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Bioterrorism: An Emerging Global Health Threat

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Abstract

The threat of bioterrorism has heightened over the past few years, given the history of asymmetric warfare. This threat posed by biological weapons is especially challenging, given the unique characteristics of these agents coupled with the dearth of knowledge in this particular subject by health care first responders. As the history of biowarfare has shown, exposure to even minute quantities of a biological agent can be fatal. As such, health care first responders will encounter the brunt of these cases. Therefore, it is imperative that health care first responders who provide emergency medical services be knowledgeable on the detection, diagnoses and response to biological agents so as to minimize adverse health effects and prevent fatalities. Information contained in this article includes overall awareness of select agents of bioterrorism and brief clinical characteristics of the most common and most likely bioterrorism agents known as Tier 1 select agents with the purpose of better preparing health care first responders in the event of a potential bioterrorism attack.

Keywords: Bioterrorism; Agents of bioterrorism; Health care first responders; Biological weapons

Nature of the Problem

In an age of advanced weaponry and tactics, the threat of bioterrorism has never been so real. This threat, long ignored and denied, poses a significant risk to not only the national security of all countries around the world, but to the health of all citizens. Recent bioterrorism events in the United States and previous events in Japan, Iraq, and Russia cast an ominous shadow [1]. The threat focuses on the overall preparedness of health care first responders by new and reemerging infectious diseases used as bioweapons. These health care first responders, who include emergency room physicians, emergency medical technicians, nurses and physician assistants, laboratorians, and other health care professionals, who provide emergency health care services, will be on the forefront of diagnosing and providing appropriate and prompt treatment in response to a bioterrorism event. Thus, their ability to detect and respond to a bioterrorism attack that utilizes an infectious disease as weaponry is essential to minimize adverse health effects and prevent fatalities.

The threat of bioterrorism is increasing as a result of the rise of technical capabilities, the rapid expansion of the global biotechnology industry, and the growth of loosely sophisticated networks of transnational terrorist groups that have expressed interest in bioterrorism. These factors are not only broadening the availability of materials, technologies, and expertise needed to produce a biological weapon, but is also lowering the barrier to execute bioterrorism and its proliferation [2]. Because health care first responders are on the forefront in dealing with potential causalities, their ability to detect and respond to a bioterrorist attack must be augmented with preventative measures to meet today's international challenges [2]. Thus, health care first responders will need to be aware of potential agents of bioterrorism, know how to rule out agents of bioterrorism, know how to detect and diagnose agents of bioterrorism, and have knowledge of treatment options available for the agent used.

A Deadlier Form of Killing

Bioterrorism is the intentional or threatened use of viruses, bacteria, fungi, or toxins from living organisms to produce death or disease in humans, animals or plants to accomplish political or social objectives [3]. Agents of bioterrorism can be altered or mutated in such a way so as to increase their virulence and ability to cause disease. They can be engineered to resist current medications. They can be spread through air, food, water, fomites, or through infected hosts (including humans, animals, insects, and other reservoirs).

Furthermore, the detection of biological agents is very difficult as the illness can take anywhere from several hours to weeks, depending on the agent. Hence, the mortality rate of utilizing bioweapons can be astronomical as compared to conventional forms of killings (Centers for Disease Control and Prevention [CDC]) [4]. Rather than nuclear or chemical weapons, microbiological agents pose the highest risk, and such agents are gaining prominence around the world [5].

History of Biowarfare

As early as 600 BC, infectious diseases were recognized for their potential impact on people and armies when the Assyrians poisoned enemy wells with rye ergot, a fungus that causes convulsions when ingested [6]. Such a strategy of polluting wells and other sources of water with infectious substances continued to be used in many European wars, the American Civil War, and other 20th-century conflicts [6].

During the Middle Ages, military leaders recognized that diseased cadavers and animal carcasses could become weapons themselves [6]. It was during the siege of Caffa (now Feodosia, Ukraine) in 1346 when Tartar forces hurled the victims of plague into the besieged city, thus initiating a plague outbreak [6]. This outbreak is theorized to be

responsible for the plague pandemic, also known as the Black Death, which swept through Europe, the Near East and North Africa during the 14th century and is said to be the most devastating public health disaster in recorded history [6].

Many other incidents indicated the deliberate use of disease during war [6]. For example, in 1422, bodies of dead soldiers were catapulted into the ranks of the enemy in Karolstein. A similar strategy of using cadavers of plague victims were utilized during the battle between Swedish forces and Russian troops in 1710 [6]. Smallpox, another devastating and highly contagious disease, was used as a bioweapon in the New World. Francisco Pizarro is said to have presented South American Natives with smallpox-laced clothing in the 15th century [6]. Likewise, Sir Jeffrey Amherst, the commander of the British forces in North America, suggested the deliberate and planned use of smallpox to demolish the native Indian population during the French-Indian War in 1754. Captain Ecuyer, one of Amherst's subordinate officers, gave the Native Americans smallpox-laden blankets, which resulted in an outbreak of smallpox among the Indian tribes in the Ohio River Valley [6].

During the 19th century, the use of biological warfare became more sophisticated. With the new founded knowledge of Koch's postulates and the development of modern microbiology, isolation and production of stocks of specific pathogens became possible. For example, during World War I, reports indicated that Germans attempted to ship horses and cattle inoculated with disease-producing bacteria, such as Bacillus anthracis (anthrax) and Pseudomonas pseudomallei (glanders), to the United States and other countries [6]. Other allegations of attempts to utilize infectious diseases as weapons by Germany include the spread of cholera in Italy and plague in St. Petersburg, Russia [6].

During World War II, several countries, including the United States, Belgium, Canada, France, Great Britain, Italy, the Netherlands, Poland, Japan, and the former Soviet Union, began to develop biological weapons even after signing the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare, commonly called the Geneva Protocol of 1925 [6]. The most notorious and treacherous biological warfare program (called Unit 731) was that of Japan's where more than 10,000 prisoners are believed to have died as a result of experimental inoculation of agents causing anthrax, plague, cholera, gas gangrene, and other highly infectious diseases between 1932 and 1945 [6]. Furthermore, the Japanese military weaponized plague by allowing laboratory fleas to feed on plague-infected rats and later released these fleas over Chinese cities to initiate plague epidemics. It was reported that 10,000 casualties occurred in the city of Changteh alone in 1941 due to biological weapons [6].

Newspapers were filled with articles regarding disease outbreaks caused by foreign agents armed with biological weapons during the years after World War II [6]. For example, the United States was accused of using biological weapons against North Korea during the Korean War. The United States later admitted it had a biological warfare program, but denied using them. Many countries mentioned above continued their biological weapons research program well into the late 19th century. In 1972, the Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological and Toxin Weapons and on Their Destruction (known as BWC) was developed and ratified among 103 nations [6]. Despite the agreement of BWC, many countries continued with their offensive biological research program. The former Soviet Union (now Russia) continued to develop and stockpile weaponized biological agents, such as anthrax and plague. In fact, an epidemic of anthrax occurred in Sverdlovsk (now Ekaterinburg), Russia in 1979, which was attributed to an accidental release of anthrax spores from a nearby Soviet military microbiology facility. The Soviet Union's offensive biological research program existed well into the 1990s. Records from 1995 reveal that the program employed 25,000 to 30,000 people [6].

During the Persian Gulf War in 1991, intelligence information revealed that Iraq had an offensive biological and chemical warfare program [6]. In fact, Iraq had used chemical weapons on its own people on many occasions in the 1980s [6]. During a United Nations inspection in 1991, representatives from the Iraqi government announced that Iraq had conducted offensive research on anthrax, botulinum toxins, and Clostridium perfringens [3].

Unfortunately, these state-sponsored and military-related biological programs are not the only ones who attempted to develop, distribute, and use biological weapons [6]. Private and civilian groups, too, have attempted to use infectious diseases as weapons. One incident was the deliberate contamination of salad bars with Salmonella typhimurium in restaurants in Oregon by the Rajneeshee cult during September of 1984. A total of 751 cases of severe enteritis were reported, and 45 victims were hospitalized. Another incident included the Aum Shinrikyo cult who attacked the Tokyo subway system with sarin gas in 1995 and attempted unsuccessful biological attacks numerous other times. At one point, the cult members attempted to acquire the Ebola virus, one of the deadliest viruses known to man, from Zaire [3,6].

Cases of individuals utilizing biological agents for malicious purposes include the 2001 anthrax attack in the United States where letters containing anthrax spores were mailed to various entities, including a news agency and a senator [7]. Bruce Edwards Ivins, a senior biodefense researcher at the United States Army Medical Research Institute of Infectious Diseases, is believed to be responsible for the attack [7]. More recently, a Mississippi man was charged with mailing letters containing the poison ricin to the President, a United States senator, and a local judge in April of 2013 [7].

Despite the effort of the United Nations, the struggle to enforce the BWC continues today [6]. As the recent developments in Syria and the lone-wolf incidents of bioterrorism in United States have shown, the development and deployment of biological weapons is a real and growing threat [7].

This cross-sectional survey was conducted for two months (June–July 2011). Study districts were selected using a two-stage cluster sampling method. The 112 districts of Uganda were divided into two: a cluster of districts that had reported at least one outbreak of highly infectious diseases during the previous five years (2005-2009) and a cluster comprising districts without such outbreaks. For each cluster, a sampling frame was developed. Using simple random sampling, one paper bearing a district name was picked at time (without replacement) until the sample size had been realized.

Bioterrorism as a Global Health Threat

Bioterrorism as a distant threat

Bioterrorism as a Realistic Threat

The threat of bioterrorism is more likely to occur now than ever before, including the following:

1. As evident from past and present cases of bioweapons, nations and dissident individuals and groups exist that have both the motivation and access to skills to develop and disperse biological agents [8].

2. The former Soviet Union's bioweapons facility that was used to produce weaponized infectious diseases, such as plague and anthrax, has missing stockpiles of its bioweapons. Intelligent reports indicate the stockpiles were sold on the black-market to Middle Eastern countries [3]. Furthermore, the scientists who worked in the offensive biological weapons program until the early 1990s have gone to other countries, such as North Korea and other Middle Eastern countries and are suspected to be collaborating with those governments in their clandestine bioweapons programs [8].

3. Biotechnology is growing tremendously, and there is readily information available on the Internet as to how to develop and manufacture sophisticated types of biological weapons with modest cost [8]. Furthermore, there are numerous publications in scientific journals, explaining how to produce very sophisticated, highly pathogenic agents [8].

4. Individuals with basic biology and engineering training could develop effective weapons at little cost [8].

5. Populations have become increasingly vulnerable to disease, and medical providers are less familiar with appropriate diagnosis and treatment, thus making such weapons an ideal choice for those looking to cause mass causalities [3].

Overall, bioweapons are relatively inexpensive, easy to produce, conceal and transport, and can cause considerable damage without elaborate weaponization [3,8] Thus, making them an ideal candidate to use as a weapon [8].

The fear of bioterrorism and its implication on public health is already starting to be seen in certain countries around the world [9]. In the United States for example, after the discovery of human anthrax cases in 2001, the Illinois Department of Public Health received over a thousand human samples of potential anthrax, all of which were negative. This data of increased volume of submissions to a local public health laboratory demonstrates the fear of bioterrorism in the general population [9].

Category A, B, and C Agents

Broadly speaking, the CDC separates agents of bioterrorism into three categories depending upon the lethality of the agent (i.e., how fast it can spread and the severity of the illness or death it causes; [10]). These categories are category A, category B, and category C.

Category A agents

Category A agents are considered the highest risk and highest priority because they can easily spread from person-to-person, result in high mortality rates, possess the potential for major public health impact (i.e., can cause extreme concern and social disruption), and require special public health preparedness provisions [10]. Category A agents include anthrax (*Bacillus anthracis*), botulism (Clostridium botulinum toxin), plague (*Yersinia pestis*), smallpox (*variola* major), tularemia (*Francisella tularensis*), and viral hemorrhagic fevers (filoviruses [i.e., ebola, marburg] and arenaviruses [i.e., lassa, machupo]; [11]).

Category B agents

Category B agents are the second highest priority because they can be moderately spread, result in moderate morbidity rates and low mortality rates, and require enhanced disease surveillance and specific enhancements of the CDC's laboratory capacity [10]. Category B agents include brucellosis (*Brucella* species), epsilon toxin of *Clostridium perfringens*, food safety threats (i.e., *Salmonella* species, *Escherichia coli* O157:H7, *Shigella*), glanders (*Burkholderia mallei*), melioidosis (*Burkholderia pseudomallei*), psittacosis (*Chlamydia psittaci*), Q fever (*Coxiella burnetii*), ricin toxin from *Ricinus communis* (castor beans), Staphylococcal enterotoxin B, typhus fever (*Rickettsia prowazekii*), viral encephalitis (alphaviruses, such as Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis), and water safety threats (i.e., *Vibrio cholerae, Cryptosporidium parvum*; [11]).

Category C agents

Category C agents are the third highest priority and are considered emerging threats for disease. These agents are easily available, easily produced and transmitted, and have the potential for high mortality and morbidity rates [10]. Category C agents include Nipah virus, hantavirus, severe acute respiratory syndrome (SARS), and HIV [11].

Select Agents of Bioterrorism and Medical Countermeasures for Tier 1 Select Agents

Select agents, short for biological select agents or toxins (BSATs), are a subset of biological agents based on CDC's three category bioterrorism agents that have been declared by the United States Department of Health and Human Services (HHS) or by the United States Department of Agriculture (USDA) as "posing severe threat to public health and plant health, or to animal or plant products" [12]. Thus, they have been divided into three broad categories: HHS select agents and toxins (affecting humans), USDA select agents and toxins (affecting agriculture), and overlap select agents and toxins (affecting both; [13]).

To further divide select agents, in accordance with Executive Order 13546, Optimizing the Security of Biological Select Agents and Toxins in the United States, HHS and CDC have designated specific select agents and toxins that present the greatest risk of intentional misuse with the most significant potential for mass causalities or devastating effects to the economy, critical infrastructure, or public confidence as "Tier 1" agents [14].

Tier 1 Select Agents

Tier 1 select agents possess the greatest risk to human health and safety [14]. They are the most important for health care first responders to understand [14].

Bacillus anthracis: Anthrax is caused by gram-positive, rod shaped bacteria, known as *Bacillus anthracis*, and can result in a serious infectious disease [15]. Depending upon the portal of entry, anthrax can cause cutaneous anthrax (presented by small blisters with a black center), inhalation anthrax (presented by shortness of breath, nausea, body aches), and gastrointestinal anthrax (presented by swelling of

neck glands, swelling of abdomen, bloody diarrhea; [16]). Because it can be found naturally in soil and commonly affects wild and domestic animals, people can contract the disease if they come in contact with infected animals or contaminated animal products ([15]). Anthrax can be treated with antibiotics, including penicillin, tetracycline, erythromycin, and ciprofloxacin [15].

Francisella tularensis: Tularemia is caused by the bacterium *Francisella tularensis* found in animals and is a potentially serious illness [17]. Patients present with symptoms of progressive weakness and joint pain and sometimes ulcers on the skin or mouth. If exposed by inhalation, then symptoms would include severe respiratory illness, including life-threatening pneumonia and systemic infection [17]. Treatment of tularemia is administering antibiotics, including the tetracycline class (i.e., doxycycline) or fluoroquinolone class (i.e., ciprofloxacin; [17]).

Yersinia pestis: Plague is caused by the bacterium *Yersinia pestis* found in rodents and their fleas [18]. In an aerosol attack using *Yersinia pestis,* patients will present the pneumonic form of plague. Treatment of plague includes administering antibiotics, such as the tetracycline class (i.e., doxycycline) or fluoroquinolone class (i.e., ciprofloxacin; [18]).

Brucella species: Brucellosis is caused by bacteria and is a serious infectious disease [19]. Individuals can get the disease through contact with an infected animal or contaminated animal product [19]. Characteristic symptoms of brucellosis include anorexia, swelling of the liver and/or spleen, and arthritis. Treatment entails administering a cocktail of antibiotics, including tetracyclines, rifampicin, and the aminoglycoside streptomycin [19].

Burkholeria mallei: Glanders is caused by the bacterium *Burkholeria mallei* and results in an infectious disease (20]). Characteristic symptoms of glanders include light sensitivity, ulceration if through localized infection, pneumonia through pulmonary infection, and potential multiple abscesses within the muscles and skin of limbs if chronic (20]). Humans can contract the disease by contact with infected animals or through inhalation of infected aerosols. Glanders can be treated with antibiotics, including tetracyclines, gentamicin, and others (20]).

Burkholderia pseudomallei: Melioidosis, an infectious disease, is caused by the bacterium *Burkholderia pseudomallei* found in contaminated water and soil [21]. Humans can become infected through contact with the contaminated source. Characteristic symptoms of melioidosis include ulceration and abscess; however, pulmonary, bloodstream, and disseminated infections of the disease may present different clinical manifestations. Treatment of melioidosis includes antimicrobial agents, such as trimethoprim-sulfamethoxazole and ceftazidime [21].

Variola virus: Smallpox is caused the *variola* virus and results in a serious infectious disease [22]. A characteristic symptom of the disease is pustules that begin to crust and then scab. There is no treatment for smallpox [22].

Clostridium botulinum: Botulism is caused by the toxin made by the bacterium *Clostridium botulinum* [23]. It is a muscle-paralyzing disease and can be foodborne (ingesting toxin) or cause wound botulism (wounds infected with C. botulinum). The treatment includes taking the antitoxin [23].

A commonality seen in these agents is that they occur naturally in nature and could be isolated and grown in a rogue laboratory [24]. The most devastating scenario using these pathogens would be airborne dispersal over a concentrated population along with food and water contamination [25]. Characteristics that make a pathogen especially high-risk for bioterrorism include highly contagious, low infective dose, survival in a variety of environmental conditions, and ability to be aerosolized. Almost all the Tier 1 agents mentioned above possess nearly all of these characteristics [25].

Responding to an Emerging Threat

Bioterrorism is seen as one of the greatest threats to society as it is a covert, unannounced event that involves the release of an organism or toxin without any public notification (HHS, 2012b; Friend, 2010). Days or weeks may pass before the release is noticed. A cluster of disease appearing after the incubation period would potentially signal the event. Health care first responders are likely to be the first to encounter these first cases of disease. Thus, they must possess the knowledge and skills to either rule out suspect agents or refer the case to their public (or national depending upon the country) health laboratory for confirmation [24].

For example, the CDC's Epidemic Intelligence Service examined global outbreak investigations from 1988 to 1999 [26]. Out of the 1,099 outbreak investigations analyzed, nearly 270 (24.6%) outbreaks were reported by health care providers and 129 (11.7%) outbreaks were reported by infection control practitioners. Combined, they reported approximately 399 (36.3%) of the outbreaks investigated. Health departments reported 335 (30.5%) outbreaks. This data confirms that the most critical component for bioterrorism outbreak detection and reporting are the frontline health care professions (i.e., emergency room physicians) and the local health departments [26].

Furthermore, 44 of the 1,099 investigations identified causative agents had bioterrorism potential [26]. The deliberate use of infectious agents was considered in six of the investigations. Of these six potential bioterrorism outbreaks, reporting was delayed for nearly 26 days (calculated from the date the initial patient became ill to the date the initial contact was reported for the unexplained critical illness investigation; [26]). It is important to note that depending on the infectious agent, hundreds of lives can be put at risk for potential exposure every day. Thus, education and support of frontline health professionals and methods to shorten the time between outbreak and reporting must be done [27].

The best way to respond to such a hypothetical situation is through preparedness [28]. On a broad scale, preparedness can take the form of education (i.e., trainings, webcasts, seminars, hands-on courses, and lectures; developing a Bioterrorism Ready Plan; ensuring a good communication system between public health agencies, hospitals, and the civilian population (i.e., sharing of medical and epidemiological information between public health and law enforcement agencies; understanding the legal and administrative preparations for a bioterrorist attack; environmental monitoring (i.e., daily testing of air samplers for potential bioterrorism agents; syndromic surveillance (i.e., evaluating unusual statistical patterns of illnesses; and provider reporting (i.e., the immediate reporting by health care providers of any suspected or confirmed bioterrorism agent; [24,28].

Current Methods of Biothreat Agent Detection

Detection and identification of biothreat agents include biosensing strategies based upon molecular/microbiological sensing technologies. This includes the use of antibodies, genomic analysis, biochemical

testing, and other cellular based responses and recognition interactions [29].

The primary identification mechanisms to identify various biothreat agents in the clinical health care environment include performing a combination of various molecular/microbiological based platforms. This includes mass spectrometry (MS), antibody-based immunoassays (IA), microbiological culturing (MB), and bioassay such as Polymerase Chain Reaction (PCR) to look for presence of specific genes (BA) [30]. For example, identification of bacterial organisms such as Bacillus anthracis and Yersinia pestis include the IA/MB/BA method. Identification of viruses, such as smallpox and hemorrhagic fever viruses, include the IA/BA method [29].

Issues encountered by these biosensing platforms include factors such as the differing physiochemical/structural properties of pathogens, the presence of different materials and matrices, differing pathology and etiology and the associated need to isolate, extract, purify and prepare samples for testing [30]. These detection platforms must also be very sensitive, specific, and capable of detecting even minute concentrations of agents. However, false-positives are common in such platforms.

Recommended Competencies for Health Care First Responders

The recommended competencies for health care first responders includes being familiar with the clinical features of illnesses caused by potential bioterrorism agents along with the clinical patterns seen when intentional outbreaks are caused; knowledge of the medical countermeasures available to treat confirmed cases, prophylactics for suspected cases, and any available vaccines to prevent future cases; know how to report suspicions immediately (i.e., alerting local law enforcement agencies; anticipate how patients with special needs such as children and the elderly will receive medical care during a biological emergency; and know how to institute infection control triage procedures for patients presenting with respiratory symptoms and fever or rash [24].

Results

In the event of a bioterrorist attack, the detection or interdiction is next to impossible. The first indication of bioweapon exposure will be cases in hospital emergency rooms [1]. Thus, health care first responders who are trained in detection and treatment of select agents will constitute the first line of defense. The promptness with which health care first responders reach a proper diagnosis and the rapidity with which they administer preventative and therapeutic measures could dictate the difference between thousands, perhaps tens of thousands of causalities [1]. However, very few health care first responders have ever seen so much as a single case of smallpox of anthrax, or for that matter, would be able to recall the clinical characteristics of such cases. Therefore, if health care first responders are educated on the clinical and the microbiological characteristics of select agents they would be able to save hundreds, maybe even thousands of lives in the event of a bioterrorist attack.

Discussion

Despite the tremendous progress made in science and medicine within the last two centuries, disease and the ability to inflict disease remains among the most powerful threats known to mankind. The use of biological weapons is not a modern occurrence. As recorded history has shown, the first documented cause of biological weapons occurred in 1346 when invading Tartar forces catapulted plague-ridden corpses into the besieged city of Caffa. The result of this tactic is estimated to have killed nearly 100 million people in the ensuing years [31]. Diseases can be more lethal and be a greater cause of death than fighting or contending in war itself. For example, the 1918 Spanish flu epidemic was one of the most deadly pandemics in world history infecting over 500 million people and killing between three to five percent of the world's population [31]. Although the Spanish flu and bubonic plague were naturally occurring pandemics, new and re-emerging diseases that are even more dangerous can be and have been developed in laboratories around the world. Humanity is still vulnerable to these diseases.

The more science society knows, the better the biological weapons that can be developed. History has shown the world time and time again that individuals, groups, and governments are capable of producing very sophisticated, highly pathogenic agents. The real threat, however, remains on the preparedness of health care first responders and their ability to detect and respond to such occasions. These health care first responders, who include emergency room physicians, emergency medical technicians, nurses and physician assistants, laboratorians, and other health care professionals, who provide emergency health care services, will be on the forefront of diagnosing and providing appropriate and prompt treatment in response to a bioterrorism event.

By providing a hypothetical scenario on the lack of knowledge and preparedness of health care first responder in properly diagnosing and treating a victim of bioterrorism coupled with the facts known about certain diseases and the rate of infection and morbidity/mortality, the seriousness of the situation can be revealed. A mathematical model of a bioterror attack on food supply, specifically botulinum toxin in milk revealed that less than one gram of botulinum toxin is required to cause 100,000 mean causalities (i.e., poisoned; [32]. With a 10 gram release of the toxin in a 5,500 gallon truck, the majority of the 568,000 average consumers of that milk would be poisoned [32]. Due to children's higher consumption of milk and greater toxin sensitivity, the percentage of pediatric causalities would be 99.97% for a 0.1 gram release of the toxin in milk [32]. Most of the causalities would occur on days three to six (48-hour incubation period) or until the attack is detected via either early symptomatics or in-process testing results. Early symptomatic detection would avoid two-thirds or 66% of the causalities [32].

Although modern medicine and advanced pharmaceutical research has allowed humanity to fight natural diseases better and is potentially prepared to deal with an outbreak of for example, bubonic plague or Spanish flu, an outbreak of a new or genetically modified agent could easily cause a detrimental and devastating impact as its predecessors did centuries ago. In this way, the use of biological weapons may be the greatest threat to human existence in the 21st century, and even beyond [31].

Conclusion

In an age of advanced weaponry and tactics, the threat of bioterrorism has never been so real. Although preparation is the best approach, it is extremely difficult and costly to prepare for a global public health disaster in practice. In addition, private enterprises, such as pharmaceutical companies, have no profit motive or incentive to

develop prophylactic and therapeutic medicines (i.e., vaccines) for bioterror agents. The onus, therefore, falls on the overall educational preparedness of health care first responders as they will constitute the public's first line of defense.

Because health care first responders will be on the forefront in dealing with potential causalities, their ability to detect and respond to a bioterrorist attack must be augmented with preventative measures (i.e., further education) to meet today's international challenges [33]. Thus, health care first responders will need to be aware of potential agents of bioterrorism, know how to rule out agents of bioterrorism, know how to detect and diagnose agents of bioterrorism, and have knowledge of treatment options available for the agent used. By participating in preparedness training and education on bioterrorism agents, the international health care first responder community will have the skills and expertise needed to effectively mitigate the global health threat of bioterrorism

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