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THE LOOMING THREAT: BIOLOGICAL AND CHEMICAL WARFARE

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ABSTRACT

Chemical and biological weapons are capable of use across a wide spectrum of warfare, from acts of assassination and small-scale terrorism to various tactical and operational situations, both defensive and offensive, including strategic population attacks. In this era biowar is really serious concern for the mankind. This article examines the role of biotechnology in protective measures and briefly surveys the biological warfare defence capabilities of different countries.

Key words: Biological warfare, chemical warfare, hazardous chemicals, microorganisms, toxicity

INTRODUCTION

Biological warfare is the intentional use of biological toxins or infectious agents is also considered a type of biological weapon. They are generally generally of microbial, plant or animal origin to produce disease and death in humans, livestock and food crops ,such as bacteria, viruses, and fungi that reproduce or replicate within their host victims. Modern chemical warfare began with the extensive use of chemical agents during World War I, initially with German use of industrial chemicals, such as chlorine and phosgene, and later use of agents tailored for military use such as the mustards. Their effects were impressive but not decisive, although Russia suffered enormous casualties from chemicals. All combatants made some use of chemicals. There was considerable research on both agents and protective equipment.

For the global security implications novel and accessible technologies give rise to proliferation of such weapons. In counteracting such threats, and in securing the culture and maintaining peace, the need for leadership and example in devising preventive and protective strategies has been emphasized through international consultation and co-operation. The misuse of science or of scientific achievements to create weapons that poison and spread disease has always created alarm and abhorrence in the public mind. The International Committee of Red Cross (ICRC) summed up the public horror at the use of such weapons in its appeal in February 1918, calling them "barbarous inventions" that can "only be called criminal". For centuries there have been taboos against such weapons, but the use of poisonous gas in World War I led to the first international agreement – the 1925 Geneva Protocol – banning asphyxiating, poisonous or other gases and even bacteriological methods of warfare. Adherence to the Biological and Toxin Weapons Convention reinforced by confidence-building measures sustained by use of monitoring and verification protocols, is indeed, an important and necessary step in reducing and eliminating the threats of biological warfare and bioterrorism. In order to counter these risks, in February 2013 the ICRC appealed to all States to limit the use of toxic chemicals as weapons for law enforcement purposes to riot-control agents only[1]. The threat of exposure to such agents has traditionally been considered a military issue. Several recent events, however, have demonstrated that civilians may also be exposed to these agents [2-4] and in the wake of recent atrocities there has been renewed apprehension regarding the deployment of chemical and biological weapons.5

The source of exposure for civilian population includes acts of terrorism, in advertent releases from domestic chemical weapon stockpiles, direct military attacks, and

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industrial accidents. The hostile use of CBW agents would be likely to cause significant impact on health care systems. Patients might come in unprecedented numbers, and demands for intensive care might overwhelm medical resources.

Following points attributed more striking the use of bioweapons in war, and for use in terrorist attacks.

1. The wide range of disease-producing biological agents,
2. Low production costs, non-detection by routine security systems, and
3. Easy transportation from one place to another

Despite all the limitations, concern continues to grow regarding the possibility of proliferation or enhancement of state sponsored offensive biological weapons programs and the possible use of biological weapons by terrorist organizations.

The use of public warning and information systems will be critical to inform the community about the nature of the incident and the appropriate measures that they can take to protect themselves.42 Timely and accurate information will assist in minimizing panic in the affected community. Measures to reduce exposure of the public to chemical agents include evacuation, sheltering in place, and the distribution of gas masks when nerve gases are suspected.[43-45] Apart from controlling a specific event, continuing public education regarding disaster planning and management would certainly play a very significant role in having desired outcome.

Potential Sources of Exposure

1. Terrorist attacks

Terrorism has been defined as the use or threat of violence to create panic in a society, to weaken or overthrow the leaders, or to bring about political change.[10] Terrorists were previously using conventional means of violence, but several recent events have demonstrated that now some have access to weapons of greater lethality, including chemical and biological agents.[10-12] Recent technical advances, easy access to raw materials, the ready availability of technical information, and the possible support to the terrorists by certain hostile foreign governments have all contributed to the proliferation of CBW agents.[13,14] .The most publicized use of chemical agents by terrorists against a civilian population was sarin vapor release in the Tokyo subway, which resulted in 12 deaths and more than 5500 casualties.[4,15] Threats against civilians by terrorists with CBW agents have also been made in USA , Chile, and Germany.[16]

2. Military usage

Uncommonly, civilian populations may become the direct targets of military attacks with CBW agents. They may also potentially sustain unintentional collateral injuries when their own nation's military uses chemical and biological weapons against enemy forces. Few cases of intentional use of CBW agents by military units against civilians have been documented, including the Iraqi attack on Kurdish population, and the recent use of nerve gas in Russia.[17,18] Any accidental release of CBW agents from military stockpiles and pesticide industries remain potential threat to the population.

3. Industrial incidents

A number of agents that have been used as chemical weapons, are actually used in a variety of industries processes. Inadvertent release of these chemicals, or actually attacks by terrorist aimed at storage and transportation facilities, have great potential to threaten surrounding large or small communities and may result in acutely life-threatening emergencies.[19]

Agents of Chemical and Biological Warfare are listed in (Table 1) all eight are known to have been studied for possible weaponization including, in some cases, actual field trials as well as laboratory study.

Agents for Chemical and Biological Warfare

A. Chemicals Agents

I. Nerve Damaging Agents (Sarin, Tabun, Soman, VX)

They are extremely toxic, odorless, tasteless and colorless gases. They are structurally related to organophosphorus compounds (insecticides), and are irreversible inhibitors of cholinesterase

enzymes.[25] Their administration results in cholinergic crisis followed by respiratory failure and polyneuropathy.

II. Blistering Agents

Blistering agents can be classified into two main groups: arsenicals and mustards. Mustard gas and Lewisite are liquids which cause chemical burns and blistering to all epithelial tissues. After inhalation or ingestion, systemic manifestations include respiratory failure, blindness, vomiting, and cancer. Mustard gas: [bis (2chloroethyl) sulphide] is a colorless or pale yellow oily liquid that smells faintly of garlic or mustard.[31] Atmospheric release occurs through explosive aerosolization. Its persistence places medical responders at greater risk of intoxication. Wearing of protective clothes and decontamination of casualties and responders is essential. Mustard gas forms highly reactive sulphonium ions in the body, which alkylate DNA and enzymes. There is a period of latency between exposure and the development of symptoms. Suspected exposure necessitates careful clinical observation and review of the patient. Cutaneous manifestations,occur after 4-12 hours, include erythema, edema, and first degree burns; vesication occurs with greater exposure. Necrosis and spreading vesication is seen within minutes of the exposure. Corneal edema is followed by vesication and corneal sloughing. Vision recovers by corneal revascularisation over a period of weeks. Exposure to high doses may lead to permanent blindness.[32] Respiratory problems occur in over 70% of victims and include dry cough, hoarseness, bronchospasm and airway collapse distal to areas of sloughed respiratory epithelium. Lung damage may be permanent.

III. Choking Agents

They are the most classical agents of chemical warfare. Chlorine,phosgene and chloropicrin are highly volatile liquids. Chlorine and phosgene were first used in 1915.[5] Chlorine is a greenish yellow gas with a distinctive smell providing adequate warning. Initial exposure causes eye pain, blepharospasm and lacrimation after inhalation, early respiratory distress occurs after a variable latent period, toxic pulmonary edema and permanent lung damage may occur in the survivors. It is an oxidizing agent and reaction with water liberates hypochlorous acid, hydrochloric acid and O2 free radicals; causing tissue damage.

IV. Vomiting, incapacitating and harassing Agents

Vomiting agents (such as adamsite and diphenylchloroarsine), tear gases [(such as 2-

chlorobenzalmalononitrile (Csgas)] and capsacain spray are sensory irritants that are used to temporarily incapacitate targets. Psychoactive drugs (such as LSD and cannabinoids)5 may also be used. They are severely debilitating but subjects do not require intensive care after treatment. With psychotropic chemicals, death is only accidental but subject is hallucinated or blinded.

V. Blood affecting Agents

Hydrocyanic acid and cyanogen chloride are metabolic poisons and prove fatal within 15 minutes of a lethal dose.[5] It is highly volatile, disseminated as a vapor and rapidly disperses throughout the atmosphere to near toxic concentrations. They interrupt cellular respiration by inhibiting cytochrome oxidases. The resulting metabolic acidosis and tissue hypoxia leads to convulsions and cardiorespiratory arrest. Inhalation causes high fatality before

VI. Toxins

Saxitoxin, Ricin and Botulinum toxin are biological products that are the most toxic produced by living organisms. They are considered by some to be chemical weapons as their effects do not require replication in humans.

Botulinum Toxin

Clostridium botulinum produces chemically and functionally distinct neurotoxins [A-G]. Neurotoxin A is 500 times more toxic than sarin nerve gas.[5] Aerosolisation is the most likely method of deployment but sabotage of food supplies may also occur. Acetylcholine synthesis is permanently inhibited. The toxin blocks neurotransmission at neuromuscular junction, postganglionic parasympathetic synapses and peripheral ganglia. One to four days after exposure (depending on the dose inhaled), bulbar palsy and ocular symptoms occur, followed by progressive symmetrical descending

weakness that culminates in respiratory dysfunction requiring prolonged ventilatory support.

B. Biological Agents

These are defined as living organisms, whatever their nature, or infective material derived from them, which are intended to cause disease or death in man, animals or plants. Like chemical weapons, biological weapons are also classified according to their intended target. Those chosen for use are similar in character; they are released in low dose into an unprotected population that has poor natural immunity.

1. Viruses

The viruses used in biological warfare are highly infectious and lethal e.g. those producing viral hemorrhagic fever (VHF). VHF describes a range of symptoms that are

caused by a variety of RNA viruses e.g. Crimean Congo fever, Ebola virus and yellow fever, viral encephalitides and Variola. Treatment beyond supportive measures is not available. Isolation and contact precautions are required.

Viral Encephalitides**:** There are three members of the genus Alpha virus that cause viral encephalitis in humans, Venezuelan Eastern and Western[5,34,35] and equine encephalitis viruses (VEE,EEE and WEE). They are highly infectious (10-100 organisms cause clinical symptoms) and stable when weaponised. Mortality may be as high as 70%.

No specific therapy exists, and treatment is therefore supportive. Vaccines are available but the WEE and EEE vaccines are poorly immunogenic requiring repeated immunization.5 Smallpox is caused by Variola, which is highly infective (10-100 organisms cause infection) when aerosolized, and stable when weaponized. It has a high mortality rate (3% in vaccinated, 30% in unvaccinated);death resulting from pneumonia.[36] Cessation of routine vaccination has increased the susceptibility of the population to variola infection.5 Cidofovir, a DNA polymerase inhibitor used to treat cytomegalvirus in AIDS patients appears to be effective in vitro when given soon after infection.

Table 1: Agents of Chemical and Biological Warfare Agents

I	**Nerve Damaging Agents**
	Sarin, *O*-isopropyl methylphosphonofluoridate
	Tabun, ethyl *N*,*N*-dimethylphosphoramidocyanidate
	Soman, *O*-1,2,2-trimethylpropyl methylphosphonofluoridate
	VX, *O*-ethyl S-2-diisopropylaminoethyl methylphosphonothiolate
II	**Vesicants (blister gases)**
	bis(2-chloroethyl) sulfide (mustard gas)
	2-chlorovinyldichloroarsine (lewisite)
	tris(2-chloroethyl)amine (a nitrogen mustard)
III	**Choking agents (lung irritants)**
	phosgene
	Chloropicrin
IV	**Tear gases, other sensory irritants, and other disabling chemicals**
	10-chloro-5,10-dihydrophenarsazine (adamsite, or DM)
	chloroacetophenone (CN)
	α-bromophenylacetonitrile (larmine, BBC or CA)
	2-chlorobenzalmalononitrile (CS)
	dibenzoxazepine (CR)
	oleoresin capsicum (OC)
V	**Blood gases**
	hydrogen cyanide
VI	**Toxinsa**
	Clostridium botulinum toxin
	staphylococcal enterotoxin
	Aflatoxin
VII	**Bacteria and rickettsiae**
	Bacillus anthracis
	Francisella tularensis
	Brucella suis
	Burkholderia mallei
	Burkholderia pseudomallei
	Yersinia pestis
	Rickettsia prowazeki
	Coxiella burnetii
VIII	**Viruses**
	Venezuelan equine encephalitis virus

Source: Documents and materials from International Committee of the Red Cross (ICRC)

Table 2: Antipersonnel toxic and infective agents whose hostile use since 1918 has been verified

Period	*Agent*	*Location of use*
1919	adamsite	Russia
	diphenylchloroarsine (a sensory irritant)	
	mustard gas	
1923–1926	bromomethyl ethyl ketone (a tear gas)	Morocco
	chloropicrin	
	mustard gas	
1935–1940	chlorine (a choking agent)	Abyssinia
	chloroacetophenone	
	diphenylchlorarsine	
	mustard gas	
	phenyldichlorarsine (a vesicant)	
	phosgene	
1937–1945	chloroacetophenone	Manchuria
	diphenylcyanoarsine (a sensory irritant)	
	hydrogen cyanide	
	lewisite	
	mustard gas	
	phosgene	
	Yersinia pestis	
1963–1967	chloroacetophenone	Yemen
	mustard gas	
	phosgene	
1965–1975	2-chlorobenzalmalononitrile	Vietnam
1982–1988	2-chlorobenzalmalononitrile	Iraq
	mustard gas Islamic	Republic of Iran
	sarin	
	tabun	
1984	Salmonella enteritidis serotype typhimurium	United States
1994–1995	sarin	Japan
2001	Bacillus anthracis	United States

Source: Documents and materials held in the Sussex Harvard Information Bank at SPRU – Science and Technology Policy Research, University of Sussex, United Kingdom

2. Bacteria

They are easy to culture and have high infectivity and lethality. Common agents used include *Bacillus anthracis* (anthrax), *Yersinia pestis* (plague) and *Francisella tularensis* (tularemia).*Bacillus Anthracis* is an aerobic Gram positive, rodshaped spore forming bacteria that primarily infects the herbivores, particularly cattle, sheep, goats, and horses. Soil is the reservoir of B. *Anthracis* and the organism is distributed worldwide.5 Humans usually contact anthrax through close contact with infected animals on products particularly hair and hides. Three clinical presentations are usually seen in humans.[37]

1. Cutaneous anthrax results from inoculation of spores through skin abrasions. It appears within 5 days of exposure, beginning with small pruritic papules which form vesicles. These rupture within a week to leave an ulcer that resolves as a black scar.
2. Inspiration of anthrax spores can result in the highly lethal inhalational form of the disease (woolsorters disease). Inhaled spores reach the alveoli and are phagocytosed to lymph nodes and a large amount of toxin is released into the circulation. Initially there is an insidious onset with malaise, fatigue, myalgia, non productive cough and fever. Hemorrhagic

meningitis with meningism and coma occurs in 50% of patients. Multi-organ failure which is refractory to treatment is the cause of death within 24-36 hrs. Historically,Penicillin was used for treatment, but now it has proved possible to bioengineer penicillin resistance in *B.Anthracis.* Currently, treatment with Ciprofloxacin is commenced as soon as possible. Chemoprophylaxis can be done with ciprofloxacin or doxycyclin. Attenuated vaccine is available (Michigan vaccine) and injected subcutaneously at 0, 2 and 4 weeks then at 6, 12 and 18 months with annual boosters. New vaccines that target the protective antigen moiety of the anthrax toxin are being developed. In a recent event on October 9, 2001, a letter containing anthrax spores were mailed from New Jersey to Washington, D.C. Five postal workers who handled the mail suffered from inhalational anthrax. The two postal workers who died had nonspecific prodromal illnesses. One developed predominantly gastrointestinal symptoms including nausea, vomiting, and abdominal pain. Both ultimately developed respiratory failure, requiring mechanical ventilation. The duration of illness was 5 days from onset of symptoms to death. Both died within 24 hours of hospitalization. Without a clinicians high index of suspicion, the diagnosis of inhalational anthrax is difficult during non specific prodromal illness.[5,38]

3. Ingestion of infected meat can lead to gastrointestinal anthrax. Pharyngeal ulcers and edema necessitate an artificial airway. Hemorrhagic mesenteric adenitis, ascites, bleeding per rectum and hematemesis may occur. Plague is caused by *Yersinia pestis*, which is an anaerobic, gram-negative cocco bacillus. There is documented evidence of the use of plague as a biological weapon, as far back as the 14th century. Plague is transmitted to humans in one of three ways, by flea vectors (*Xenopsylla Cheopsis*) from rodent reservoirs, by animal to human droplet infection, or by human to human droplet infection. Bubonic, septicemic and pneumonic forms of infection are recognized. Pneumonic plague is the most likely result of a deliberate epidemic. Bubonic plague has a mortality rate of 40% and pneumonic plague has a mortality of 100%, unless treatment is commenced within 24 hours. Treatment is with Streptomycin twice daily for 10 days, the alternate are gentamycin, doxycyclin, or chloramphenicol.[5]

Severity of CBW Attacks

1. Type of release

The severity of attacks by CBW agents depends in part on the dispersal method used.CBW release into water supplies or food chains produce fewer casualties than airborne release (aerosolized or powdered preparation), as this is not easily detectable, and secondarily causes food and water supply contamination. Several factors influence casualty rates after an air borne attack.

2. Volatility

Volatility is the tendency of a liquid to evaporate and form vapors. At usual atmospheric temperatures and pressures, most CBW agents are in liquid form.[20,21] After the explosion of ammunition containing a CBW agent; the agent is dispersed primarily as a suspension of fine liquid droplets. The vapors of all CBW agents in general are heavier than air. Therefore, the exposed individuals are safest if they are able to ascend to a higher point, such as the top floor of a building.

3. Persistence

Persistence is inversely related to volatility. The more volatile an agent, the quicker it evaporates and disperses and vice a versa. Military CBW agents are intended to be persistent, or semi-persistent. This is clinically relevant, as persistent agents are slower to

evaporate and will remain in contact with body surfaces for longer periods causing harmful effects. Such agents also pose greatest threat to rescue and medical personnel, as

there is a risk of secondary exposure and contamination from patients and the surrounding environment.[22,23]

4. Toxicity

Toxicity is defined as the potential for an agent to cause injury to biological systems.24

Two important concepts related to the toxicity of CBW agents are lethality and incapacitating effects. The cyanides and nerve agents are the most lethal of the CBW agents, and can cause death within minutes.[20] The incapacitating effects of CBW agents can be even more important than their lethality.[22] The military utility of these agents may result in the diversion of military resources to casualty evacuation and the provision of medical care.

5. Latency

Latency refers to the time delay between the exposure or absorption of an agent and the onset of clinical manifestations. This is as much important for chemical weapons as that for biological weapons. The individuals who have been exposed to any agent with significant clinical latency may require medical monitoring and quarantine for many days.[22]This need for monitoring a large number of exposed individuals can potentially overwhelm the resources of medical facilities.

Table 2 summarizes the record of antipersonnel use, taken from the same archive as that used for Table 1. Its entries are restricted to those instances since 1918 in which the fact of use can be regarded as indisputable, and in which the toxic or infective agents employed have been identified.

CONCLUSION

Education of the public and institutional preparedness can mitigate the horror of CBW agents. The media can play an active prevention role, by realistically educating the public about the impact of CBW attack, as the threats posed by biological weapons are likely to continue into the future.[19] The use of public warning systems, will be critical to inform the community about the nature of the incident, and the appropriate measures that they can take to protect themselves.46 The stresses associated with a biological terrorist attack could create, high numbers of acute and potentially chronic psychiatric casualties who must be recognized, diagnosed and treated to facilitate triage and medical care.[40]

Every effort should be made to ensure safety of personnel and other patients. Inadequate personnel protection reduces the efficiency and efficacy of the medical response. Despite the alarming projected mortality statistics quoted for a significant CBW attack, actual mortality has been relatively low. Morbidity, however, has been high; reflecting a lack of medical preparedness for such an attack. Only by planning, and investing, in the right training and defensive measures, we can decrease the risks, disruptions, and casualty morbidity and mortality. By improving our readiness to respond to terrorism, many lives can be saved and terrorists denied their goal of creating panic and crises situations.[46]

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