

Dark Biotechnology: Reminding the Imminent Threats for World Largest Food Producers During COVID-19 Pandemic Situation



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Abstract

Dark Biotechnology is related to biocrimes, bioterrorism, biowarfare, bioweapen, and the study of anticrop warfare toxins and microorganisms that affects humans, livestock and crops. This article aims to study the events related to bioterrorism, especially in Brazil, one of the largest food producers in the world to enlighten the importance of the awareness about this issue. Bioterrorist attacks against food producers such as Brazil and the USA can impact the global food supply and affects millions of people simultaneously such a virus as SARS-COV-2, which we were not, and in some countries are still not, prepared for it. Important safety aspects applied in the agricultural sector can help in cases of accidents or intentional acts against animals and plantations intended for population consumption and therefore should not be ignored. In this context, it is important to build and apply appropriate instruments for the sectors responsible for security in food producer's countries such as Brazil and the USA and other largest food producers in the world.

Keywords: Dark Biotechnology Biosecurity; Biotechnology; Biodefence; Bioterrorism; Agroterrorism

Introduction

In general, the biotechnology area encompasses the management of animals, plants, and microorganisms, to offer products, services, and processes of social interest [1]. It comprises different subareas including, among others, biotechnology applied to health, applied to agriculture and livestock, environment, and industry. Thus, it is possible to highlight that biotechnology can impact the production of vaccines, biofuels, improvement of agricultural and animal production [2]. Biosafety composes one of the several subdivisions of biotechnology with a focus on research, and investigation [3] and includes a wide range of activities aimed at ensuring human, animal, and environmental security [4]. Bioterrorism is a part of the biosafety area, in which the misuse of microorganisms can have negative impacts on the population, with repercussions on the economy in general or on the physical or psychological well-being of these individuals [5].

The literature reports that bioterrorism intentionally uses biological agents or derivatives of these agents, which can cause material damage and potential mortality and morbidity to the population. In addition, it can affect the civilian population and military, animal, or agriculture [6]. Bioterrorism is also described as a tactic of war used for human survival in the very beginning of humanity. One of the first records goes back to Neanderthal man, who infected the arrows at the end of his spears with animal feces, to increase the lethality potential of his weapon. In another record, during the expansion of the Roman Empire, legionnaires used animal carcasses in a putrefaction state to contaminate the water of people that resisted the expansion of the Empire [7]. According to Christian [5], bioterrorism can also affect humans indirectly, through attacks on animals or crops, through agroterrorism. The food producers' countries play an essential role in feeding

the world population. Brazil is considered the world-leading producer and exporter of several important and essential foods such: soy (grain and bran), orange, sugar, coffee, cotton, and pork. It is the second in the production of beef and chicken meat and the greatest exporter of these meats. In addition, it also ranks third in the world in the production and export of corn [8].

One of the first records of biological attacks in Brazil dates from 1815 and occurred in Caxias, a municipality in the state of Maranhão. On that occasion, the Canelas Finas Indians received utensils and clothes from local authorities that were contaminated by the smallpox virus. This event was considered one of the first intentional contaminations by the smallpox virus registered in Brazil [9]. However, Brazil history only reports fewer victims and deaths caused by the intentional use of biological agents. This history profile leads to low interest in developing strategies related to biological defense, involving counter-attack and/or defense weapons, which also encompass biological issues [9]. Considering the important role of Brazil in the world-food-production chain and the large impact of a bioterrorist attack [8], this research aimed to evaluate agroterrorism and threats that can reach countries like Brazil.

Possible Pathogens as Bioterrorist Threats

For a pathogenic biological agent to be considered effective and with possible use as a biological weapon, some requirements need to be met, according to Schatzmayr [10]:

1. the agent must be able to consistently exert a certain effect;
2. the dose needed to produce this effect have to be low;
3. the incubation period must be short and well defined;
4. the target population must not have immunity for the agent;
5. the treatment of affected individuals must not be readily available;
6. it must be possible to produce the agent in large quantities;
7. it must be possible to disseminate the agent efficiently;
8. the agent must be stable, in order to allow his guard and transport to the areas of use.

As a form of defense, three types of actions that any nation must master to have a counterattack and defense power are described as essential:

- a) rapid presumptive clinical diagnosis and laboratory confirmation,
- b) immediate treatment of the first cases and
- c) the use of vaccines, when available, for the protection of populations in contact with the first cases [10].

Table 1: Classification of biological agents, according to the criteria defined by CDC.

Category	Characteristics	Diseases/Agents
A	They are high-priority biological agents, which include a risk to national security. - Can be easily disseminated or transmitted from person to person. - result in high mortality rates and have the potential to have a major impact on public health; - can cause public panic and social unrest; - require specific actions for the preparation of public health.	Anthrax (<i>Bacillus anthracis</i>); Botulism (<i>Clostridium botulinum</i> toxin); Prague (<i>Yersinia pestis</i>); Smallpox (<i>Variola major</i>); Tularemia (<i>Francisella tularensis</i>); Viral hemorrhagic fevers: 1-Filoviruses (Ebola, Marburg); 2-Arenaviruses (Lassa fever, Machupo)
B	It is the biological agents that occupy the second place in priority. - They are moderately easy to spread; - moderate rates of morbidity and low mortality rates;	Brucellosis (<i>Brucella</i> spp.); Epsilon toxin from <i>Clostridium perfringens</i> ; Threats to food security (<i>Salmonella</i> spp., <i>Escherichia coli</i> O157: H7, Shigella); Glanders (<i>Burkholderia mallei</i>); Melioidosis (<i>Burkholderia pseudomallei</i>); Psittacosis (<i>Chlamydia psittaci</i>); Q fever (<i>Coxiella burnetii</i>); Toxin from <i>Ricinus communis</i> (castor bean); Staphylococcal enterotoxin B; Typhus fever (<i>Rickettsia prowazekii</i>); Viral encephalitis (alphaviruses, such as encephalitis eastern equine, Venezuelan equine encephalitis virus and Western equine encephalitis); Threats to water security (<i>Vibrio cholerae</i> , <i>Cryptosporidium parvum</i>)
C	They are emerging biological agents, which can be manipulated in order to achieve mass dissemination, due to: -Availability; -Ease production and dissemination; - Potential to cause high rates of morbidity and mortality.	<i>Nipah virus</i> ; Hanta virus; Yellow Fever Virus; multi-drug resistant tuberculosis.

Source: Adapted from CDC [12].

There is an extensive variety of biological agents that can be used as weapons in bioterrorist attacks. Among these microorganisms, it is possible to mention bacteria, fungi, viruses, chlamydiae, rickettsiae, mycoplasmas, prions, parasites, cell lines and other organisms with the ability to self-reproduce or be used for genetic modification, causing deaths or diseases in human beings, animals, and plants. In addition to contamination of food, water and soil, capable of preventing the production of materials or the self-subsistence of a certain population [11]. Biological agents are classified into three categories (A, B, and C) according to the Centers for Disease Control and Prevention (CDC) (Table 1). According to this classification, they are divided according to their potential for infectivity, virulence, lethality, pathogenicity, incubation period, stability, and transmissibility [12]. Thus, it appears that the number of pathogenic agents that can be used as a biological weapon is significant. However, even those with high lethality and destruction power need to be properly packed, transported, and released in a given attack area. In addition, they must maintain the proportions of lethality and morbidity, which requires a lot of research to reach this level of efficiency [13].

Biotechnology: From the Production of Good and Services to Biological Weapons

Biotechnology is based on the production of goods and

services, from the use of scientific knowledge for health, well-being, and improvement of daily living conditions [2]. However, they can be used as a basis for the production of biological weapons, that can destabilize a population economically and psychologically, whether for political, social, ideological, religious, or economic reasons [14,15]. Due to the diversity of biotechnology applications, a classification the system has been proposed. This system is based on colors to subdivide biotechnology [3] (Table 2). To restrict the advance in the production and use of biological weapons, a worldwide Convention, such as the one that took place in Geneva in 1925, is still and established the Geneva Protocol, which prohibited the use of chemical and bacteriological weapons. This Protocol did not include viruses as a form of destructive weapon, because these microorganisms were not differentiated from bacteria. It is important to consider that this ban was related only to the use, but not to the research or development of this type of weapon [9,16]. Given the scenario, Brazil is similar to other food producers countries belatedly adhered to the Geneva Protocol of 1925 through Legislative Decree 39 of 1970 [17], which was promulgated by Decree 67,200 (1970) [18]. The Convention for the Prohibition of Bacteriological (Biological) Weapons and Toxins and their Destruction was created in Brazil in 1972, which was approved by Legislative Decree no. 89 of 1972 [19] and promulgated by Legislative Decree nº. 77,374 of 1976 [20, 21].

Table 2: Color-based representation of the subdivision of biotechnology area.

Color	Subarea	Examples
Red	Healthcare/Medicine	Production of vaccines and antibiotics
Yellow	Food Production	Genetic modification of foods to improve nutrition
Blue	Marine resources	Raw materials for food production such as hydrocolloids
Green	Agriculture	Plant cloning and <i>in vitro</i> cultivation
Brown	Arids lands and deserts	Innovation, creation of agricultural techniques, and resource management in desert environments.
White	Industry	Development of products or processes more sustainable than those already offered such as biofuels
Black	Biosafety	Development of biological weapons: bioterrorism
Gray	Environments protection	Animal protection, such as the use of microorganisms for water decontamination
Gold	Data processing	Bioinformatics and nanobiotechnology such as biosensors
Purple	Ethical, philosophical, and legal area	Patents and inventions records

Since then, Brazilian legislation has classified, as sensitive goods, biological materials that are potentially lethal and capable of being used as weapons of mass destruction. Brazilian Law 9,112 of 1995 [21] treats sensitive goods, defining them as being used in the biological, chemical, nuclear and missile areas, and can be used peacefully or for war purposes [22]. According to Law 9,112, the Interministerial Commission for Export Control

of Sensitive Goods was created, composed of representatives of federal agencies coordinated by the Ministry of Science, Technology, and Innovations of Brazil [21]. They are supposed to be in charge of controlling research related to the manipulation of biological agents for both civil and military uses and are listed by the Commission for Export Control of Sensitive Goods Resolution 13 (2010). This control also includes equipment that may be

used for production, storage or to disseminate biological agents. They also manage international monitoring conventions and treaties related to disarmament and control of weapons of mass destruction. In addition, it has the responsibility to follow up on the export policy regarding sensitive goods [23].

Among the few actions developed to combat bioterrorist attacks, Brazil has invested in epidemiological and clinical-based surveillance strategies to monitor cases of emerging and reemerging infectious diseases. This proposal was carried out by the Ministry of Health in 1995, through the Brazilian Project for Scientific and Technological Training of Emerging and Re-emerging Infectious Diseases. Among the actions developed by the Ministry of Health for the surveillance strategy, the training of health professionals belonging to the public health network and the implementation of laboratories with adequacy to the required safety level were carried out [9,16]. Another action developed by the Brazilian government apparatus, aiming the food security, was the implementation of the National Program of Pathogens Control, through the Ministerial Ordinance, nº 17/2013. This originated a link between the Academy and the Government, with the objective of improving the management related to microbiological inspection in Brazil. However, only three pathogens are monitored by the National Program of Pathogens Control: *Listeria monocytogenes*, *Escherichia coli* and *Salmonella* [24].

Brazil has laboratories with Biosafety Level-4 (BL-4) aimed at diseases capable of affecting animals destined for human consumption. In these laboratories, microorganisms capable of causing cause a great impact in the agricultural sector are studied, such as the foot-and-mouth disease, lethal to cattle and that can cause enormous damage to Brazil since its agriculture has a great impact on its economy. Therefore, the importance of handling these types of microorganisms at the BL-4 laboratory, minimizing, to the maximum, any type of contamination that can cause economic problems and/or losses in food production, significantly impacting the Brazilian agricultural sector [25]. In the context of bioterrorism, other subareas of biotechnology are important, as to allow interaction among professionals from different areas. These professionals can assist in the construction of devices, products and services that can be used to contain and/or mitigate the effect of the spread of pathogens on society [13,26].

Agroterrorism

Agroterrorism is a technical term used to characterize the intentional use of a biological agent as a weapon in attacks on the agricultural sector. Throughout history, records of this type of attack indicate that its main objective is to exploit the enemy's weaknesses in official wars [5,27]. An example is Germany in the First World War, which used some pathogens to attack the animals used by the United States of America (USA). Some attacks against animals such as horses and mules that were used by the Allies in European territory used the Anthrax and Glanders pathogens.

Although the first attempt failed, the Germans did not give up and carried out another attack with the same pathogens in New York City and Maryland in the USA [27]. These attacks are not exclusive of military forces and there are records of civilian groups that used this form of attack to weaken the economies of those who were considered their oppressors. Some of these attacks have been described throughout the 20th century, according to data in Ryan's research. The author showed that during the 20th century there were at least nine attacks on agriculture with characteristics of agro-terrorism [27].

Among them, there is that one verified in Brazil, in the state of Bahia, in 1989, which a devastating infection against cocoa, known as witch's broom, was discovered, by technicians, during a routine inspection. This plague did not exist, until then in the region, considered the main cocoa producer in the country [25]. At first, it was believed to be an isolated case, but this plague spread quickly, over the next three years, through the region's cocoa plantations leading to the suspicion that Brazil might have suffered attacks from other cocoa producers such as those from Côte d'Ivoire, Africa and Ghana. Thus, a huge decrease was observed in Brazilian competition capacity, since national cocoa production was reduced by less than half. This caused Brazil to lose its second position as the world largest cocoa producer, forcing the country to become an import of fruit. The fact was investigated by the Brazilian Federal Police, but the investigations were closed with no answers [28].

Given this historical overview, it is possible to verify that agro-terrorism is a non-remote attack option to affect the economy of any opponent. This can be justified by several pathogens with the potential for attack exists in natural reservoirs. In addition, there may be a lack of structure to combat and react to this type of attack. It is also important to consider the vulnerability of the agricultural sector, as the diseases that infect the animal population or agriculture, generally spread easily, quickly, and widely. This is due to the transport dynamic of these products where they are transported among the various regions of the country and/or being exported during marketing negotiations. There is also the possibility of contamination of a natural vector, used as a biological product. As the use of a biological vector is a common practice in Brazil, it would be difficult to detect the disease and identify the aggressor. In addition, the incubation period for this agent may allow it to spread during the period when there is no clinical manifestation [9,28].

Bioterrorism In Asymmetric Wars - The Potential Brazilian Risk

The atomic bomb became a weapon that stimulated the development of other types of attacks by nations or groups with structural limitations and/or limiting policies. This has caused a warming of wars and bioterrorist attacks, which present themselves as effective weapons of attack together with chemical

weapons in the globalized world society [9,28,29]. Among the available weapons, capable of widespread destruction, biological weapons are the ones that most concern those responsible for these countries' security. Food production systems of animal origin and agriculture are the most vulnerable to threats of attacks by pathogens. Generally, these agents cause devastating scenarios when disease outbreaks occur in animals, or plants, whether naturally, accidentally or intentionally caused [27]. When considering this new war scenario, the Brazilian Intelligence Agency (ABIN) defended the need to improve Brazil's response and ways of preventing possible chemical and biological threats, including laboratory accidents or attacks by extremist groups, using chemical weapons, and practicing agroterrorism [30].

According to ABIN, Brazil was in a highly vulnerable situation. Among the factors, can be highlighted the lack of a list of agents that should occupy a prominent place concerning the control and intersectoral policies, as in other countries where there was communication among the sectors involved in security, defense, intelligence, and health [29]. In addition, another vulnerability pointed out is the risk of non-state threats being, in many cases, greater than a state threat since Brazil adopts in its foreign policy the strategy of non-intervention and peaceful resolution of its conflicts. This posture facilitates the action of extremist groups, internal or external, for the use of chemical or biological weapons [30]. Thus, Brazil is in an alarming situation, considering the hypothesis of accidental or deliberate dispersion of a pathogen, aiming to destroy the country economy. As an example, any type of plague capable of affecting soybean agriculture or cattle herd. This concern is since Brazil is one of the largest exporters of beef meat. In the period from January to September 2019, Brazil grew 9.2 % in its exports, reaching a revenue of US\$ 4.9 billion. About soybean production, Brazil, in June 2019, reached productivity of 3,206 kg/ha, is considered the second-largest grain producer in the world, which represents something around US\$ 8.172 billion. Thus, the spread accidental or intentional of a biological agent could cause serious damage to the economy country economy and its stabilization [31,32].

Bioterrorism also can cause panic in society. Agroterrorism can lead to the idea of food scarcity for the subsistence of the population, in addition to the possibility of becoming ill through the consumption of these food products. This news can lead the population to great anxiety and, consequently, social destabilization [33]. It should be noted that outbreaks of diseases in animals or plants threaten the supply of food to the population of the country, and the trade that the nation establishes in international relations. This can lead to losses of great proportions for the national economy. A biological threat to the agricultural sector can mitigate people's confidence in their government seeing them as an obstacle to assure human health and well-being [27]. The agricultural sector is a strategic sector for large nations, which can be seen not only in studies carried out in the USA [27] but also in large nations that make up the BRICS, such as Russia

[34] and China [35]. Studies point out that the application of security and defense is essential for the protection of agribusiness in these countries [34,35].

In the face of these data and the growth of terrorism and asymmetric wars, in which the differences between the opponents are financial, military, objective, etc. and they are generally irregular wars (i.e., guerrillas), therefore it is of huge importance to protect the agricultural sector aiming to maintain the economic integrity of the country. Generally, these countries' economic integrity is significantly based on the export of their products in this segment. Thus, investment for an effective defense program becomes essential, aiming at maintaining the sovereignty of Brazil [36].

Impacts of Agriculture and Livestock on the Economy

Independence in agriculture and livestock, as mentioned previously, are important for any society that wishes to remain in a certain territory. For Ryan [27] so hugely important, it is possible to perceive how significant self-sufficiency in food production is for the nation's prosperity. Agriculture and livestock assume a broader influence than they initially appeared from the perspective of self-sufficiency. Agribusiness is the definition of the union of several activities that directly or indirectly involve the entire agricultural production chain. According to data published by the Ministry of Agriculture, Livestock and Supply of Brazil, the last Gross Domestic Product of Brazilian agribusiness in 2018 corresponded to 21.6 % of the national total [37]. Gross Domestic Product related to agribusiness comprises activities related to the creation, production or cultivation of animals in addition to the transformation and distribution activities, (i.e., the entire production chain). The sector is considered essential for the economy of Brazil, as it employs one in three Brazilians [22] This is due to the characteristics of the various links that the agricultural sector maintains with the industry. This is a sector that requires machinery, fertilizers, animal feed, labor, financial services in banks, transportation, packaging, among others, to complete the food production cycle [37]. Thus, disease outbreaks affecting crops and animals using the population's consumption can lead to an immeasurable destabilization of a nation, with loss of human life due to lack of food, thus threatening its independence from other nations [38].

The Brazilian population was estimated, until December 2020, at more than 212 million inhabitants [39], while the estimated world population for the same year is greater than 7.7 billion, according to information from the United Nations [40]. The world population is estimated to reach 9.7 billion people in 2050, with the peak of growth around the end of the current century, reaching 11 billion people. This represents an increase of approximately 43 % in the population over the 80 years [41]. These data show the great challenge that the population will face to avoid food shortages. As Brazil is one of the largest food producers in the world, it is important to protect this wealth and

all the inputs involved in food production [38].

Forms of Attack on Agriculture and Livestock

The World Organization for Animal Health tracks diseases worldwide and establishes rules to control outbreaks and animal diseases in all countries that are members of the Organization. It is an intergovernmental organization considered a reference by the World Trade Organization. It is composed of 182 member countries and maintains relations with 75 other organizations at the regional or international level. The World Organization for Animal Health, in 2005, organized a single list of mandatory reporting diseases, replacing the old A and B lists. In 2006, this list was updated and other pathogens and new ones were added. This change was intended to follow the terminology of the World Trade Organization's Sanitary and Phytosanitary Agreement, and this list is reviewed and updated regularly [8]. This list allows checking the extensive variety of pathogens that have the potential to transmit diseases in such a way as to cause outbreaks or potential damage to people. The characteristics of the pathogen will determine how the disease is transmitted. However, there are three main forms of contamination: through direct contact (i.e. viruses); through the air, (i.e. aerosol) that can reach great distances, and employing vector-insects [27,42]. Among the diseases whose contamination occurs by air, through aerosols are foot-and-mouth disease, avian influenza (which is highly pathogenic) and Newcastle disease. They can cause outbreaks, as they spread over long distances. Airborne diseases such as COVID-19 for humans are the most difficult to contain and the most challenging to create barriers in cases of outbreaks, in addition to being transmitted by direct contact [5,27].

About the diseases that are transmitted only by direct contact, we can cite rinderpest, swine cholera, and African swine fever. These diseases are transmitted through direct contact between animals and direct contact with contaminated objects such as drinking troughs and milking machines. They can also be spread by the clothes, shoes, and equipment from individuals who have had contact with infected animals. These aspects demonstrate the importance of employing an effective biosecurity system, maintaining hygiene, and restricting the traffic of people [27,42]. Regarding disease vectors, insects stand out. But birds, arachnids, mosquitoes or ticks that, when biting a contaminated animal, become hosts of the pathogen and can contaminate healthy animals or humans. In this form of contagion, it is necessary to control insects and arachnids to prevent outbreaks of the disease [5,27]. To avoid economic damage or the internal food supply capacity, as well as to people's health, it is necessary actions of recognition, prevention, isolation, and notification actions are needed, according to the guidance of the World Organization for Animal Health. Brazil is committed to notifying the World Organization for Animal Health of animal diseases, infections, and infestations that are detected in the country for being a founding member of the entity. In 2019, among the diseases capable of

affecting several species, the highest frequency of notifications was about cases of Brucellosis (2116 infections of cattle, which had to be sacrificed) [8]. However, Brucellosis does not belong to the list of the 34 most important diseases to maintain surveillance and combat, contained in the OIE report [8]. The spread of pathogens can be caused in a natural or incidental way, caused intentionally or by the negligence of the professionals involved. However, the implementation and use of complete and structured monitoring protocols are important to reduce these accidents and/or incidents, as well as help front-line professionals, health professionals, in these identifications [43].

Strategies to Prevent Dark Biotechnology

Bioterrorist attacks may not be successful due to several factors, such as technical restrictions, work in secrecy, leading to low technology. Even so, such types of attacks must be anticipated, since they can negatively impact society, directly or indirectly [20]. Yeh et al. [42] corroborated this statement about bioterrorism used against agriculture and animals. The authors pointed out that, despite the difficulty of acquiring pathogens for use in biological weapons, some initiatives should be applied to inhibit this feasible risk situation [42].

Based on the literature one of these initiatives may be the restriction on the acquisition of agricultural pathogens. This restriction must meet the same level of bureaucratic and legal requirements as for human pathogens. It is necessary to establish criteria for this type of acquisition and to communicate to government authorities. This will make it possible to map and control suspected use of microorganisms for purposes other than those officially declared, allowing for more consistent investigations [42]. According to most researchers of bioterrorist attacks aimed at areas of the agricultural sector, the creation of a wide system of early detection promotes favorable conditions for the non-proliferation of pathogens. As well, it makes it impossible for terrorist groups to act in the face of the complex articulated barrier that needs to be overcome [44,45].

For the construction of an early detection system, some steps are considered important. Elbers and Knutsson [44] & Keremidis et al. [45] highlighted that, for early detection to be successful, it is necessary to establish the first line of defense through customs and police, preventing the entry of the pathogen into the territory. The second step is the implementation of effective surveillance systems within the territory since all knowledge about prevailing diseases is the basis for the effective control of potential pathogens.

Another possible way to inhibit attacks of this type would be to reduce the circulation of pathogens capable of affecting animals or the environment, thus making it difficult to obtain them in their natural habitat. This can be achieved with the help of international agencies, allowing different teams to respond on time to outbreaks of animal diseases [42].

The front line of defense, which can be composed of customs

and police aims to be the first means/instrument of the defense mechanism. The work done by this team should have the least possible impact [44,45]. The front line can also be composed of those who work directly with the target of the attack and/or host of the pathogen. In the case of agroterrorism, properly trained farmers/creators should participate to immediately report suspicions of unusual diseases to the competent agencies [42]. However, Yeh et al [42] reported that all detection system must be

integrated for this control to be efficient. It is a fact that it is not enough for frontline workers to act properly if the other steps are not well executed. An example is the Brazilian case of foot-and-mouth disease that was raised as a suspect by livestock farmers. This case, however, was not detected by the competent agencies in time, it caused an outbreak throughout a region, reaching national proportions.

How to Mitigate the Effects of Bioterrorism

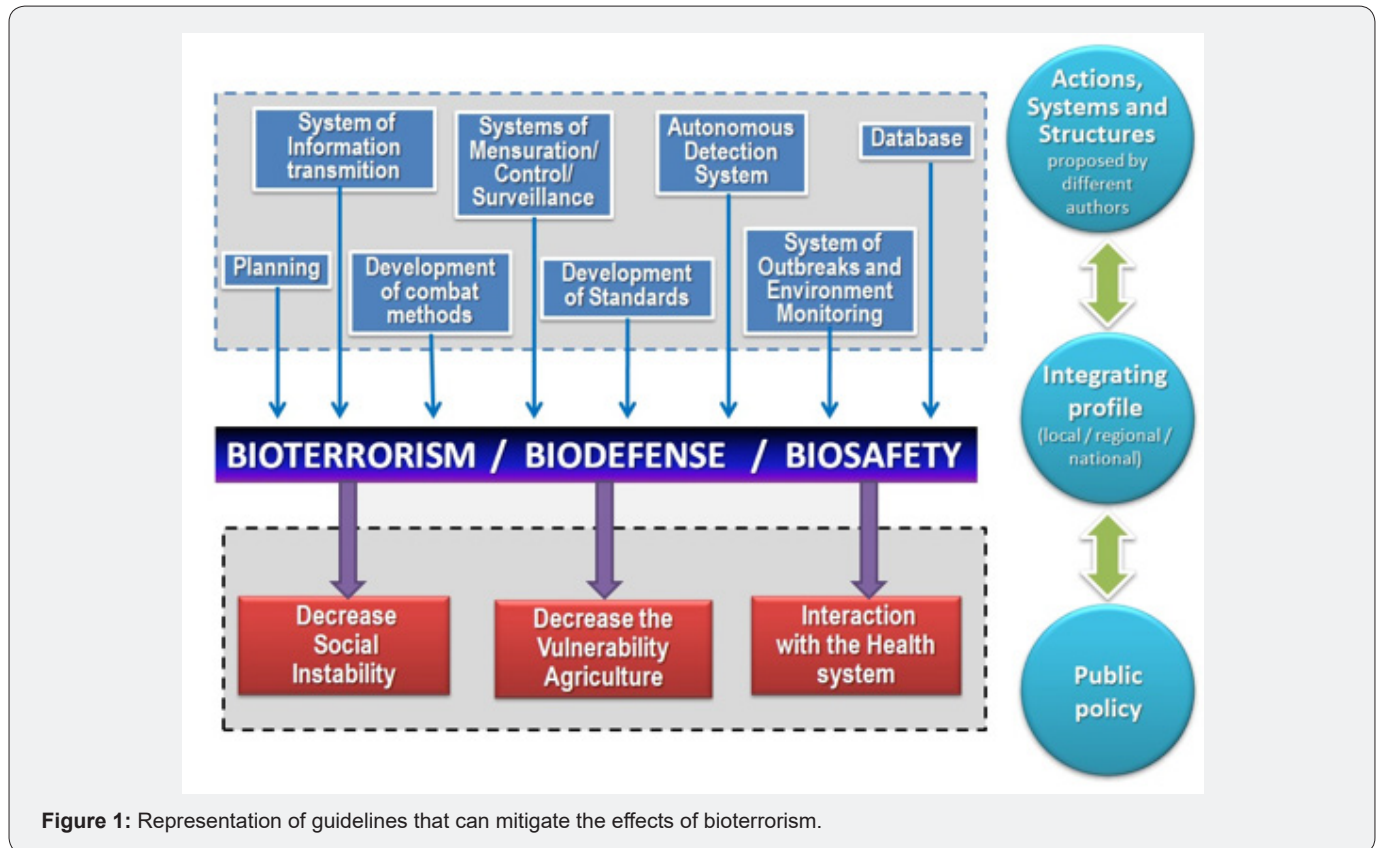


Figure 1: Representation of guidelines that can mitigate the effects of bioterrorism.

To maintain an adequate response to the insecurities that bioterrorism causes (intentional or not), it is possible to establish important guidelines to try to mitigate the effects of actions of a bioterrorist character and the consequences of adopting these guidelines (Figure 1). Planning is essential to fight outbreaks and to ensure the availability of financial resources for the prophylaxis and treatment of a significant number of people. It is also necessary to provide adequate knowledge to identify, carry out the diagnosis, and control of infections [13]. Efficient planning requires the adoption of actions and measures to control diseases, impacting the better attendance to public health demands [14]. However, the execution of planning requires that the transmission of information is effective since this transmission associated with the dissemination of knowledge and the training of professionals working on the front lines allow a more assertive treatment of the victims of bioterrorist attacks [16].

After the execution of the action planning and the dissemination of information, a new knowledge base is built, this makes it possible to minimize social instability since they demonstrate that the authorities know how to deal with bioterrorism cases [15]. It is important to emphasize that bioterrorism should be considered as an imminent risk, and the ethical reflection on the topic should be encouraged [46]. Regarding the development of combat methods, it was observed that permanent preparation based on improving public health, surveillance, training, and education represents the best way to deal with possible outbreaks [33]. Doctors are the first professionals to assist victims of bioterrorism, so They must always keep up to date to recognize possible attacks, with constant vigilance for possible agents who may be involved [29]. However, many countries do not have the financial resources to implement these guidelines to combat outbreaks. In this way, political authorities are demanded to apply

the available resources in the best possible way, to minimize vulnerability, whether in the agricultural sector or human health directly. This demand has led many governments to authorize the use of genetically modified organisms, in an attempt to prepare for and combat possible outbreaks [38]. The establishment of combat methods and surveillance systems with measurement and control can reduce the vulnerability of the agricultural sector to agroterrorism. Empirical data on agroterrorism on the world stage are scarce, which may be explained by the small number of events cataloged from 1945 and 2012 [45]. It must be considered that the attack on the agricultural sector is an imminent possibility, which can have important consequences, given the model of raising large herds [42,45].

Among the strategies, education, and training for health professionals should be included, especially for doctors working in emergencies, as well as for professionals working in the agricultural sector. This preparation makes it possible to detect, make the correct diagnosis and respond to cases of infections or reemerging diseases. From the perspective of integrating bioterrorism control actions with health systems, it is possible to insert the need for constant outbreak monitoring and environmental monitoring [9,26,36]

Finally, there are few studies on the subject, which makes it impossible to build a database with concrete information capable of supporting public policies [47]. Investments in research and vulnerable areas are known to generate more efficient responses, which requires continuously planning [27].

Conclusion

The world largest food producers, such as Brazil and even the USA, need to develop effective government strategies to support the biosecurity system against possible threats. For a quick response in cases of accidents or intentional attacks to these countries' agricultural sectors, there must be a robust and effective technical and legal structure to react to natural endemic situations or those that may have been implemented. The different agencies of health and agriculture must be integrated so that the production of data and information can be available to the federative entities responsible for combating biological threats.

This research pointed out safety aspects that can be applied in agriculture, helping in cases of accidents or intentional acts against animals and plantations destined for human consumption. It also pointed out the multidisciplinary nature of this theme. Ensuring the effective security of the population in the face of bioterrorist events provides more chances of success when articulated with various instances of public and private administration. In general, the best way to prevent possible attacks is through the adoption of policies and supervision, with the construction of an autonomous detection system and environmental monitoring in a broad way [27,43]. In addition to the development and adoption of standards at the individual, social, and/or political levels, the

aim of prohibiting the development and use of weapons with bioterrorist characteristics should be pursued [48].

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