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Review Article

Bioterrorism and Biodefence: Biotechnology and Security Implications for Nigeria

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Abstract

The need for Nigeria to be proactive in enhancing its capacity in maintaining its territorial integrity and National security using modern Biotechnology cannot be over emphasized. Bioterrorism is no more a potential threat but a real tool that could be deployed by Terrorists operating within the country for mass destruction. Bioterrorism is the deliberate use of biological agents like microorganisms and other toxins to cause diseases and death in humans, livestock, and crops. The attraction for these materials by these evil elements is attributed to their low production costs, non-detection by conventional security systems, and easy transportation from one place to another. These substances pose danger to global peace and security and as such must be contained at all levels. It was Sir Isaac Newton who stated in his third law of motion that to every action, there is equal and opposite reaction. So, there is need for a biodefense as a counter mechanism. Biodefense is simply any measure or action taken biologically or medically to contend with harms emanating from bioterrorism. This may include the use of medicines and vaccines to treat diseases from pathogenic organisms. This current review therefore is an attempt to dissect the biotechnological implications of bioterrorism and biodefense as proverbial out-growths of the same plant by way of examining one as a weed and the other as the weed killer.

Keywords: Bioterrorism; Biodefense; Bioweapons; Biotechnology; Security; Nigeria

Introduction

Science and Technology has revolutionized warfare in recent times. One of the areas is the application of biotechnology in recreating nature by manipulating genes of living organisms especially microorganisms for use as bioweapons. This has resulted in diverse possibilities like creating bio agents capable of spreading deadly diseases amongst a population without detection or even changing harmless organisms into very virulent types for negative purposes. Biological weapons are designed to spread disease among people, plants, and animals through the introduction of toxins and microorganisms such as viruses and bacteria. The method through which a biological weapon is deployed depends on the agent itself, its preparation, its durability, and the route of infection. Attackers may disperse these agents through aerosols or food and water supplies or as war heads [1]. Therefore, the intentional release of traditional or combinatorial bioweapons remains one of the most important challenges that are shaping the securities of most nations including Nigeria in recent times. Due to this danger waiting for full manifestation, Strong public health and biodefense research is essential for the prevention, detection, and management of biological threats and infectious diseases from harmful biological agents. Over the last century, the focus of biodefense research has been redefined due to modern advances in biotechnology. Specifically, a biological revolution where novel genes are been generated via editing and synthetic biology technologies is transforming modern medicine [2]. The threat of bioterrorism, in which biological agents are used by extremists as weapons against civilian populations, is a matter of concern to countries. Nations and dissident groups exist that have both the motivation and access to skills to selectively cultivate some of the most dangerous pathogens and to deploy them as agents in acts of terrorism. Although a bioterrorist attack is difficult to predict, the consequences of a successful attack could be devastating and cannot be ignored easily [3].

Bioterrorism is the intentional release or threat of release of biological agents (i.e. viruses, bacteria, fungi or their toxins) in order to cause disease or death among human population or food crops and livestock or to terrorize a civilian population or manipulate the government [4]. Popular scenarios of bioterrorism, that may have some mythical origins and cinematic Hollywoodian links, include the use of psychotic substances to contaminate food; the use of toxins and poisons in political assassinations; raids with crude biological cloud bombs; use of dried viral preparations in spray powders; and low-flying cruise missiles adding destruction and havoc with genetically-engineered micro-organisms. The rise of bioterrorism as a priority item on the agendas of international gatherings and co-operation is now being reflected in the establishment of verification procedures to guard against contravention of the Biological and Toxin Weapons Convention, and in institutionalizing a desirable and much needed state of preparedness. Around the world, there have been a surge in funding researches that will invent defensive measures against the abuse of this agents by disgruntled organizations like Al-Qaida or even Boko Haram in Nigeria.. Public awareness of the growing threat of bioterrorism in the USA for instance has been gathering momentum over some time now [5]. Development of national

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preparedness and emergency response focus in essence, on the co-ordination of on-site treatment of the incapacitated and wounded, on-spot decontamination of the affected environment, detection of the type and character of the biological agent, and its immediate isolation and neutralization. This paper therefore, is going to examine the concept of bioterrorism and its current state as a real threat to global security and how the knowledge of modern biotechnology could be used to develop biodefense strategies against it. It's pertinent to state here that both phenomenons are two sides of the same coin.

Biowarfare

The advancement of knowledge especially in the sciences has made warfare more remote but more dangerous than the classical physical combat of ages past. This is because of the array of armaments deployed by warring parties. Biological, chemical and nuclear weapons possess the common property of wreaking mass destruction due to their effect over larger areas than the conventional bullets and bombs. Another consideration is that several biological agents' e.g. toxic metabolites produced by either micro-organisms, animals or plants could also be produced via normal chemical synthesis [6]. One main feature of a typical biological warfare is the undermining and destruction of economic progress and stability. The emergence of bio-economic warfare as a weapon of mass destruction can be traced to the development and use of biological agents against economic targets such as crops, livestock and ecosystems. Furthermore, such warfare can always be carried out under the pretexts that such traumatic occurrences are the result of natural circumstances that lead to outbreaks of diseases and disasters of either endemic or epidemic proportions. Biological and chemical warfare share several common features. A rather comprehensive study of the characteristics of chemical and biological weapons, the types of agents, their acquisition and delivery has been undertaken by a number of researchers [7]. Formulae and recipes for experimenting and fabricating both types of weapons results from increasing academic proficiency in biology, chemistry, engineering and genetic manipulations. Both types of weapons, to date, have been used in bio- and chemo terroristic attacks against small groups of individuals.

Several other factors make biological agents more attractive for weaponization, and use by terrorists in comparison to other weapons. Production of biological weapons has a higher cost efficiency index since financial investments are not as massive as those required for the manufacture of chemical and nuclear weapons. Again, lower casualty numbers are encountered with bigger payloads of chemical and nuclear weapons in contrast to the much higher numbers of the death that result from the use of invisible and microgram payloads of biological agents. To a great extent, application or delivery systems for biological agents differ with those employed for chemical and nuclear weapons. With humans and animals, systems range from the use of live vectors such as insects, pests and rodents to aerosol sprays of dried spores and infective powders. In the case of plants, proliferation of plant disease is carried out through delivery systems that use propagative material such as contaminated seeds, plant and root tissue culture materials, organic carriers such as soil and compost dressing, and use of water from contaminated garden reservoirs. In terms of lethality, the most lethal chemical warfare agents cannot compare with the killing power of the most lethal biological agents. Amongst all lethal weapons of mass destruction -chemical, biological and nuclear, the ones most feared are bioweapons [5].

Biological agents listed for use in weaponization and war is many. Those commonly identified for prohibition by monitoring authorities are the causative agents of the bacterial diseases anthrax and brucellosis; the rickettsial disease Q fever; the viral disease Venezuela equine encephalitis (VEE), and several toxins such as enterotoxin and botulinum toxin [8]. Despite the use of biological agents in military campaigns and wars, it is only since the mid-1980s that the attention of the military intelligence has been attracted by the spectacular breakthroughs in the life sciences like Biochemistry and Molecular Biology. Military interest in harnessing genetic engineering and DNA recombinant technology for updating and devising effective lethal bioweapons has been spurred on by availability of funding in many advance countries, even in times of economic regression.

Bioweapons

A bioweapon simply refers to any agent from a living organism with the potential of been used as a weapon in war or terrorist attack. Although bioweapons have been used in war for many centuries, a recent surge in genetic understanding, as well as a rapid growth in computational power, has allowed genetic engineering to play a larger role in the development of new bioweapons. In the bioweapon industry, genetic engineering can be used to manipulate genes to create new pathogenic characteristics aimed at enhancing the efficacy of the weapon through increased survivability, infectivity, virulence, and drug resistance. While the positive societal implications of improved biotechnology are apparent, the "black biology" of bioweapon development may be "one of the gravest threats we will face" [9]. They are characterized by a dual-use dilemma. On a lower scale, a bioweapon production facility is a virtual routine run-of the-mill microbiological laboratory. Research with a microbial discovery in pathology and epidemiology, resulting in the development of a vaccine to combat and control the outbreak of disease could be intentionally used with the aid of genetic engineering techniques to produce vaccine-resistant strains for terroristic or warfare purposes. The best known example, reported by united nation scientific commission (UNSCOM) is the masquerading of an anthrax-weapon production facility as a routine civil biotechnological laboratory in some parts of the world. In summary, the dual-use dilemma is inherent in the inability to distinctively define between offence -and defense- oriented research and development work concerning infectious diseases and toxins. Whilst progress in immunology, medicine, and the conservation of human power resources are dependent on research on the very same agents of infectious diseases, bans and non-proliferation treaties are associated with the research and production of offensive bioweapons [10]. Genetic engineering information emanating from it are increasingly open to misuse in the development and improvement of infective agents as bioweapons. Such misuse could be envisaged in the development of antibiotic-resistant micro-organisms, and in the enhanced invasiveness and pathogenicity of commensal. Resistance to new and potent antibiotics constitutes a weak point in the bio-based arsenal designed to protect urban and rural populations against lethal bioweapons. An attack with bioweapons using antibiotic-resistant strains could initiate the occurrence and spread of communicable diseases, such as anthrax

and plague, on either an endemic or epidemic scale.

Bioterrorism and Biotechnology

"Bioterrorism refers to the intentional release of biological agents or toxins for the purpose of harming or killing humans, animals or plants with the intent to intimidate or coerce a government or civilian population to further political or social objectives" [6]. The earlier belief that bioterrorism is not a serious threat has been proved wrong. It is evident from recent events that bioterrorism is not a myth but a reality. The threat from bioterrorism is real, with current reports indicating that individuals, terrorist groups and criminals have both the capability and intention to use biological agents to cause harm to society. Access to knowledge and data is also increasingly available through the Internet, and criminals use hidden and anonymous streams of communication, such as the Darknet, to buy, sell and share data and communicate with each other. The damage caused by such an event could reach untold magnitude, causing widespread illness and death, and instilling fear and panic on a global scale [11].

Biotechnology can be used by committed terrorist groups to produce microorganisms that are capable of large scale morbidity and mortality. Incidents of bioterrorism in the last three decades fortunately have been rare. In the USA, the most publicized case is that of the deliberate contamination of salad bars in 1984, with Salmonella typhimurium, an intestinal pathogen. The bioterroristic act, carried out by members of the Rajnaashee cult in Oregon, was aimed at securing an electoral result by incapacitating voters lacking empathy with the cult's preferential candidate. This outbreak of salmonellosis and that of shigellosis are documented examples of bio-threats to public health. Reporting of such cases have often been rare since credence was generally attributed to the more common occurrence of food infection or food intoxication rather than to the criminal, and intentional, contamination of food supplies and catering facilities [12]. In another well publicized case, the Japanese Aum Shinrikyo sect released the nerve agent sarin in a Tokyo subway in 1995 following failure to obtain the Ebola virus for weaponisation in 1992 from (then) Zaire, and inability thereafter to release anthrax spores from a building, and botulinum toxin from a vehicle. There have been a number of other isolated cases of bioterrorism but the anthrax incidence immediately after the attack on the world trade centre in the United States still remains fresh. The explosion of knowledge in molecular biology stems from three main discoveries. These discoveries were the discovery of DNA structure, the polymerase chain reaction and the human genome project. The initial discovery of the structure of DNA by Watson et al paved the way for the discovery of the polymerase chain reaction. This in combination with the human genome project which allowed scientists to copy, mutate, sequence and manipulate DNA. In addition to the human genome, the sequences of several other microorganisms are freely available on the Internet. This knowledge of molecular biology and genomic structure has helped greatly in the construction of dangerous pathogens [3].

Bacteria, mycobacteria and viruses are prone to genetic manipulation. In an attempt to understand why tuberculosis remains latent in some infected individuals, a group of researchers described the creation of a hypervirulent mutant strain of tuberculosis. Genetic manipulation brought out a strain that side stepped the mouse immune system. Similar experiments have been carried out with protozoa like Leishmania major. This only goes on to prove that manipulation of known microbiological agents is not in the realm of science fiction any more. Microorganisms can be modified to be more pathogenic or to weaken the host immune system so that they can proliferate and create an uncontrolled infection. The above description briefly outlines how it is possible to create lethal microorganisms using easily available methods. It would be wrong to assume that the methods would be limited to legitimate research laboratories alone. Most of the techniques used are easily available and can be reproduced in the average laboratory by disgruntled elements.

The growing accessibility of DNA synthesis capabilities, computational power, and information means that a growing number of people will have the capacity to produce bioweapons. Scientists have been able to transform the four letters of DNA-A (adenine), C (cytosine), G (guanine), and T (thymine)-into the ones and zeroes of binary code. This transformation makes genetic engineering a matter of electronic manipulation, which decreases the cost of the technique. According to United States former Secretary of State Hillary Clinton, "the emerging gene synthesis industry is making genetic material more widely available. A crude but effective terrorist weapon can be made using a small sample of any number of widely available pathogens, inexpensive equipment, and college-level chemistry and biology." Scientists and genetic engineers are considering several techniques to increase the efficacy of pathogens in warfare which is capable of being used by terrorist as well.

Biodefense and Biotechnology

Biodefense and bioterrorism are actually two sides of the same coin. In fact both of them are from common origin with biotechnology playing major role in each. The two concepts could be liken to a "virus (Bioterrorism) and an antivirus (Biodefense)". It is easy for the bioterrorist to manipulate the microscopic world for his benefits. However, it is equally easy for the biotechnologist to detect the organism and institute appropriate actions. There are still some challenges which are unique to bioterrorism and others are common for all testing situations. Ideally, detection platforms should be capable of rapidly detecting and confirming bio threat agents, including modified or previously uncharacterized agents, directly from complex matrix samples, with no false results. Furthermore, the instrument should be portable, user-friendly and capable of testing for multiple agents simultaneously. Such an instrument is yet unavailable. It's imperative to know that bioterrorist attacks could be caused by virtually any pathogenic microorganism. However microorganisms (like virus, bacteria, fungi) or toxins to be effective as a bioterrorist agent must consistently produce a given effect, death or disease, at low concentrations. The agent should be highly contagious, have a short and predictable incubation period and the target population should have little or no immunity against the organism. The agent should be amenable to economic mass production, difficult to identify in the target population and little or no prophylaxis or treatment should be available with the native population. In view of this therefore, strong public health and biodefense research is essential for the prevention, detection, and management of biological threats and infectious diseases.

Rapid advances in next-generation sequencing (NGS)

technologies have helped improved biodefense research by enabling the development of new methods for identifying and characterizing pathogens. Amplification and sequencing of the 16S rRNA gene allow for high-throughput detection of prokaryotic communities, while shotgun metagenomic sequencing approaches capture the composition and functional potential of multi-domain populations. Metagenomic analyses used for pathogen detection and identification are often time sensitive. The results help inform high-stakes decision-making, such as choosing an appropriate medical treatment, deciding if a food product should be recalled due to contamination, or determining if an area should be shut down due to a suspected act of bioterrorism. In addition, geospatial and temporal metagenomic analyses are essential for tracking the dynamic responses of microbial populations to changes in environmental or human health. However, improvements in precision, sensitivity, speed, cost, and accuracy of NGS and downstream analyses are very necessary for effective utilization in biodefense research [13].

As biotechnology becomes increasingly globalized, it is important to devise new methods and tools for infectious disease detection and surveillance that will help protect against bioterrorism and manage disease outbreaks. Bioterroristic risks are minimized through effective responses built around the development of preventive and control measures to contain, control, and eradicate outbreaks of travel-related vaccine preventable diseases.

Public Health Emergency Preparedness and Response to Bioterrorist Attack

The responsibilities of public health agencies are surveillance of infectious diseases, detection and investigation of outbreaks, identification of etiologic agents and their modes of transmission and the development of prevention and control strategies. The measures needed to prevent and control emerging infections are strikingly similar to those needed to check the threat of bioterrorism. Maintaining effective disease surveillance and communication systems are fundamental components of an adequate public health infrastructure. Ensuring adequate epidemiologic and laboratory capacity are prerequisites to effective surveillance systems. One approach to early detection is "syndrome surveillance", in which electronic symptom data are captured early in the course of illness and analyzed for signals that might indicate an outbreak requiring public health investigation and response [14]. Syndrome surveillance has been used for early detection of outbreaks to follow the size, spread and tempo of outbreaks, to monitor disease trends and to provide reassurance that an outbreak has not occurred. Syndrome surveillance systems seek to use existing health data in real time to provide immediate analysis and feedback to those charged with investigation and follow-up of potential outbreaks. The public health approach to bioterrorism must begin with the development of local and state-level plans. Close collaboration between the clinical and public health communities is also critical. To effectively respond to an emergency or disaster, health departments must engage in preparedness activities..

Conclusion

"There are those who say: 'the First World War was chemical; the Second World War was nuclear; and that the Third World War - God forbid - will be biological'. Bioterrorism remains a legitimate threat both from domestic and international terrorist groups. From a public health perspective, timely surveillance, awareness of syndromes resulting from bioterrorism, epidemiologic investigation capacity, laboratory diagnostic capacity and the ability to rapidly communicate critical information on a need to know basis to manage public communication through the media are vital. Ensuring adequate supply of drugs, laboratory reagents, antitoxins and vaccines is essential. Formulating and putting into practice Standard Operating Procedures (SOP)/drills at all levels of health care will go a long way in minimising mortality and morbidity in case of a bioterrorist attack. The threat of biological warfare seems remote to most industrialized and developing nations. However, the threat of bioterrorism, in which biological agents are used by extremists as weapons against civilian populations, is a matter of concern. Nations and dissident groups exist that have both the motivation and access to skills to selectively cultivate some of the most dangerous pathogens and to deploy them as agents in acts of terrorism. Since Terrorists groups work in close network, it will be suicidal to underestimate what our local terrorists like Islamic state in West Africa (ISWAP) can do with such tool at their disposal. Although a bioterrorist attack is difficult to predict, the consequences of a successful attack could be devastating and cannot be ignored. Bioterrorism and its effects can impose heavy demands on the public health care system which will be called upon to handle the consequences. An effective public health care system with strong disease surveillance, rapid epidemiological and laboratory investigation, efficient medical management, information, education and communication (IEC) will be required to counter any act of covert or overt bioterrorist attack nationally or internationally.

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