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Disease or bio-warfare? The usage of various pathogens in bio-terrorism

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Abstract: *Although it is a general belief that epidemics of plague, smallpox or yellow fever are highly unlikely nowadays due to the existence of antibiotics and immunization shots, the agents causing the disease have remained a threat due to the possibility of them being weaponized and spread on a large scale. Contemporary terrorism is no longer confined to detonating bombs in buildings of great importance, suicide attacks or airplane hijacking. It can also comprise the usage of pathogens/ biological agents to cause massive health disturbances. The preference expressed towards the usage of such agents is justified by the easy access and primary skills needed in manufacturing a weapon, as well as the high rates of morbidity and mortality among the affected population. Additionally, states are confronted with high healthcare risks due to the fact that such agents are difficult to be detected and often pass as common diseases, such as influenza, until the greater scale of the epidemic is acknowledged by the authorities.*

Keywords: *bio-terrorism, bio-warfare, agents, pathogens, diseases*

I. Introduction

The need to prohibit the use of substances with effects by bioterrorism

It is a fact that bio-terrorism is a type of terrorism, more and more preferred by its perpetrators, due to the facilities it entails: it has proved highly accessible, both from the point of view of the access to materials and the means of manufacturing, as well as due to its impressive effect on the intended target (large number of casualties, within minimum efforts).

We believe that to do anything for recognition and establishing measures to prohibit or real control the use of farm chemicals in criminal purposes against people, communities. [9] Biological weapons are highly toxic, can be used in variable quantities and similar to explosives, they allow for a gradual release of the effects and the intended messages to be transmitted to the target audience [Marret, 2002, 40]. [5] In addition to this, such weapons are highly difficult to detect, as metal and radiographic detectors find it hard to identify a small volume of substances containing a chemical or biological agent, especially should it be in a lyophilized form. This form, as well as the purity and volatility of the products, contributes to the easy dissemination of the respective products [Marret, 2002, 40-41]. [5] The possibility of biological and chemical agents being used as weapons of mass destruction does not simply date back to October 2001, and the anthrax attacks that occurred in the United States at the time. Previous to those, there are other noteworthy attacks or attempts at attacks such as: the spreading of sarine gas in 1995 in the Tokyo subway, by the Aum sect, the arrest in 1972, in Chicago, of a right wing extremist, for possession of 35-40 kg of cultures of typhoid fever, which he intended to throw into the city's water reservoir, the deliberate contamination of salads in a restaurant in Oregon with Salmonella, in September 1984, by a sect, while in January 1994, the British Front for the Freedom of Animals mailed various envelopes containing the remains of a syringe infected with HIV [Marret, 2002, 38-40]. [5] Additionally, extensive research has been conducted, both by the United States and the Soviet Union in the Cold War years, in order to establish the potentially strategic and tactical effect of these agents.

The offensive biological weapons research program conducted by the United States, which would be ended in 1969, focused on the following: Bacillus anthracis, botulinumtoxin, Francisellatularensis, Brucellasuis, Venezuelan equine encephalitis virus, staphylococcal enterotoxin B, and Coxiellaburnetti [Kortepeter, Parker, 1999]. [4] On the other hand, the similar research programme conducted by the Soviet Union referred to smallpox, plague, anthrax, botulinum toxin, equine encephalitis viruses, tularemia, Q fever, Marburg, melioidosis, and typhus [Kortepeter, Parker, 1999]. [4]

II. THE BIOLOGICAL AGENTS WHICH CAN BE USED IN WARFARE AS WEAPONS. Their knowledge to combat / eradication use

The criteria which led to these choices of pathogens were infectivity and degree of toxicity, the stability within a regular environment (a critical aspect which contributes to a great extent in the disguising of the pathogen as a regular outbreak of flu, smallpox, etc.), access to large-scale production means and dissemination and the severity of the disease in the long-term.

Throughout time, certain evolutions in the choice of these chemical and biological agents have been recorded, mainly due to the easy access to some of them, as well as the accessibility to the means of mass production. According to the British Medical Journal [2002], [1] there are several conditions to be fulfilled by these biological agents, which would lead to a biological conflict.

Firstly, the employed agent would cause a significant effect – death or disease. Secondly, the agent would be highly contagious and infectious, especially in smaller doses. The incubation period is short and predictable, while the presence of the agent would be difficult to identify within the population in general.
Moreover, the agent is stable during dissemination and a low persistence after delivery, which makes such agents appropriate for mass production, storage and usage as a weapon. In order for a biological agent to become a biological weapon, it needs to be put in a weaponised form/ be weaponised.

In order for an organization/ group of people/ individuals to be able to use such biological agents / pathogens to its advantage it needs to be endowed with "organizational capabilities, adequate finances, logistical support, sufficient knowledge and necessary skills, access to materials and technology, ability to culture and propagate the organism and the capacity to weaponize and deliver the agent" [Christian, 2013, 718]. [3] There are several definitions available as far as biological agents becoming biological weapons are concerned. Such an example of a definition is provided by Jeanne Guillemin [2002, 18] [6] – "Biological weapons refer to munitions, equipment or other means of delivery including bombs, aircraft spray tanks and other devices, intended for use in the dissemination of biological agents and toxins for hostile purposes.

The principal means of dissemination are as an aerosol to be inhaled by a target population or as a spray to be deposited on crop plants. An aerosol is a suspension in air of particles so small that they travel with air currents instead of settling to the ground". As can be easily seen, this definition refers already to the presence of the agents in a weaponised form and the means of dissemination of the respective agents/weapons.
As a result, the current article shall draw an overview of the main agents used in bio-terrorism, beginning with the already acknowledged ones, and ending with the newer agents used currently.

The mention valid for all the presented agents is the fact each of them can be weaponized in various forms and disseminated to a wide extent in order to cause harm. The Center for Disease Control and Prevention (CDC), together with the National Center for Environmental Health (NCEH), Agency for Toxic Substances and Disease Registry (ATSDR) and National Center for Injury Prevention and Control (NCIPC) have created a list of all the biological agents which can be used in warfare as weapons [CDC, 2016]. [2]

Table 1. List of all the biological agents which can be used in warfare as weapons [CDC, 2016]. [2]

List of biological agents and diseases they cause		
Anthrax (Bacillus anthracis)	Emerging infectious diseases such as Nipah virus and hantavirus	Shigellosis (Shigella)
Arenaviruses	Epsilon toxin of Clostridium perfringens	Smallpox (variola major)
Bacillus anthracis (anthrax)	Food safety threats (e.g., Salmonella species, Escherichia coli O157:H7, Shigella)	Staphylococcal enterotoxin B
Botulism (Clostridium botulinum toxin)	Francisellatularensis (tularemia)	Tularemia (Francisellatularensis)
Brucella species (brucellosis)	Glanders (Burkholderia mallei)	Typhoid fever (Salmonella Typhi)
Brucellosis (Brucella species)	Lassa fever	Typhus fever (Rickettsia prowazekii)
Burkholderia mallei (glanders)	Marburg virus hemorrhagic fever	Variolamajos (smallpox)
Burkholderiapseudomallei (melioidosis)	Melioidosis (Burkholderiapseudomallei)	Vibrio cholerae (cholera)
Chlamydia psittaci (psittacosis)	Plague (Yersinia pestis)	Viral encephalitis (alphaviruses [e.g., Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis])
Cholera (Vibrio cholerae)	Psittacosis (Chlamydia psittaci)	Viral hemorrhagic fevers (filoviruses [e.g., Ebola, Marburg] and arenaviruses [e.g., Lassa, Machupo])
Clostridium botulinum toxin	Q fever (Coxiellaburnetii)	Water safety threats (e.g.,

(botulism)		Vibrio cholerae, Cryptosporidium parvum)
Clostridium perfringens (Epsilon toxin)	Ricin toxin from Ricinuscommunis (castor beans)	Yersinia pestis (plague)
Coxiellaburnetii (Q fever)	Rickettsia prowazekii (typhus fever)	
Ebola virus hemorrhagic fever	Salmonella species (salmonellosis)	
E. coli O157:H7 (Escherichia coli)	Salmonella Typhi (typhoid fever)	

All these agents have been ranked by the CDC into several categories, based on their offering potential for biological warfare. Thus, there are three main categories - A, B and C.

Category A comprises agents such as: Bacillus anthracis, Clostridium botulinum toxin, Yersinia pestis, Variola major, Francisellatularensis, Filoviruses (Ebola, Marburg fever, etc.) and Arenaviruses (Lassa, Machupo, etc.) [Christian, 2013, p.720]. [3]

These are considered high-priority agents, posing risks to national security, due to their easily dissemination process, the high mortality and great public health impact, the causing of social disruption and the entailed need of special public health measures to be taken in order to ensure preparedness.

The agents of category Baresecond-highest priority ones and the list comprises: Brucella species, Clostridium perfrigens, Salmonella species, Escherichia coli, Shigella, Burkholderia mallei, Burkholderiapseudomallei, Chlamydia psittaci, Coxiellaburnetii, Ricinuscommunis, Staphylococcus aureus, Rickettsia prowazekii, Alphaviruses(e.g. Venezuelan equine encephalitis, Eastern equine encephalitis, Western equine encephalitis) and water safety threats, such as Vibrio Cholerae and Cryptosporidium parvum, etc. [Christian, 2013, 720]. [3] The placement of these agents in this category is due to the moderate access to their usage and dissemination, rather low mortality and morbidity rates and the fact that they would require enhanced laboratory surveillance of the disease.

A third category – C – includes those pathogens which could be engineered to become weapons of mass destruction in the future, due to the easy access to means of production and dissemination, the impressive health impact they have and risks of high morbidity and mortality. This category includes: Nipah virus, Hantavirus, tick-borne hemorrhagic fever viruses, tick-borne encephalitis viruses, Yellow fever and multidrug-resistant tuberculosis [Christian, 2013, 720]. [3]

Some of these agents have been existing for centuries and have even been, at certain moments in history, used as weapons to exterminate populations – e.g. the American Indians by the Spanish conquistadores. However, the particularly striking element is their continuous use as weapons against both civilian and military forces, and the incapacity of governments to respond to such threats. Below, the author shall refer to some of these agents, by briefly presenting their means of manifestation and their importance to the biological warfare, through the highlighted references to their degrees of mortality.

Anthaxis caused by the *Bacillus anthracis* bacterium, and is a "gram-negative, facultative, anaerobic, nonmotile and spore forming bacterium" [Thavaselvam, Vijayaraghavan, 2010]. [7] The bacterium can be transmitted via wounds, through ingestion or aerosol and is highly resistant to extreme environmental conditions such as humidity, heat, UV radiation and even disinfectants. Moreover, live spores can be formed only in the presence of oxygen (oxygen being thus a conductive channel in the spread) and can survive up to 40 years in water or soil.

Its deadly potential is augmented by the means of transmission. Thus, local inoculation through open wounds is less likely to lead to septicemia and death, unlike ingestion and inhalation through aerosols, where fatality rates range between 25-75% in gastrointestinal cases and 90-100% in case of inhalation [Thavaselvam, Vijayaraghavan, 2010]. [7] The plague is an infectious disease caused by the *Yersinia pestis* bacterium. It is a zoonotic infection caused by an "gram-negative, nonmotile, facultative anaerob" bacterium, existing for centuries, and still manifesting as reports from the World Health Organization show [Thavaselvam, Vijayaraghavam, 2010]. [7] A recent outbreak occurred in September 2014 in Madagascar, with 263 cases of infected people, of which 71 died (as reported in February 2015) [WHO, 2016]. [8] Regular transmission of the disease is through rodent flea bites or by handling an infected rodent. Its manifestation is in the form of bubonic plague, which, in the absence of treatment, is followed by septicemia, and infection of the lungs, which leads to pneumonic plague.

However, in the event of it being used as a biological weapon, the bacilli would be inhaled as an aerosol and would directly lead to pneumonic plague, which is highly contagious and spreads through airborne droplets. Untreated, it can lead to death in 50% of cases. Variola (smallpox) has been eradicated in 1980, but virus strains are still to be found in research labs in the United States and Russia. Its double-stranded DNA structure is responsible for the mutations that could be performed in a laboratory.

Common clinical manifestations include headaches and fever, which makes it often easily mistaken for influenza. The incubation period is 12 days, but in the event of genetically modified strains, could last shorter. In addition to headaches and fever, skin lesions follow and in the lack of treatment, the disease causes multiple

organ failure and then death. The mortality rate is centered at around 30% and given the fact that immunization is no longer available (since the eradication in 1980), the possibility of it becoming a weapon in bio-warfare is a noteworthy threat.

The detection of the usage of such biological agents as weapons can be very difficult, due to their means of manifestation. Thus, in some cases, the diagnosis is stalled as the diseases produced manifest similarly to respiratory deficiencies or a mere influenza. Should the incubation period be longer, by default, and in the event in which the secondary transmission of the disease is made from primary cases, the disease can degenerate in epidemics, and given the common aspects of the disease, it might prove hard to identify the presence of disseminated biological agents on purpose.

Such an example is the rapid spread of the "foot and mouth" disease on animal farms in England. Moreover, the situation becomes even more problematic should genetic engineering be involved, as it can alter the pathogenesis, the incubation period or the clinical syndromes of these biological agents. In such cases, conventional immunization or the presence of antibodies would not be sufficient [BMJ, 2002]. [1]

III. Conclusions

Taking all the above into consideration, there are numerous pathogen agents which could be used by organizations/individuals as potential weapons of mass destruction, in warfare and not only.

The dynamical manifestation of these pathogens, as well as the accessibility to their reproduction and modification are important assets which should be taken into consideration by states when creating national security policies and strategies.

Even though some of these agents have been manifesting independently in some areas – as was the case of the plague outbreak in Madagascar in 2014 – their potential to be weaponized is noteworthy, as detection mechanisms are difficult to be put in place.

An advantage of such agents, which could work in favor of the perpetrators, is that fact that some of the initial symptoms they cause could be easily mistaken for common colds, flu, etc. Thus, even though some of these agents have been existing for centuries, and have shown their maleficent potential in accidental outbreaks and epidemics, and despite the fact that states acknowledge the threat they pose to their national security, no effective mass counter-measures have yet been devised in this regard.

We believe that further studies should be performed, research and identify solutions to neutralize any negative effect derived from the type of substance that could be used for criminal purposes against humanity. also, there is a need for clearer juridical regulation, strong and firm in the field.

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