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WEAPONS OF MASS DESTRUCTION

BIOLOGICAL WEAPONS

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Biological warfare as the intentional use:

* of microorganisms,and toxins, (generally of microbial, plant or animal origin), to produce diseases and deaths among humans, livestock and crops.

Biological warfare and bioterrorism are

- very complex subjects, mainly due to the many agents that can be used as weapon and for the wide range of ways for dissemination into the environment and population.

A biological event provides for the presence of at least two actors:

- ❖one or more pathogens (bacteria, viruses or toxins) and
- ❖a vehicle for their dissemination.

In addition to the high spread capacity and lethality of potential biological agents, their invisibility and extremely difficult short-term detection makes it impossible for immediate diagnosis until the subsequent increase of infections.

Biological warfare: history

The use of biological agents as war weapons is not a modern era novelty.

Although it is not easy to identify a definite time when the use of bioweapons began, ancient evidence reported that

- in pre-Christian era, around 300 B.C., the Greeks used animal cadavers to contaminate water wells of enemies.
- This strategy was also used the by the Romans and Persians.
- In a later period, during the battle of Tortona, Italy, in 1155, bodies of dead soldiers and animals were used to contaminate water wells by Emperor Barbarossa's troops.

Biological warfare: history

- In the 14th century, during the siege of Kaffa by the Tartars (now Feodosiya, Ukraine, a city near the Black Sea, at that time under the control of the Genoese), among the Tartar army, **an epidemic of plague** was spread. The besiegers thought to catapult the cadavers of their dead comrades within the walls of the city of Kaffa, resulting in a turning point in the war; the Genoese fled from Kaffa, carrying with them their sick.
- On the return trip to Genoa, they ported at several ports in the Mediterranean Sea.
- While some sources believe a possible correlation between the epidemic of plague in Kaffa and the pandemic that decimated most of the population of Europe in the following decades (Black Death), most authors share the view of two events were independent.
- If so, this early use of biological warfare caused the eventual deaths of around 25 million Europeans.

Biological warfare: history

- In 1422, during the siege of Carolstein, Lithuanian soldiers catapulted cadavers of dead soldiers and excrements into the city, frightening the population affected and **spreading lethal fevers** in many cases.
- During the French-Indian War (1754-1767), the British commander, Sir Jeffrey Amherst, ordered the distribution of blankets infected with **smallpox** to decimate the population of Indian tribes hostile to the British. The distribution of infected blankets occurred in the summer of 1763, and the resurgence of the virus among the indigenous lasted for more than 200 years.

  Although we now know that this would be a relatively ineffective way to transmit smallpox, the intent was there.

Scientific research on biological weapons did not begin until the 19th century, after discoveries made by scientists such as Koch, Pasteur and Lister.

Biological warfare: history

Several biological warfare actions carried out during the World War are not sufficiently confirmed in the literature.

❖However, it is frequently reported that the Germans inoculated cattle with *Bacillus anthracis* and *Pseudomonas mallei*, responsible to cause severe diseases such as anthrax and glanders, before sending them into enemy states.

- During **World Wars II**, many countries conducted research programmes on the development of bioweapons;

Biological warfare: history

- The Japanese programme, conducted under the direction of Lt. Gen. Shiro Ishii, was certainly the most ambitious (1892-1959). The research in this direction started in 1928; during this year, Lt. Gen. Ishii visited many European and American countries to learn useful techniques and information about the possible uses of biological weapons.

Upon returning to his homeland, he was provided a substantial grant in order to constitute a massive bioweapons research centre, known as the Unit 731, located at Beiyinhe in Manchuria. The research centre staffed over 3,000 scientists, mainly microbiologists. The experiments were conducted on prisoners of war, principally Koreans, Chinese and Russian soldiers. The prisoners were used to test numerous bioweapons, including ***Yersinia pestis***, ***Vibrio cholerae***, ***Neisseria meningitidis*** and ***Bacillus anthracis.***

(Leitenberg, 2001). Christopher *et al.* (1997) report that during this research, several thousand prisoners died as a result of the experiments conducted on them. However, the mortality rate around the area of Unit 731 remained very high for several years.

If we consider the total count these deaths, we reach the considerable sum of 200,000 deaths as a result of the activities carried out by Lt. Gen. Ishii (Harris, 2002).

- In 1942, the poor control of the infection spread resulted in the death of 1,700 Japanese soldiers (Sokolski & Ludes, 2001).

Biological warfare: history

Many other nations carried out experiments on potential biological agents, but information reported in the literature is rather limited.

❖It is important to note the experiments conducted in 1942 by the British army on the Island of Gruinard, off the Scotland coast, where **anthrax dirty bombs** were tested . The island was contaminated and uninhabitable until 1990, when extensive land decontamination was carried out.

❖In September 1950, the U.S. Navy conducted an experiment on civilians in order to assess the vulnerability of a large American coastal town to a biological attack; in the San Francisco Bay, a cloud of ***Serratia marcescens*** (a low pathogenic bacterium mainly responsible for infections of skin and respiratory tract) was spread by boat. The infection struck, as a result of subsequent checks, almost the entire population (1 million people). Even though the bacterium was almost harmless, several individuals showed effects of respiratory diseases and some of them died.

Biological warfare: history

- A last large scale experiment which was documented, consists of the dissemination of ***Bacillus subtilis*** in the New York subway in the summer of 1966.The experiment resulted in the infections, although without consequences, of more than one million people.

It demonstrated that the spread of a pathogen in the whole subway network from a single station, due to the displacement of air in the tunnels, was possible (Zygmunt, 2006).

Biological warfare: history

- The first measures against the use of bioweapons were taken in the 19th century during the Hague Conference in 1899, and then confirmed in the same place in 1907, with the document entitled *Laws and Customs of War on Land*, signed and ratified by 24 countries regarding the prohibition on the use of poisoned arms.
- In 1925, the Geneva Protocol on the *Prohibited Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare* was signed.

- But - it only prohibited the use of biological agents as weapons, but not their development and stockpiling.
- In 1972, the *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction* was initiated.

Biological warfare: history

The use of biological agents in the last decades is mainly attributable to terrorist groups, more or less isolated, who used bioweapons as a strategy to defend extremist religious ideas by striking civilian populations or sensible government Targets.

- In 1984, in The Dalles, Oregon, U.S., a group of extremist followers of Bhagwan Shree Rajneesh (also known as Osho) contaminated the salad in 10 different salad bars with the pathogen of salmonellosis, ***Salmonella thyphimurium,*** in order to disable the population. A total of 751 people contracted the disease and several of them were hospitalised.

Although there were no fatalities, this terrorist act is considered the largest bioterrorist attack in the history of the U.S.

Biological warfare: history

- In the 1990s, the Japanese cult of Aum Shinrikyo tested different bioweapons, including **botulin toxin**, **anthrax**, **cholera**, and **Q fever**. In 1993, during a humanitarian mission in Africa, it tried to obtain samples of the **Ebola virus**.

Between 1990 and 1995, the cult attempted to carry out several bioterrorist acts in Tokyo using vaporised biological agents, including **botulinum toxin** and **anthrax spores.** Fortunately, the attacks were unsuccessful.

A significant bioterrorist event occurred in the U.S. contextually to the dramatic attacks to the World Trade Center in New York in September 2001.

- The release of ***Bacillus anthracis* spores** through the U.S. postal system was carried out with letters addressed to the press and to government officials. There were 22 confirmed cases of anthrax contamination, consisting of 12 cutaneous and 10 inhalational cases.

Biological warfare: history

- In 2002, in Manchester, U.K., six terrorists were arrested for being found in possession of **ricin**, and in 2004, traces of the same toxin were found at the Dirksen Senate Office Building in Washington.

It appears evident then that the use of biological agents has moved, in recent times, to terrorist groups.

This creates very strong concerns that the use of bioweapons by terrorists can create unexpected scenarios characterised by massive destructive potential.

Categories of Biological Agents

The U.S. Centers for Disease Control and Prevention (CDC) defines a bioterrorism attack as "*the deliberate release of viruses, bacteria or other germs (agents) used to cause illness or death in people, animals, or plants*" (CDC, 2013).

It classifies biological agents into three categories:

- **1. Category A:**
  Agents that can be easily disseminated or transmitted from person to person.
  They result in high mortality rates and have the potential for major public health impact.
  They might cause public panic and social disruption, and require special action for public health preparedness.
- **2. Category B**:
  Agents that are moderately easy to disseminate.
  They result in moderate morbidity rates and low mortality, and require specific enhanced diagnostic capacity and disease surveillance.
- **3. Category C**:
  Emerging agents that could be engineered for mass dissemination in the future because of their availability.
  They are easy to produce and disseminate.
  They are potentially linked to high morbidity and mortality rates, and major health impact.

Table 1: Major biological agents that are possible to be used as bioweapons (CDC, 2013).

Groups	Diseases	Agents
A	Anthrax	*Bacillus anthracis*
	Botulism	*Clostridium botulinum* toxin
	Plague	*Yersinia pestis*
	Smallpox	*Variola major*
	Tularemia	*Francisella tularensis*
	Viral hemorrhagic fevers	*Filoviruses and Arenaviruses*
B	Brucellosis	*Brucella spp.*
	Epsilon toxin	*Clostridium perfringens*
	Food safety threats	*Salmonella* spp., *E.coli* O157:H7, *Shigella*
	Glanders	*Burkholderia mallei*
	Melioidosis	*Burkholderia pseudomallei*
	Psittacosis	*Chlamydia psittaci*
	Q fever	*Coxiella burnetii*
	Ricin toxin	*Ricinus communis*
	Staphylococcal enterotoxin B	*Staphylococcus spp.*
	Typhus fever	*Rickettsia prowazekii*
	Viral encephalitis	*Alphaviruses*
	Water safety threats	*Vibrio cholerae, Cryptosporidium parvum*
C	Emerging infectious diseases	*Nipahvirus* and *Hantavirus*

Generally, biological agents (included those used as bioweapons) can be further classified according to certain characteristics that define the hazard to health (NATO, 1996):

a. Infectivity: The aptitude of an agent to penetrate and multiply in the host.

b. Pathogenicity: The ability of the agent to cause a disease after penetrating into the body.

c. Transmissibility: The ability of the agent to be transmitted from an infected individual to a healthy one.

d. Ability to neutralise: Its means to have preventive tools and / or therapeutic purposes.

Biological agents can be transmitted through one or more ways.
The transmission modes are the following:

a. Parenteral: Agents that are transmitted through body fluids or blood.

b. Airway (by droplets): Agents that are emitted by infected people, which can then be inhaled by surrounding people.

c. Contact: Through which the agents present on the surface of the infected organism can infect another organism.

d. Faecal - oral route: Through objects, foods or other items contaminated with the faeces of infected patients, or through sexual contact.

Table 2: Fatality rates of Category A biological agents.

Pathogen	Biological Agent	Fatality rate (%)	Reference
Bacteria	*Bacillus anthracis*	Cutaneous: <1% Respiratory: 75% Gastrointestinal: 25%-60%	CDC, 2013
	Clostridium botulinum	Foodborne: 3-5% Wound and intestinal: 15%	
	Yersinia pestis	8-10%	WHO, 2004
	Francisella tularensis	Subspecies *tularensis*: 2%	WHO, 2007; Dennis *et al.*, 2001
		Subspecies *holarctica*: fatal cases are rare	WHO, 2007
Virus	*Variola major*	30%	CDC, 2013
	Filoviridae	90%	Warfield *et al.*, 2005
	Arenaviridae	15-30%	Briease *et al.*, 2009

Table 3: Biosafety levels (BSL) required to work with Category A biological agents.

Pathogen	Biological Agent	BSL	Reference
Bacteria	*Bacillus anthracis*	3	WHO, 2004
	Clostridium botulinum	3	Arnon *et al.*, 2001
	Yersinia pestis	2-3	WHO, 2004
	Francisella tularensis	3	Bhalla & Warheit, 2004
Virus	*Variola major*	4	DHHS, 2009
	Filoviridae	4	
	Arenaviridae	2-3	

CONCLUSION

The use of biological agents as bioweapons has its roots in ancient times, when the concepts of bacteria, toxin or virus were not known yet.

Over 2,000 years ago, rudimentary techniques of biological warfare resolved the first disputes among people. Hand by hand with the evolution of modern science (especially in the 18th century), the possibility of using biological agents as bioweapons has been refined.
In the last few decades, the development of innovative biotechnology techniques has provided the knowledge to create more aggressive bioweapons.

These new organisms cause great concern, because they can produce devastating and completely unexpected effects, of the same level or even higher than the most dangerous wild type biological agents.

CONCLUSION

Although international conventions prohibit the use of biological agents for offensive purposes, it is known that many terrorist groups continue their research about the possible use of biological agents as bioweapons.

The concerns related to biological agents are aroused, as well as the effects in terms of victims, both from the objective difficulties in the detection of a potential attack.

A release of biological agents is difficult to detect with current technology, especially when it comes to a stand-off revelation compared to point detection.

Biological agents have a unique feature when compared to other non-conventional weapons (chemical or radiological); with the exception of toxins, they are able to multiply in the host and in turn be transmitted to other individuals.

Hence, immediate identification of a biological attack is essential, in order to take appropriate containment measures to contain further dissemination.

Therefore, there is a clear need to develop new technologies to detect biological agents from long-range, in order to take immediate action in the event of both intentional and unintentional biological agents releases.

Orlando Cenciarelli et al.; Defence S&T Tech. Bull., 6(2): 111-129, 2013