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Bioterrorism: Looming Threat, Potential Consequences and Defence

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A B S T R A C T

Biological weapons have recently attracted the attention and the resources of the world. Discerning the nature of the threat of bioweapons as well as appropriate responses to them requires greater attention to the biological characteristics of these instruments of war and terror. The dominant paradigm of a weapon as a nuclear device that explodes or a chemical cloud that is set adrift leaves us ill-equipped conceptually and practically to assess and thus to prevent the potentially devastating effects of bioterrorism. Strengthening the public health and infectious disease infrastructure is an effective step toward averting the suffering that could be brought by a terrorist's use of a biological agent.

Introduction

Bioterrorism is terrorism involving the intentional release or dissemination of biological agents. These agents are bacteria, viruses, or toxins, and may be in a naturally occurring or a human-modified form.

The past years have been marked by escalating concerns in the world about the threat of biological weapons. Primarily, discussions about the implications of this threat and its possible scenarios were confined primarily to those in the military, diplomatic, law enforcement, and intelligence communities and to those concerned with arms reduction issues. Only recently have the civilian medical and public health communities begun to be engaged in examining the practical challenges posed by this threat. Professional societies recently have begun to incorporate discussions of bioterrorism in national meetings. On the international scene, in 1998 the World Health Organization (WHO) decided to establish an expert group to review and revise its 1970 landmark document, Health Aspects of Chemical and Biological

Weapons. Clearly, there is growing public awareness of the threat of bioterrorism, and there is nascent concern among medical and public health professionals as well. This is important because if real progress is to be made in addressing this difficult problem, a substantially greater input of good science, medicine, and public health will be needed along with constant effort of creating awareness.

According to the U.S. Centre for Disease Control and Prevention a *bioterrorism* attack is the deliberate release of viruses, bacteria, toxins or other harmful agents used to cause illness or death in people, animals, or plants. These agents are typically found in nature, but it is possible that they could be mutated or altered to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment. Biological agents can be spread through the air, water, or in food. Terrorists tend to use biological agents because they are extremely difficult to detect and do not cause illness for several hours to several days. Some bioterrorism agents, like the smallpox virus, can be spread from person to person and some, like anthrax, cannot.

Bioterrorism is an attractive weapon because biological agents are relatively easy and inexpensive to obtain, can be easily disseminated, and can cause widespread fear and panic beyond the actual physical damage they can cause. Military leaders, however, have learned that, as a military asset, bioterrorism has some important limitations; it is difficult to employ a bioweapon in a way that only the enemy is affected and not friendly forces. A biological weapon is useful to terrorists mainly as a method of creating mass panic and disruption to a state or a country.

History

Other allegations occurred during the post—World War II period (11):

The Eastern European press stated that Great Britain had used biological weapons in Oman in 1957.

The Chinese alleged that the USA caused a cholera epidemic in Hong Kong in 1961.

In July 1964, the Soviet newspaper Pravda asserted that the US Military Commission in Columbia and Colombian troops had used biological agents against peasants in Colombia and Bolivia.

In 1969, Egypt accused the “imperialistic aggressors” of using biological weapons in the Middle East, specifically causing an epidemic of cholera in Iraq in 1966.

Types of Agent

Under current United States law, bio-agents which have been declared by the U.S. Department of Health and Human Services or the U.S. Department of Agriculture to have the "potential to pose a severe threat to public health and safety" are officially defined as "select agents".

The CDC categorizes these agents (A, B or C) and administers the Select Agent Program, which regulates the laboratories which may possess, use, or transfer select agents within the United States. As with US attempts to categorize harmful recreational drugs, designer viruses are not yet categorized and avian H5N1 has been shown to achieve high mortality and human-communication in a laboratory setting.

Category A

These high-priority agents pose a risk to national security, can be easily transmitted and disseminated, result in high mortality, have potential major public health impact, may cause public panic, or require special action for public health preparedness.

Tularemia

Tularemia, or rabbit fever, has a very low fatality rate if treated, but can severely incapacitate. The disease is caused by the *Francisella tularensis* bacterium, and can be contracted through contact with the fur, inhalation, ingestion of contaminated water or insect bites. *Francisella tularensis* is very infectious. A small number (10–50 or so organisms) can cause disease. If *F. tularensis* were used as a weapon, the bacteria would likely be made airborne for exposure by inhalation. People who inhale an infectious aerosol would generally experience severe respiratory illness, including life-threatening pneumonia and systemic infection, if they are not treated. The bacteria that cause tularemia occur widely in nature and could be isolated and grown in quantity in a laboratory, although manufacturing an effective aerosol weapon would require considerable sophistication.

Anthrax

Anthrax is a non-contagious disease caused by the spore-forming bacterium *Bacillus anthracis*. An anthrax vaccine does exist but requires many injections for stable use. When discovered early anthrax can be cured by administering antibiotics (such as ciprofloxacin). Its first modern incidence in biological warfare were when Scandinavian "freedom fighters" supplied by the German General Staff used anthrax with unknown results against the Imperial Russian Army in Finland in 1916. In 1993, the Aum Shinrikyo used anthrax in an unsuccessful attempt in Tokyo with zero fatalities. Anthrax was used in a series of attacks on the offices of several United States Senators in late 2001. The anthrax was in a powder form and it was delivered by the mail. Anthrax is one of the few biological agents that federal employees have been vaccinated for.

Additional facts affecting its possible use by terrorists include the following:

Anthrax can be cultured from almost any soil that supports livestock. Anthrax seed stock, however, is difficult to process and disseminate with great success. The minimal lethal dose for inhalation of anthrax (reportedly 5,000 to 10,000 spores) is high compared with other biological agents.

Most infections (about 95 percent) occur when the bacterium enters a cut or skin abrasion--for example, in unprotected workers handling the wool, hides, leather, or hair products (especially goat hair) of infected animals. Skin infection begins as an itchy bump resembling an insect bite; within two days, it develops into a vesicle and then a painless ulcer, usually 1-3 cm in diameter, with a characteristic black necrotic (dying) area in the centre. Lymph glands in the area may swell. About 20 percent of untreated cases of infection through the skin result in death. Deaths are rare with appropriate antimicrobial therapy.

The anthrax vaccine is effective for preventing anthrax infection through the skin. It appears to be effective for some, but not all, strains of inhalation anthrax in some animal species. Testing to determine the effectiveness and possible side effects of this vaccine is on process.

Smallpox

Smallpox is a highly contagious virus. It is transmitted easily through the atmosphere and has a high mortality rate (20–40%). Smallpox was eradicated in the world in the 1970s, with the aid of worldwide vaccination program. However, some virus samples are still available in Russian and American laboratories. Some believe that after the collapse of the Soviet Union, cultures of smallpox have become available in other countries. Although people born pre-1970 will have been vaccinated for smallpox under the WHO program, the effectiveness of vaccination is limited since the vaccine provides high level of immunity for only 3 to 5 years. Revaccination's protection lasts longer. As a biological weapon smallpox is dangerous because of the highly contagious nature of both the infected and their pox. Also, the infrequency with which vaccines are administered among the general population since the eradication of the disease would leave most people unprotected in the event of an outbreak. Smallpox occurs only in humans, and has no external hosts or vectors.

Botulinum Toxin

The neurotoxin Botulinum is one of the deadliest toxins known, and is produced by the bacterium *Clostridium botulinum*. Botulism causes death by respiratory failure and paralysis. Furthermore, the toxin is readily available worldwide due to its cosmetic applications in injections.

Bubonic Plague

Plague is a disease caused by the *Yersinia pestis* bacterium. Rodents are the normal host of plague, and the disease is transmitted to humans by flea bites and occasionally by aerosol in the form of pneumonic plague. The disease has a history of use in biological warfare dating back many centuries, and is considered a threat due to its ease of culture and ability to remain in circulation among local rodents for a long period of time. The weaponized threat comes mainly in the form of pneumonic plague (infection by inhalation) It was the disease that caused the Black Death in Medieval Europe.

Viral Hemorrhagic Fevers

This includes hemorrhagic fevers caused by members of the family *Filoviridae* (Marburg virus and Ebola virus), and by the family *Arenaviridae* (for example Lassa virus and Machupo virus). Ebola virus disease has fatality rates ranging from 50–90%. No cure currently exists, although vaccines are in development. The Soviet Union investigated the use of filoviruses for biological warfare, and the Aum Shinrikyo group unsuccessfully attempted to obtain cultures of Ebola virus. Death from Ebola virus disease is commonly due to multiple organ failure and hypovolemic shock. Marburg virus was first discovered in Marburg, Germany. No treatments currently exist aside from supportive care. The arena viruses have a somewhat reduced case-fatality rate compared to disease caused by filo viruses, but are more widely distributed, chiefly in central Africa and South America.

Category B

Category B agents are moderately easy to disseminate and have low mortality rates.

Brucellosis (*Brucella* species)

Epsilon toxin of *Clostridium perfringens*

Glanders (*Burkholderia mallei*)

Melioidosis (*Burkholderia pseudomallei*)

Psittacosis (*Chlamydia psittaci*)

Q fever (*Coxiella burnetii*)

Ricin toxin from *Ricinus communis* (castor beans)

Abrin toxin from *Abrus precatorius* (Rosary peas)

Staphylococcal enterotoxin B

Typhus (*Rickettsia prowazekii*)

Viral encephalitis (alphaviruses, for example: Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis)

Water supply threats (for example, *Vibrio cholerae, Cryptosporidium parvum*)

Food safety threats (for example, *Salmonella Species, E.coli O157:H7, Shigella,* Staphylococcus aureus)

Category C

Category C agents are emerging pathogens that might be engineered for mass dissemination because of their availability, ease of production and dissemination, high mortality rate, or ability to cause a major health impact.

Nipah virus
Hantavirus
SARS
H1N1 a strain of influenza (flu)
HIV/AIDS

Defence against Bioterrorism

Effect of Biotechnology on Biological Warfare Conventional / Traditional Agent

Historically, BW (Biological warfare) agents of concern have included a selective group of pathogens and toxins. They are all naturally occurring organisms or their toxic product, e.g. Anthrax, plague, botulinum toxin, etc. Genetically Modified Agents: with the advent of recombinant DNA technology, an organism's genetic makeup may be altered and genetically modified BW agents may be produced. Examples of potential modifications include antibiotic resistance, increased aerosol stability, or heightened pathogenesis. Importantly, genetic modifications may epitopes or sequences used for detection and diagnostics, necessitating that multiple points of reference be incorporated into these systems and highlighting the need for security regarding biodetection strategies. However, genetically modified BW agents will remain closely related to the parent agent at the genetic level and should be generally identifiable using traditional diagnostics. Ultimately, these modifications serve to increase effectiveness of a traditional BW agent or counteract known aspects of the target population’s biomedical defence strategy without significantly manipulating the parental organism in a manner that might compromise natural properties suitable for biological warfare use.

Advanced Biological Warfare Agents (ABW)

Developed technologies across multiple disciplines in the biological sciences have revolutionized bio war by facilitating an entirely new class of fully engineered agents referred to as advanced biological warfare

(ABW) agents. Emerging biotechnologies likely will lead to a paradigm shift in biological warfare agent development; future biological agents could be rationally engineered to target specific human biological systems at the molecular level. This is a departure from the traditional model of BW, which is focused on the naturally occurring agent, not the target organism. Biological science allow BW agent developers to identify biochemical pathways critical for physiological processes and engineer specific ABW agents to exploit vulnerabilities The threat presented by traditional agents has been increasing since the early 20th century but eventually will level off because of two major factors:

1. Development of targeted medical counter measures probably will reduce threats posed by current biological warfare agents.

2. The number of such agents that contain properties suitable for biological warfare is finite.

New Biological warfare Use Options

The wide range of effects that can be designed into ABW agents will expand options for employment significantly. Among these new use options, for example, would be the opportunity to covertly target a civilian population for strategic effect with minimal risk of attribution. Other may include:-

Customizable aspects of advanced agent development may allow for predictable, desired results following agent release.

Unusual clinical presentation could allow a biological warfare attack to be mischaracterized as a natural outbreak and remain undetected.

Development of novel agents previously unknown to the medical community would yield BW agents that are difficult to diagnose and treat.

Advanced agents could be developed to circumvent vaccines or treatments designed to counter traditional agents.

Agents could be tailored to target a specific population based on genetic or cultural traits.

Sterilizing, oncogenic, or debilitating agents could be created for use as a strategic weapon against a target population for long term effects. These new use options likely will make BW more attractive. Thus, advances in biotechnology research may lead to a coming revolution in BW development for technologically proficient rogue nations and possibly sophisticated terrorist organizations.

Microbial Forensics

A new Forensic discipline has come up, dedicated to analyzing evidence from a bioterrorist attack, biocrime or inadvertent microorganism / toxin release for attribution purposes (who was responsible for the crime). Microbial forensics has led to some high-pro-file discoveries. For example, sequencing of amplified viral fragments from the dentist and the infected patients supported the alleged transmission of HIV from a Florida dentist to several patients. Recently, using multiple locus Variable Number Tandem Repeat (VNTR) analysis, the Aum shinrikyo b. Anthracis bioterror strain was identified as the veterinary vaccine strain, Sterne 34f26.

Significance of Microbial Forensics

It will help law enforcement to identify the source of the evidence sample. Evidence can stand to the scrutiny of judges in the courtroom as well as national decision and policy makers.

1. Prevents and deters biocrime and identifies perpetrators
2. Having a well-prepared response plan might discourage at least some terrorists.
3. Cases in which infected people have intentionally infected others may well end up in court.
4. A major benefit, however, is that much of the outcome would also be applicable to tracing natural outbreaks of disease.

Aspects of Protection against Bioterrorism Include

Detection and Resilience Strategies in Combating Bioterrorism like that of USA: This occurs primarily through the efforts of the Office of Health Affairs (OHA), a part of the Department of Homeland Security (DHS), whose role is to prepare for an emergent situation that impacts the health of the American populace. Detection has two primary technological factors. First there is OHA's BioWatch program in which collection devices are disseminated to thirty high risk areas throughout the country to detect the presence of aerosolized biological agents before symptoms present in patients. This is significant primarily because it allows a more proactive response to a disease outbreak rather than the more passive treatment of the past.

Implementation of the Generation-3 Automated Detection System

This advancement is significant simply because it enables action to be taken in four to six hours due to its automatic response system, whereas the previous system required aerosol detectors to be manually transported to laboratories. Resilience is a multifaceted issue, one way in which this is ensured is through exercises that establish preparedness; programs like the Anthrax Response Exercise Series exist to ensure that, regardless of the incident, all emergency personnel will be aware of the role they must fill. Moreover, by providing information and education to public leaders, emergency medical services and all employees will significantly decrease the impact of bioterrorism.

Enhancing the Technological Capabilities of First Responders: This is accomplished through numerous strategies. The first of these strategies was developed by the Science and Technology Directorate (S and T) of DHS to ensure that the danger of suspicious powders could be effectively assessed, (as many dangerous biological agents such as anthrax exist as a white powder). By testing the accuracy and specificity of commercially available systems used by first responders, the hope is that all biologically harmful powders can be rendered ineffective.

Enhanced Equipment for First Responders: One recent advancement is the commercialization of a new form of Tyvex™ armor which protects first responders and patients from chemical and biological contaminants. There has also been a new generation of Self-Contained Breathing Apparatuses (SCBA) which has been recently made more robust against bioterrorism agents. All of these technologies combine to form what seems like a relatively strong deterrent to bioterrorism.

Table.1 Examples of Biological and Chemical Warfare Use During the Past 2000 Years

Time	Event
600 B.C.	Solon uses the purgative herb hellebore during the siege of Krissa
1155	Emperor Barbarossa poisons water wells with human bodies in Tortona, Italy
1346	Tartar forces catapult bodies of plague victims over the city walls of Caffa, Crimean Peninsula (now Feodosia, Ukraine)
1495	Spanish mix wine with blood of leprosy patients to sell to their French foes in Naples, Italy
1675	German and French forces agree to not use "poisones bullets"
1710	Russian troops catapult human bodies of plague victims into Swedish cities
1763	British distribute blankets from smallpox patients to Native Americans
1797	Napoleon floods the plains around Mantua, Italy, to enhance the spread of malaria
1863	Confederates sell clothing from yellow fever and smallpox patients to Union troops during the US Civil War
World War I	German and French agents use glanders and anthrax
World War II	Japan uses plague, anthrax, and other diseases; several other countries experiment with and develop biological weapons programs
1980–1988	Iraq uses mustard gas, sarin, and tabun against Iran and ethnic groups inside Iraq during the Persian Gulf War
1995	Aum Shinrikyo uses sarin gas in the Tokyo subway system

Table.2 Biological Warfare Programs During World War II

Nation	Numbers of workers (estimated)	Focus
Germany	100–200	Offense research forbidden
Canada	small	Animal and crop diseases, rinderpest, anthrax
United Kingdom	40–50	Animal and crop diseases, anthrax, foot and mouth disease
Japan	several thousand	Extensive; official information suppressed by a treaty with USA in which all charges for war crimes were dropped for exchange of information from experiments
Soviet Union	several thousand	Typhus, plague
USA	1500–3000	Chemical herbicides, anthrax (started too late to be important)

Project Bio Shield: The accrual of vaccines and treatments for potential biological threats, also known as medical countermeasures has been an important aspect in preparing for a potential bioterrorist attack; this took the form of a program beginning in 2004, referred to as Project BioShield. The Department of

Defense also has a variety of laboratories currently working to increase the quantity and efficacy of countermeasures that comprise the national stockpile. Efforts have also been taken to ensure that these medical countermeasures are able to be disseminated effectively in the event of a bioterrorist attack.

Developing a Defence Strategy: In formulating a biochemical defence policy, hazard assessment is an essential factor. Thus the utility and advantages and disadvantages of CB (Chemical Bio warfare) weapons require careful consideration. In general war, the use of CB weapons would do little harm to the infrastructure of territory to be occupied—an advantage for the user. The fact that they may incapacitate rather than kill outright is an important consideration. This is because they could overwhelm the medical and casualty services, whereas the dead have no need of either. However, at present, weaponization and dispersion of CB weapons present difficulties. Accurate targeting is seldom possible and collateral effects may occur in the attacker's own troops; moreover, retribution in kind might also follow. In CB attacks on civilian populations the fear factor works to the advantage of the terrorist. The use of anthrax letters illustrates this point; additionally this method allows for a delayed onset of infection, enabling the perpetrators to move away and attack elsewhere. CB agents may be used as weapons of mass destruction by spreading epidemics among human or animal populations or commercial crops while avoiding collateral damage to the infrastructure. It is not generally recognized that, although many CB agents are easy and cheap to produce, effective detection and countermeasures are as yet inadequate to meet a large-scale challenge. Little progress has been made on antivirals and vaccine research, and development requires further input1. The threat of a smallpox attack by terrorists is still one of the major concern.

Of the weapons of mass destruction (nuclear, chemical, and biological), the biological ones are the most greatly feared , but the world is least well prepared to deal with them. Virtually all federal efforts in strategic planning and training have so far been directed toward crisis management after a chemical release or an explosion. Should such an event occur, fire, police, and emergency rescue workers would proceed to the scene and would stabilize the situation, deal with casualties, decontaminate, and collect evidence for identification of a perpetrator. This exercise is not unfamiliar. Spills of hazardous materials, explosions, fires, and other civil emergencies are not uncommon events. The expected scenario after release of an aerosol cloud of a biological agent is entirely different. The release could be silent and would almost certainly be undetected. The cloud would be invisible, odorless, and tasteless. It would behave much like a gas in penetrating interior areas. No one would know until days or weeks later that anyone had been infected (depending on the microbe). Then patients would begin appearing in emergency rooms and physicians' offices with symptoms of a strange disease that few physicians had ever seen. Special measures would be needed for patient care and hospitalization, obtaining laboratory confirmation regarding the identity of microbes unknown to most laboratories, providing vaccine or antibiotics to large portions of the population, and identifying and possibly quarantining patients. Trained epidemiologists would be needed to identify where and when infection had occurred, so as to identify how and by whom it may have been spread. Public health administrators would be challenged to undertake emergency management of a problem alien to their experience and in a public environment where pestilential disease, let alone in epidemic form, has been unknown.

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