Biosecurity in the Crosshairs

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Biological warfare remains a critical concern in modern geopolitics due to its potential for devastating effects and intricate diplomatic implications. Biological warfare employs pathogens to spread diseases among populations, posing unique challenges in detection and defense. While historically less prevalent in modern conflicts due to its unpredictable nature and potential for unintended consequences, advances in gene editing technologies like CRISPR-Cas9 are reshaping the landscape, democratizing the ability to create tailored biological agents. Delivery methods, including nanotechnology, offer enhanced precision and control over dissemination. Detection of biological agents is advancing with biosensors technology and real-time monitoring systems, though challenges persist in identifying genetically engineered pathogens and the costs of such systems. This article explores the evolving dynamics of biological warfare, highlighting the intersection of scientific innovation, security imperatives, and ethical considerations in an era of heightened global interconnectedness and technological advancement. The difficulty in regulating the spread of biological warfare technology arises from the dual-use nature of equipment, with civilian research facilities inadvertently facilitating the development of harmful agents. Despite the American government's renunciation of biological weapons and the ratification of the Biological Weapons Convention, enforcement remains challenging, as exemplified by instances like Iraq's use of biological agents during the Iran-Iraq War. Moreover, advancements in gene editing have made the production of biological agents more accessible, leading to concerns about the future proliferation of such weapons and bioterrorism. Additionally, the prospect of ethnically targeted bioweapons adds a troubling dimension to discussions of mass casualty warfare, posing complex ethical dilemmas that require careful consideration of security imperatives and moral responsibilities.

Keywords: *Biological Warfare, Bio-agents, Bioterrorism, Biosensors, Biodefense*

Introduction

Biological warfare is not a new tactic in the battlefield as armies using disease as a strategic advantage in their war of attrition has been happening since before the dark ages. It also poses tremendous security risk and is crucial in diplomacy between nations. Biological warfare is often combined with chemical warfare when mentioned. The US military groups them all under the acronym CBRN, which stands for chemical, biological, radiological, and nuclear. To further understand and define biological warfare, a comparison will be made between biological and its brother, chemical.

The difference is telling as chemical attacks are by definition chemical substances with toxic properties, while biological attacks are biological substances meant to spread and cause diseases.[1] The uniqueness of biological warfare is unlike chemical

Protecting our national homeland from foreign and domestic threats in the biological sphere is lacking and ignored by current military leadership. The strict discipline of conventional small arm tactics push military technology to make mechanical and computer equipment more agile and light as observed in the M10 Booker and the lancet Kamikaze Drone. This paper sets out to offer new possible uses of modern commercial biotechnology in the current US biodefense program. This paper also outlines the political and strategic overlay on internal and international politics in the context of both an insurgency and an established state.

warfare where once the soldier is tainted by the chemical, he becomes incapacitated or dead. In biological warfare, the soldier who is contaminated first becomes vectors of much further spread. This is the dangerous effect of biological warfare as diseases are harder to spot than gas attacks. Not to mention, countering a chemical attack is easier than countering a biological agent. It is more economically viable to mass produce gas masks in the event of a gas attack than it is to research and develop a vaccine and/or drug to counteract or lessen the effects of the biological agent.

Developing and mass-producing a biological agent takes one year on average, while it takes approximately five years to develop a vaccine or drug to counteract the same biological agent.[1] The per capita cost of killing citizens per square kilometer is significantly lower for biological weapons compared to chemical, nuclear, and conventional weapons. Despite this, biological warfare has not been prevalent in modern war zones like Syria, Lebanon, Colombia, Israel, and Ukraine due to the unpredictable nature of diseases. Attempts to use biological warfare often resulted in unintended consequences, such as infecting and killing one's own soldiers, or environmental factors like sunlight, extreme cold, wind changes, or rain destroy the effectiveness of the biological agent. These uncontrollable variables make biological agents more of a liability than a strategic asset. However, advancements in gene editing technology could potentially change this by making diseases more resistant and controllable for modern military use.

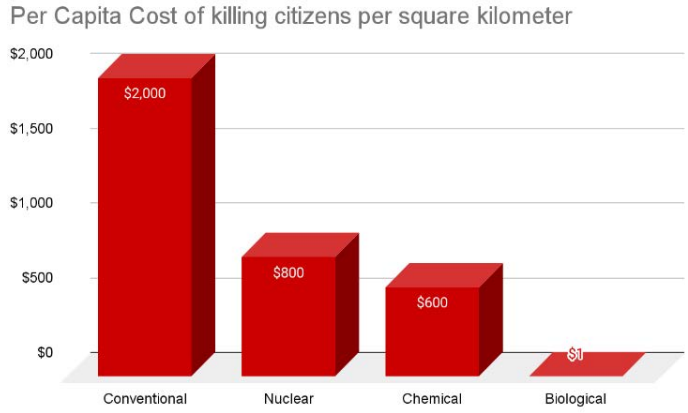

Figure 1. Killing Power of Each Method of Warfare
The data is calculated by the average cost of development, equipment, and materials and the average death count of citizens per square kilometer/area of the attack radius.[1] With conventional being exponentially higher partly due to a smaller damage radius. The data was gathered in 1969 by the United Nations. There is no available update on these statistics but it is assumed that costs for all types have declined since then.

International Security

CRISPR-Cas9 (a tool that enables scientists to manipulate DNA) has "democratized" gene editing technology from a tool of the high tech labs to the hands of the common people. Before, professional armies were the only ones who could afford the logistics and money to use already existing contaminates and diseases but with genome editing, even a civilian with proper knowledge can develop their own biological agent with very few resources. As much as democratizing technology is good for pushing more innovation in the field and reducing cost constraints for new firms, it brings the threat of bioterrorism.

Also, genetic engineering allows for the creation of new genetic agents that have never existed before. With catalogs of many different genes and diseases, it is possible to genetically engineer genes that only affect people of a certain race, genetic features, or other such qualities that can be interpreted at the genetic level. It is also possible to engineer non-contagious diseases or diseases that naturally die within a short period of time to reduce the chance of unintentionally infecting civilians. Genetic engineering can even destroy the need for biological agents to be dependent on weather and environmental conditions.

Most Used Agents	Mortality rate	Incubation Period	Treatment	Vaccine	Reference
Anthrax	90%	7 to 43 days	✔	✔	[2]
Smallpox	30%	7 to 17 days	✔	✔	[2]
Plague	11%	1 to 3 days	✔	✔	[6]
Tularemia	45%	3 to 14 days	✔	✘	[7]
Botulism	10%	12 to 80 hours	✔	✘	[8]
Ebola	50%	2 to 10 days	✘	✘	[4]

Figure 1. Most Used Agents
Table of the six most popular used bioagents by countries that the CDC has observed. The list of bioagents are not listed in a particular order. The mortality rate is based on that of infection through inhalation because most delivery methods are through aerosol. The mortality rate may differ if infected under different circumstances such as consuming tainted foods.

Delivery Methods

The delivery of biological agents can occur through various means such as bombs, missiles, and aerosol sprayers. Biological bombs are generally ineffective, as explosions destroy approximately 95% of the bioagent,[1] but aerosol clouds are preferred for modern armies. Aerosols can be dispersed

through air, water, or underwater. Aircraft equipped with aerosol sprayers can be used, but they require the absence of enemy anti-air capabilities and must fly at low altitudes for effectiveness. Ships can also be fitted with sprayers to disperse aerosols along coastlines, particularly in flat terrain where dispersion is optimal. Notably, 90% of the world's population resides within 160 km of coastlines. In a realistic scenario, submarines can deploy biological mines, which surface and release aerosol clouds after a set time. Additionally, bioterrorists may use makeshift aerosol sprayers hidden in bags to release agents in crowded areas at predetermined times.

Mosquitoes and other small insects like lice and fleas can be engineered to deliver contagious bio-agents. The Germans during the late war had developed a theoretical method to use mosquitoes to spread biological agents to kill the incoming allied soldiers and also sacrifice their whole German population at the same time. Although that did not bear fruit due to a lack of technological and political will, with today's modern technology that is now more than ever possible as genetic engineering of mosquitoes to stop the spread of malaria has already been created. It is very possible to create a mosquito with the opposite effect, to become a host of more deadly diseases. This dispersion radius is greater than mere aerosol clouds as mosquitoes are not limited to the same environmental factors and the wind can disperse them to farther distances.

Another technology that can advance biowarfare delivery is nanotechnology. Nanotechnology allows for the use of tiny capsules that will hold the biological agent, which will be used in the transportation of the disease during the delivery process. And once it reaches the human target the nano capsule can bypass the blood brain barrier and cause the most damage with the least amount of disease.[6] There also lies the possibility of having outside control over the nano capsule: controlling when to open the capsule of the disease to the human body or not. This is a great assurance for making sure that only enemy soldiers will feel the brunt of the attack and not allied soldiers even if allied soldiers breathe the disease in. Or, it could also be used for a more precise timing of infection before the enemy learns about a possible biological attack.

Biological Detection

There is a major need for a public health detection system, where it can analyze data in an efficient and timely manner. This will reduce deaths but will also allow a cleanup of a biological attack to disinfect the bacteria and virus residue.[1] Traditionally, a biological attack is reported when more and more patients with similar symptoms go to the hospital, doctors test their blood samples, then officially confirm there was a possible biological attack. The hospital contacts the authorities to handle the containment, investigation, and vaccination.[8] At this point, it would have been weeks, even months, after the initial exposure to biological agents.

A method used for detecting bioagents are bio-sensors that use probe and transducer technology. Both technologies are needed for detection to work, with the probe recognizing the particular type of bacteria or virus and the transducer communicating this information to the output device, usually a handheld electronic device. Earlier prototypes of bio-sensors were developed by the Navy Medical Research Institute, and can detect various agents like Y. pestis, B. anthracis, and ricin within 15 minutes.[6] These early prototypes were fast but at times had wrong readings and required further testing to confirm results. Though that changed with advancements in biosensor technology. With modern probe technology, there are numerous options ranging from nucleic acid to ligand based. And in transducers, the use of electrochemical, piezoelectric, and especially the more common optical systems, allows for faster and more accurate readings.

Strategic Uses

To effectively counter a biological attack, understanding potential enemy strategies is crucial. Biological agents are most effective in wars of attrition, where surprise tactics can create aerosol clouds to infect enemies in defensive positions, softening them for infantry assaults. Alternatively, engineered agents may dissipate before an assault, infecting enemy soldiers in preparation. However, biological weapons are unsuitable for fast-paced warfare with constantly shifting borders due to unpredictable enemy movements, making them unrealistic for use against insurgencies employing guerrilla tactics. Nevertheless, insurgents may find biological weapons advantageous against established states. Establishing deterrence against biological attacks involves maintaining stockpiles of vaccines, vaccinating military personnel, and ensuring food and water security to prevent contamination.

While some insurgent groups may desire to develop and use biological agents, many lack the logistical and technological capabilities to do so effectively on a large scale. Insurgent movements are often decentralized, with regional commanders and limited central authority. Even if they have microbiologists loyal to their cause, conflicts among regional commanders, like those seen in the Taliban, can impede the implementation of an effective bioweapons program. Any biological attack would likely cause significant damage to an established state but also harm innocent civilians, reducing domestic support for the insurgents, crucial for intelligence and recruitment. Moreover, the attack might not significantly harm the established state, which likely has ample vaccines

compared to civilians in a failed state. Conversely, if an established state uses bioweapons against insurgents, it may strengthen unity and recruitment for the insurgent cause, while victimizing civilians. For insurgents, a more centralized structure could facilitate the development and distribution of biological agents among regional groups.

Biological weapons rely heavily on surprise, a tactic at which insurgents excel due to their civilian guise outside of active combat. Unlike conventional warfare, biowarfare doesn't destroy property, making it advantageous for states seeking to seize enemy industrial capacity and cities intact for economic gain. A surprise attack on urban populations can cause catastrophic damage comparable to a hydrogen bomb. Agents like anthrax and smallpox initially mimic flu symptoms, making winter, or "flu season," an opportune time for delivery, with Christmas week offering added effectiveness due to reduced vigilance.

Biological agents can not just be used to incapacitate enemy soldiers but can be used to taint the agricultural output of the enemy country. Introducing a biological agent to the water supply, crops, and livestock would destroy the morale of enemy civilians and also their production output for the war effort. Depending on the enemy country's resources and possible supporters, they would be forced to import food from outside to feed their military and civilian counterparts. This will reduce war resources as more would have to be spared for the newly imported food.

The negative effect biological agents have on the enemy's morale should be noted, as a biological attack will be seen with great fear within the enemy's military due to the fact that biological agents cause a slower death compared to conventional weaponry. For example, Anthrax causes the infected to feel as if they are unable to breath and have gained a thousand pounds. With further symptoms progressing and getting worse day by day for up to 4 days (once symptoms start) until death. It can be compared to mustard gas or chlorine gas during WW1, where it was one of the largest fears of infantry, even though soldiers were more likely to die from artillery, as artillery shredding your body apart is more humane than dying from mustard gas.

Biological agents are very attractive to dissatisfied states and terrorist groups that are pathetic in their conventional military capabilities. As already established powers would not risk using biological warfare because it would hurt international relations and distance themselves from allies, not to mention they usually already have significant conventional military capabilities. But disgruntled and militarily disadvantaged states such as Iran, Syria, and groups who rely strongly on extremely religious and violent doctrines such as IS and the PKK.(1) It is very difficult to stop and regulate the spread of biological warfare technology to other states because the same equipment used in civilian research can be used in war.

Hawai'i's Defensive Capabilities

The geography of Hawai'i plays a significant role in its defensive capabilities, particularly concerning transportation limitations for evacuation. Understanding these limitations involves considering potential enemy attack scenarios. A coastal delivery method, utilizing wind currents to disperse aerosol clouds among the islands, would be essential for a full assault on the Hawaiian islands. A vessel or submarine wouldn't have to traverse the entire coast for a meaningful assault; an initial delivery on the island of Hawai'i could spread the agent far enough to reach Ni'ihau in the right conditions. If a bioterrorist is lacking a vessel, one could dive a considerable distance from the coast with a timed aerosol sprayer, allowing for a swift escape before activation. If an assault were to occur during hurricane season it would have diminished returns because of unpredictable wind currents and frequent rains that would result in reduced dispersion of the bioagent. May is a perfect month for the chronic terrorist because of heightened wind speeds and dryer conditions, allowing for a larger dispersion. Hawai'i lacks biodefense capabilities, leaving it vulnerable to biological threats. Even with current detection systems in place, there's insufficient time for evacuation, mass vaccination, or distribution of protective equipment due to logistical challenges. Unlike the continental US, Hawai'i's islands require separate stockpiles of vaccines and equipment per island.

A possible solution for early detection in a coastal setting as seen in Hawai'i could be through unmanned aerial vehicles (UAV). A UAV would require a 266 nm UV laser, a biosensor, and a large commercial drone due to the weight it would have to carry. The 266 nm UV laser purpose is for initial detection of any aerosol clouds; however, it is unable to determine if the cloud is toxic or non-toxic. The drone would move to the location of the detected aerosol cloud and use its attached biosensor to test the molecular compounds. If a positive reading for biological agents was found, the report would be sent to the State of Hawai'i Department of Health and U.S Health & Human Services for proper procedure. The major issue with a UAV is that it's not economically feasible because a multitude of drones would be needed in order to cover significant space and a UAV has a constant maintenance cost as biosensors have a limited life span, not to mention all machines have wear and tear. It is unrealistic for government officials to cough up taxpayers' money on a threat that many are oblivious to. Due to this, it is doubtful that government institutions will ever take active preventative measures unless it becomes a communicable threat to public safety. Although such a device could be life-saving when conversely used in a military setting where this threat is realized.

Conclusion

Biological warfare remains a significant geopolitical threat due to its devastating impact and complex diplomatic repercussions. The use of pathogens to spread diseases among populations presents unique challenges in detection and defense. Advances in gene editing technologies, such as CRISPR-Cas9, have made it easier to create targeted biological agents, while nanotechnology has improved the precision and control of their delivery. Despite progress in detection methods, identifying genetically engineered pathogens remains difficult and costly. The dual-use nature of biological research complicates regulation, as civilian facilities can inadvertently aid in developing harmful agents, raising concerns about future proliferation and bioterrorism. As the current world stands, researching and stockpiling vaccines are the best methods of defense. Although advancements in biosensors in increasing accuracy, speed, and longevity of the device will be the most pivotal technology against any biological attacks by giving the most time to stage a proper defense.

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