Concepts of offensive use of biological weapons

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Production and employment of biological weapons in warfare is illegal and so it has been for more than a hundred years [1]. Nevertheless, biological weapons have been and possibly still are part of some nations' armamentarium, and they have been used on civilian populations with severe consequences even surpassing the other main weapon of mass destruction, the nuclear bomb. During the last fifty years, technology within various disciplines has developed to the extent that mass destruction through biological weapons is not only restricted to a wide range of nation states but has also come within reach of non-state actors. The threat of terrorists acquiring biological weapons is serious and has been characterised by the UN Secretary-General as "the most important under-addressed threat relating to terrorism" in a recent report on global counter-terrorism strategy [2]. To prepare and defend against biological attacks it is important to understand the concept of operations of offensive use of biological weapons. It may feel like a somewhat uncomfortable exercise to consider these illegal and repugnant weapons from a user's perspective, but understanding the specifics of the threat is critically important for defensive efforts to be focused on relevant capabilities.

Such understanding is limited by the secrecy surrounding biological weapons. By their very nature biological attacks may not be obvious and instances of historical use are often disputed. However, there are sufficient cases where allegations of use are credible or where offensive doctrines have been revealed to outline the primary ways of employment for which biological weapons have been intended or actually used.

Objectives

A biological weapon consists of a weaponized biological agent and a delivery vehicle. Within both categories there are multiple choices possible and the numerous combinations make biological weapons very versatile and adaptable to different purposes.

Covert attack – non-attribution

An important characteristic of biological weapons is their potential for covert attacks. After dispersal a biological agent is not visible or immediately detectable as there are as yet no reliable sensor systems for stand off detection. If the delivery vehicle is not detected itself, a biological payload can be released at a distance from the target and allowed to reach the target by airflow or the food chain without the attack being discovered. Only the subsequent outbreak of disease, which will happen after the incubation time has run out, may indicate that a deliberate biological attack has taken place – or it may even remain undetected if the disease outbreak simulates a naturally occuring endemic disease.

The attempt of a religious cult in Oregon to influence a county election by covert contamination of salad bars with salmonella in 1984 resulted in more than 700 non-fatal casualties but the disease outbreak was not recognized as an attack but assumed to be caused by natural food contamination [3]. Only after a confession by the perpetrators a year later was the true origin of the outbreak realised. Similarly, the several deployments of biological agent in Japanese cities by the Aum Shinrikyo organization using ordinary trucks with hidden spraying devices were not recognized until reported by the perpetrators themselves during interrogation [4].

Even if an attack has been recognized or suspected it may not be possible to attribute the attack to a specific perpetrator. The anthrax spore preparations sent in envelopes to various media representatives in the USA in the autumn of 2001 were visible upon opening the letters, but even though both the biological agent and delivery vehicle has

now undergone intense investigation for several years the attack has not been attributed to any specific perpetrator [5]. Non-attribution is in general a common feature of historical incidents where biological attacks are suspected to have taken place. 'Plausible denial' was part of the American doctrine for biological warfare in the early 1950'ies. Chinese and Korean allegations that US made several sorties in the early part of 1952 both south of the Yalu River and also intrusions into China with airdrops of biological wapons have consistenly been denied despite reports describing fragments of munitions, carrier material and insect vectors, microbiological identification of several biological warfare agents and thousands of human casualties from plague, cholera and encephalitis [6].

Wide area coverage

Whether employed covertly or overtly biological weapons may be used for small scale sabotage or wide attacks depending both on the delivery vehicle and attack method and on the agent and the way it is weaponized (i.e. formulated and stabilized). Even before special weaponization, dry biological agent can disperse over a wide area as exemplified by the 1979 incident in Sverdlovsk in the former Soviet Union where less than one gram of dry anthrax spores was released by accident from a weapons factory and drifted by wind for several kilometers [7]. Apart from approximately more than 70 human deaths the farthest casualty were sheep standing in a field approximately 45 kilometers from the release site [8]. During the offensive biological weapons programmes in the 1960'ies both American and British tests indicated an even wider area dispersal potential of especially dry agent [9].

However, also wet biological agent as a slurry can be dispersed by aerial spray over a large area. In 1999 the Canadian authorities eradicated insects from the woods around the city of Victoria by aerial spray of a solution of spores of Bacillus thuringiensis, which is non-pathogenic for humans but lethal for lumber eating insects and which in all pysical properties is identical to anthrax spores [10]. The spraying was monitored by testing airsamples from both inside and outside homes in Victoria city. The results showed that not only were the spores dispersed by air over a wide area but also inside homes where doors and windows had been kept shut a significant concentration was reached of spores in the right size for human inhalation. It was estimated that had the spraying been done with anthrax spores 17% of the population of Victoria would have been killed. Similar penetration into closed buildings of airborne biological agent was experienced in the Hong Kong apartment complex Amoy Gardens, when a small amount of aerosolized SARS virus infected several residents after having been released into the open air [11].

The wide area coverage possible with biological weapons even without using agents with epidemic potential is an important reason why such weapons have mass destruction potential.

Table 1. Urban area in hectares with more than 50% casualties after delivery of a payload that can be carried by one fighter-bomber. Adapted from SIPRI 1972 [9].

Weapon	**Area**
High explosive	22
Nerve gas	75
Nuclear fission (10 Kt)	3,000
Biological	5,000
Nuclear fusion (10 Mt)	200,000

Wide area coverage not only allows for attacks against widely dispersed targets but also allows for attacks where the targeting information is very imprecise. However, the way wide area coverage is reached, namely airborne dispersion, also reduces the predictability of a biological aerosol release because weather conditions will greatly impact the dispersion.

Area denial

Area denial as it can be accomplished by chemical weapons on a battlefield to reduce the maneuverability of the enemy is not a purpose for which biological weapons are well suited. In general most

biological agents decompose rapidly after exposure to open air and especially ultraviolet radiation from sunlight, and biological agents do not penetrate intact skin. Also the effects of biological weapons have a latency of days or even weeks. So on a battlefield with highly manouverable forces especially if they use respiratory protection biological weapons are not suited for area denial. However, the persistency of anthrax spores can be attractive to an agressor in certain circumstances. When Saddam Hussein was asked by his staff officers to choose which agent he wanted filled on the SCUD missiles targeted for Tel Aviv in the first Gulf War he answered “the many years kind”, i.e. anthrax spores [12]. Experience from British tests of anthrax bombs on Gruinard Island in the Atlantic showed that it took years of very cumbersome and harsh decontamination with formaldehyde and sea water to finally eliminate all risk of infection on the island.

Thus, the persistency of sporeforming biological agents can be used against cities, buildings and fixed installations to obtain denial of critical infrastructure function as exemplified by the contamination of the US postal system of the five letters with small amounts of anthrax spores in 2001.

Effect multiplication

Among the different caracteristics of biological agents (see below), potential contagiousness is particularly important as a contagious agent that allows human-to human transmission can greatly multiply the effect of the primary attack. For centuries contaminated corpses have been used to spread plague and dysentry among the enemy but the first recorded written order to perform a biological attack was given by the British Commander-in-Chief Jeffry Amherst in 1763 when he ordered small pox to be used against Indians in North America. Unwashed blankets from a smallpox hospital were then distributed to the enemy tribe of local Indians, and the ensuing smallpox epidemic devastated the Indian population in the Ohio area [13].

During the war in China 1932-1945 Japanese troops preferred contagious agents for their biological attacks primarily because they did not sufficiently master the weaponization technology necessary for wide area dispersion of aerosolized agent. Therefore they preferentially used agents like plague, typhoid, dysentry and cholera where human-to-human transmission was sought in order to spread the agent from those primarily exposed and thus multiplying the effect. One among many examples of this strategy was an attack in May 1942 on the city of Baoshan on the Chinese line of supply from Burma. In this attack, first special force units contaminated the water sources of Baoshan. Then a few weeks later, when the incubation period for cholera had run out, a flight of fifty-four bombers with a combination of cholera filled ceramic bombs and conventional explosives heavily damaged the city which made the population flee into the countryside. The ensuing cholera epidemic resulted in more than 200,000 fatalities in the Yunnan province, which made the Chinese Army unable to base its troops there and released large numbers of Japanese troops for use on other battlefronts [14].

Conditional lethality

For some purposes lethality may not be necessary or may even be counter-productive depending on the military doctrine. While the Soviet weapons programme focused almost exclusively on lethal biological weapons, the US programme put much more emphasis on non-lethal, incapacitating agents.

One of the American attack plans for Cuba in 1962 has been alleged to include an initial line dispersal along the coast of Cuba with a combination of biological toxins, viruses and bacteria with rapid, intermediate and delayed action respectively. They were all non-lethal and were intended to incapacitate the enemy defences prior to an invasion. The effects were calculated to dissappear after a couple of weeks with a fatality estimate for the civilian population of less than one percent [3].

In a military context incapacitants may be particularly attractive if exposure of non-combatants cannot be avoided, and

an advantage of biological incapacitants as illustrated in the US example is the possibility of a relatively long duration of incapacitation as compared with chemical incapacitants.

Economic targets

Biological weapons may not only be used as biospecific weapons directly against humans but also against economic targets. Several of the offensive programmes known included biological agents capable of destroying wheat, rice or potatoes. Against such agricultural targets self-propagating contagious agents are preferable as it is the very transmissibility which gives a biological agro-weapon a far greater potential than chemical poisons.

While contagious agents could also be used against animal husbandry with severe effects on a country's agricultural basis as illustrated by the outbreak of Foot and Mouth Disease in Britain in 2001 costing $25 billion [15], the instances where biological weapons have been used on husbandry are primarily limited to anthrax. The known examples include attempts by German agents to infect enemy horses with anthrax during the first world war, but the most significant attack may have been performed in Zimbabwe by special forces from South Africa. In 1978-80 anthrax spores were allegedly used to contaminate the feeding areas of the livestock of the population supporting the guerillas. While the primary target apparently was cattle more than 10,000 mostly non-fatal human casualties have also been reported [4, 16].

Because of the persistency of anthrax spores, anthrax contamination and resulting cattle infection in Zimbabwe remains a problem to this day.

Agents employed

As indicated above biological weapons can be employed in a variety of situations and for many different purposes. This versatility is primarily caused by the variation of natural characteristics inherent in the biological organisms themselves. However, common to all of them except for the biological toxins is the ability to replicate once taken up by a susceptible host. This is the main reason why biological weapons on a weight basis are so potent. On average a person must inhale or ingest a certain number of organisms for infection to take hold, but in some cases the mean infectious dose is quite low and in principle no dose of any microorganism is without a certain risk of infection.

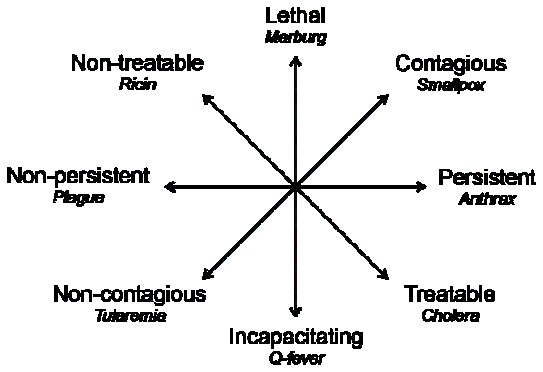

Figure 1. All biological agents can be characterised on four primary dimensions: contagiousness, lethality, persistency and treatability. A biological agent exemplifying each characteristic is indicated in italics.

As the number of microorganisms or toxins with weapon potential is quite large no biological weapons programme can develop all agents for offensive use. Even the large American and the very large Soviet programmes chose to put emphasis on some agents rather than others. This choice was primarily based on the way the specific agents fitted into the overall military doctrine, and as this can differ widely between nations because of the security situation, other military capabilities, technical level and political ambitions offensive biological programmes will always be different from nation to nation or sub-state actor.

For optimal offensive use of any biological weapon it is necessary to consider the defensive capabilities of the enemy target. In many cases medical countermeasures in the form of prophylaxis by vaccination or chemotherapy is possible and in some cases treatment sufficiently effective to mitigate or entirely thwart the consequences of an attack is also possible if implemented rapidly [17]. Therefore an offensive strategy will also consider whether it is necessary to enhance the effectiveness of a weapon in order to defeat enemy defences.

Protection of own forces also needs careful consideration. Early Japanese attacks in China with plague, dysentery and typhoid led to several thousand deaths among their own troops. This can easily result if an airborne release is used too close to own positions and the wind turns or if a contagious agent is used and the resulting epidemic spreads to own troops or homeland. As the Japanese learned at the end of the campaign in China prior vaccination of own soldiers against the particular biological agents intended for use is a preferential method to avoid own casualties.

Weapon combinations

Apart from the obvious advantage of covertly attacking unsuspecting and unprotected targets, one way of enhancing the effect of a biological attack is to combine the biological agent with other substances. Prior radiation will significantly damage the human immune system and the natural resistence to infections, and vaporized chemical lung irritants will decrease the barrier against inhaled biological agents.

Combining several biological agents in one attack will also decrease the natural resistence of human targets, and the clinical challenge of combined infections could overwhelm medical countermeasures. In the Soviet biological weapons programme strategic missiles with multiple warheads are reported to have been filled with a combination of agents e.g. plague, anthrax and smallpox on the same missile but divided into separate submunitions [4]. Deployment of such a missile over one or more population centres will severely stress the health care system of any nation.

Designer agents

Biological agents themselves can also be modified artificially in order to defeat medical countermeasures. Microbiological procedures to selectively confer resistence against antibiotics are fairly well known and have been used to for production of biological agents in e.g. the Soviet programme, and through genetic manipulation also resistence against vaccination have been conferred on e.g. anthrax or poxvirus [17, 18]. In general, modern techniques of molecular biology open a huge potential to modify existing microorganisms or even to create new microorganisms or hybrid organisms with effects that have rarely been seen in natural disease outbreaks. These techniques not only make it possible to design agents with higher lethality, stability or transmissibility but also to select for non-lethal special effects targeted for specific populations or ethnic groups as with the alleged South African attempts to create a weapon selectively decreasing the fertility among black citizens [4]. The possibilities for creation of third generation biological weapons carrying ‘designer bugs’ are rapidly expanding as the science of molecular biology and biotechnology crosses new frontiers.

Methods of attack

Munitions suitable for biological agents should be able to deliver the agent in sufficient quantitity and intact on the target. In the early weapons programmes of Japan and the US in the second World War this proved to be a difficult challenge both because efficient weaponization technology was unknown at the time and because the munitions initially employed either destroyed the biological payload or did not disseminate the agent sufficiently well. As one of several alternative methods of attack the Japanese chose to use natural vectors, plague infested fleas, which were bred in huge numbers and dropped by air on towns and cities. Although a rather inefficient method of dispersal the casualty numbers from these

vector-borne attacks were in the tens of thousands [14]. This method is however also significant as an example where skin penetration - which is uncharacteristic of biological agents – can be obtained through the bite of fleas and transferral of plague bacilli to the victims. Allegedly, US forces adopted the same attack method in Korea [6].

Lacking capability of efficient aerosol dispersal by air several options are available. Often used is dissemination of a contagious agent through drinking water as shown by several Japanese attacks on Chinese populations and military forces using typhoid and cholera contamination of wells and rivers [14]. Although the Chinese suffered more than 180,000 fatalities in the Shandong province in 1943 as a result of Japanese cholera dispersal around the Wei River, in general this method of attack is not very efficient, requires large amounts of biological agent and has a risk of uncontrollable spread to friendly forces because a contagious agent is necessary to multiply the otherwise limited effects. Contamination of rivers with cholera was allegedly also used by South African special forces in attacks on black townships in South Africa and Namibia [4].

Using the food chain or a specific food item as a vehicle for a biological attack has been used by military forces as well as terrorists against selected civilian targets. Publically known examples of actual use include the salmonella contamination of salad bars mentioned above and also a targeted attack on workplace collegues using shigella contaminated donuts. Unless a food item with rapid mass distribution is used, specific food items are however difficult to use as vehicles of mass destruction.

Airborne aerosol

Airborne dissemination of an aerosol whether as a dry powdery preparation or a liquid suspension remains the preferred method of dispersing a biological agent if the number of primary casualties is to be maximised. A multitude of military delivery vehicles and dispersal devices have been developed to deliver payloads from kilogrammes to tonnes of biological agent. They range from man portable devices over bombs, grenades, cruise missiles to ICBMs and can be used for single or multiple point releases or sprayed in a line release. Both naval and air delivery is possible particularly for drift-on attacks, where an aerosol after release is brought by the wind onto the target area which can be many kilometers from the release position. Such an aerosol rapidly becomes invisible after release and dispersal in the air, and attacks can be performed clandestinely. Delivery devices need not be military type of munitions as improvised delivery devices can also be constructed from commonly accessible hardware goods or simply using dual-use equipment that is normally used for crop dusting, spray painting etc.

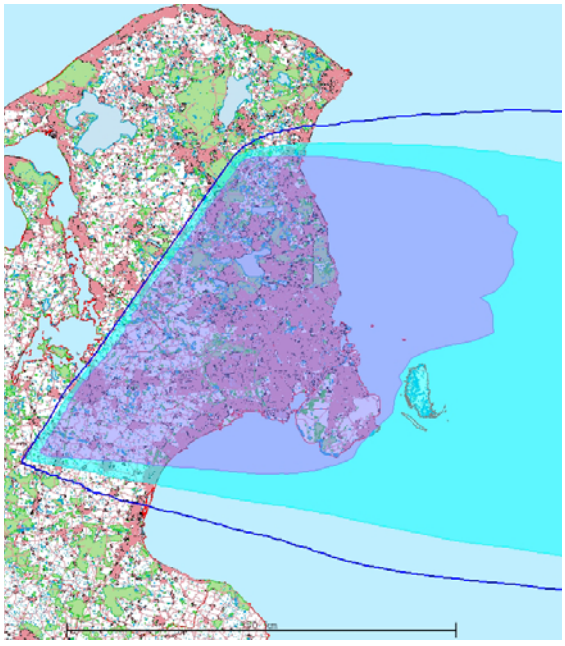

Figure 2. Line dispersal of 100 kg biological agent by airplane over Zealand, Denmark with a fatality estimate of 995,000 people.

In order to optimize the effectiveness of a biological weapon especially for open air releases it is necessary to formulate the biological agent in special ways (weaponization). Biological agents may otherwise be inactivated by exposure to the environment, and it is also necessary to maintain the agent in particles of 1-5 micrometers so that they float on the air and on inhalation penetrate into the lower

airways. The technology to weaponize biological agents was primarily developed in the offensive biological weapons programmes of the 1960'ies, 70'ies and 80'ies. However, for the last couple of decades dual-use knowledge and technology suitable for weaponization has also been developed - and even to some extent improved - by industry particularly in pharmaceutics, agriculture and biotechnology.

Planning an open air attack with a biological weapon requires a synthesis of a variety of parameters: agent characteristics and amount, delivery device and release speed and height, metereological data concerning e.g. wind speed and humidity, target information concerning topography and demographics, and so on. For an attack to be predictable and succesful a computerised decision support system synthesising all these parameters is necessary to consolidate the offensive planning. Computer technology combined with advances in other sciences – e.g. aerobiology and meteorology – has greatly increased the possibilities for offensive planning.

While open air release and wide area coverage is typically an objective in a military context, other methods of attack may be particularly attractive to terrorists using improvised delivery devices. Aerosol release inside buildings or other closed systems like subways has the advantage of achieving higher concentrations of agent with much smaller releases. The airflow inside buildings are often quite sufficient to effectively disseminate a biological agent, and it has the added advantage that environmental exposure is less likely to degrade the agent. While the anthrax letters in the US in 2001 were targeting specific individuals, the opening of the letters also released small amounts of spores into the air and resulted in collateral casualties in other parts of the buildings. This kind of attack has more the character of assasination, and biological agents delivered by different vehicles like e.g. cigarettes, chocholate and umbrellas have previously been developed and used for assasination by several governments [4].

Conclusion

Because of the high cost-effectiveness in killing power biological weapons may be attractive as equalizers of asymmetric conventional or nuclear military capability. Their utility lies not, however, in tactical use on a military battlefield. Their strength is best realised in covert attacks on civilian populations ranging from individual assassinations to mass destruction performed by transnational terrorist organizations or by special forces in clandestine operations on enemy homeland where deniability is a priority. From fear of retaliation overt attacks by state actors are less likely to be used except in situations where the laws of war have broken down and ultimate solutions are sought.

Unlike nuclear weapons which confer high status on a country and deter its enemies, biological weapons are illegal and 'dirty' and therefore unsuited for public deterrence. The Iraq wars may, however, provide an important qualification. When Saddam Hussein did have biological weapons in the first Gulf War he met limited military defeat but not the loss of his country, but when he didn't have them in the second Gulf War he met total defeat and lost his country. Whether there is a causal relationship here or not is debatable but some countries may regard it as a lesson.

If the Soviet biological weapons arsenal of the Cold War period had been used in an all-out conflict with NATO, we would have been unable to withstand the attack and in all probability NATO would have been completely denied the possibility of victory in any meaningful way. Biological weapons programmes of such a size are hopefully unlikely to occur again, but as biotechnology develops still further size may not be critically important for devastation through biological means to be a real option for an aggressor.

Although biological weapons are banned by the laws of war and a UN convention, technical skills and offensive knowledge are proliferating and many nation-states are in principle capable of maintaining a biological stand-by WMD capability. It is legal to develop defensive countermeasures against biological

weapons and this also entails development of biological agents and delivery devices on a small scale to test defensive measures, and such activity has intensified in many countries in recent years [19, 20]. While this proliferation of knowledge and technology may be unavoidable it will allow a country to transform a defensive biological program overnight into an offensive one, and because of the dual-use nature of civilian production facilities offensive biological weapons corresponding to at least a small nuclear capability can be produced within a few weeks in any country with the technical capability equalling a small western country. The footprint of such a stand-by biological capability may be very small and would primarily risk discovery if delivery vehicles specially designed for biological payloads were constructed and tested in preparation of wide area attacks.

Apart from the biological weapons ambitions of terrorist organisations and their potentially developing capabilities, the future threat from biological weapons is primarily determined in individual nations by a political decision concerning whether or not to establish a stand-by biological capability. Even if all nation-states at present both in words and deeds abstain from offensive biological weapons this may not be the case in all future circumstances, and the potential threat of biological weapons should not be handled with complacency.

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