Sanyal S. (2023). Crossroads in virology: current challenges and future perspectives in the age of emerging viruses. Disease models & mechanisms, 16(10), dmm050476. https://doi.org/10.1242/dmm.050476
5. National Research Council (US) Committee on Opportunities in Biotechnology for Future Army Applications. Opportunities in Biotechnology for Future Army Applications. Washington (DC): National Academies Press (US); 2001. 2, Biotechnology and the Army. Available from: https://www.ncbi.nlm.nih.gov/books/NBK207444/
6. Rathish B, Pillay R, Wilson A, et al. Comprehensive Review of Bioterrorism. [Updated 2023 Mar 27]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK570614/
7. Giese B. (2021). The viral era: New biotechnologies give humans an unprecedented control over Nature and require appropriate safeguards. EMBO reports, 22(9), e53229. https://doi.org/10.15252/embr.202153229
8. Cartwright, M. (2018, May 24). . World History Encyclopedia. Retrieved from https://www.worldhistory.org/article/1230/siege-warfare-in-medieval-europe/
9. Nikolakakis, I., Michaleas, S. N., Panayiotakopoulos, G., Papaioannou, T. G., & Karamanou, M. (2024). Instances of Biowarfare in World War I (1914-1918). Cureus, 16(4), e59329. https://doi.org/10.7759/cureus.59329
10. Frischknecht F. (2003). The history of biological warfare. Human experimentation, modern nightmares and lone madmen in the twentieth century. EMBO reports, 4 Spec No(Suppl 1), S47–S52. https://doi.org/10.1038/sj.embor.embor849
11. Heirbaut, J. M. F., & van Bronswijk, J. E. M. H. (2002). Unit 731. Technische Universiteit Eindhoven.
12. Guillemin J. (2006). Scientists and the history of biological weapons. A brief historical overview of the development of biological weapons in the twentieth century. EMBO reports, 7 Spec No(Spec No), S45–S49. https://doi.org/10.1038/sj.embor.7400689
13. Gonsalves Ty.(2020) How the Cold War Shaped Science and Technology Today. Science, Technology, and Society, A Colby Community Website for ST112, Fall 2020
14. Oeschger, F. M., & Jenal, U. (2018). Addressing the Misuse Potential of Life Science Research-Perspectives From a Bottom-Up Initiative in Switzerland. Frontiers in bioengineering and biotechnology, 6, 38. https://doi.org/10.3389/fbioe.2018.00038
15. Riedel S. (2005). Smallpox and biological warfare: a disease revisited. Proceedings (Baylor University. Medical Center), 18(1), 13–20. https://doi.org/10.1080/08998280.2005.11928026
16. Cenciarelli, O., Gabbarini, V., Pietropaoli, S., Malizia, A., Tamburrini, A., Ludovici, G. M., ... & Gaudio, P. (2015). Viral bioterrorism: Learning the lesson of Ebola virus in West Africa 2013–2015. Virus research, 210, 318-326.
17. Madjid, M., Lillibridge, S., Mirhaji, P., & Casscells, W. (2003). Influenza as a bioweapon. Journal of the Royal Society of Medicine, 96(7), 345–346. https://doi.org/10.1177/014107680309600709
18. Somerville, Margaret & Atlas, Ronald. (2005). ETHICS: Ethics: A Weapon to Counter Bioterrorism. Science (New York, N.Y.). 307. 1881-2. 10.1126/science.1109279.
19. Trump BD, Florin MV, Perkins E, et al. Biosecurity for Synthetic Biology and Emerging Biotechnologies: Critical Challenges for Governance. 2021 Sep 8. In: Trump BD, Florin MV, Perkins E, et al., editors. Emerging Threats of Synthetic Biology and Biotechnology: Addressing Security and Resilience Issues [Internet]. Dordrecht (DE): Springer; 2021. Chapter 1. Available from: https://www.ncbi.nlm.nih.gov/books/NBK584259/ doi: 10.1007/978-94-024-2086-9_1
20. Knight D. (2021). COVID-19 Pandemic Origins: Bioweapons and the History of Laboratory Leaks. Southern medical journal, 114(8), 465–467. https://doi.org/10.14423/SMJ.0000000000001283
21. Filip, R., Gheorghita Puscaselu, R., Anchidin-Norocel, L., Dimian, M., & Savage, W. K. (2022). Global Challenges to Public Health Care Systems during the COVID-19 Pandemic: A Review of Pandemic Measures and Problems. Journal of personalized medicine, 12(8), 1295. https://doi.org/10.3390/jpm12081295
22. Song, P., Adeloye, D., Acharya, Y., Bojude, D. A., Ali, S., Alibudbud, R., Bastien, S., Becerra-Posada, F., Berecki, M., Bodomo, A., Borrescio-Higa, F., Buchtova, M., Campbell, H., Chan, K. Y., Cheema, S., Chopra, M., Cipta, D. A., Castro, L. D., Ganasegeran, K., Gebre, T., … International Society of Global Health (ISoGH) (2024). Setting research priorities for global pandemic preparedness: An international consensus and comparison with ChatGPT's output. Journal of global health, 14, 04054. https://doi.org/10.7189/jogh.14.04054
23. DiEuliis, D., & Giordano, J. (2018). Gene editing using CRISPR/Cas9: implications for dual-use and biosecurity. Protein & cell, 9(3), 239–240. https://doi.org/10.1007/s13238-017-0493-4
24. Brokowski, C., & Adli, M. (2019). CRISPR Ethics: Moral Considerations for

Applications of a Powerful Tool. Journal of molecular biology, 431(1), 88–101. https://doi.org/10.1016/j.jmb.2018.05.044
25. Mouton, C. A., Caleb, L., and Ella, G. (2023). The operational risks of AI in large-scale biological attacks: a red-team approach. RAND Corporation, Santa Monica, CA. Available at: https://www.rand.org/pubs/research_reports/RRA2977-1.html
26. Biological Weapons Convention – UNODA". United Nations Office for Disarmament Affairs. Archived from the original on 15 February 2021.
27. Report on universalization activities, 2019 Meeting of States Parties to the Biological Weapons Convention, BWC/MSP/2019/3. Geneva, 8 October 2019.
28. Lentzos, Filippa (2019). "Compliance and Enforcement in the Biological Weapons Regime". WMDCE Series, United Nations Institute for Disarmament Research. 4. Geneva, Switzerland: 11–12. doi:10.37559/WMD/19/WMDCE4
29. Shapira, Shmuel & Oren, Meir. (2006). Ethical Issues of Bioterror. Studies in Conflict & Terrorism - STUD CONFL TERROR. 29. 395-401. 10.1080/10576100600695390.
30. Das, S., & Kataria, V. K. (2010). Bioterrorism : A Public Health Perspective. Medical journal, Armed Forces India, 66(3), 255–260. https://doi.org/10.1016/S0377-1237(10)80051-6
31. Loike JD, Fischbach RL (2013) Ethical Challenges in Biodefense and Bioterrorism. J Bioterr Biodef S12:002. doi: 10.4172/2157-2526.S12-002
32. Meyer, R. F., & Morse, S. A. (2008). Viruses and Bioterrorism. Encyclopedia of Virology, 406–411. https://doi.org/10.1016/B978-012374410-4.00549-5
33. Meeting Report: November 2023. Workshop on Deincentivizing State Bioweapons Development and Use: Theory and Policy approaches.Disincentivizing-Bioweapons_NTI-Book_12.10.24-Final.pdf(Accessed 05.09.2025)