



## Bioterrorism: A contexture in Indian perspective\*

N RANA<sup>1</sup>

Indian Council of Agricultural Research, KAB-II, Pusa, New Delhi 110 012

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### ABSTRACT

The threat of biological warfare has been engaging the attention of Indian defence and medical experts for a long time indicating the vulnerability of the country to a potential public health threat. This paper gives an overview of bioterrorism; its historical facets, attributes of bioterrorism agents and impact of advancement in biotechnology on development of biowarfare agents. Effective bioterrorism planning, prevention and response requires cooperation and collaboration between law enforcement and public health. The paper discusses the biodefence preparedness and constraints from the Indian standpoint and identifies the need for a definitive constitutional framework to put into place a robust legislative mechanism to check the growing threat of biological warfare. Keeping in view the expertise of veterinarian in education and surveillance of zoonotic diseases, their integration in the public health disease surveillance and reporting system and participation in the fight against bioterrorism is imperative.

**Key words:** Bioterrorism, India, Public health, Veterinarians

*‘The First World War was chemical; the Second World War was nuclear; and the Third World War – God forbid – will be biological’*

– Sir William Stewart

Terrorism has become an integral paradigm of modern warfare. Several nations in the world including Iran, Libya, Syria, North Korea and Sudan are suspected to possess biological warfare agents and after the disintegration of the erstwhile Soviet Union, microbe stocks and technology appear to have passed into hands of terrorists (Godsen and Gardener 2005). The use of biological agents appeals to the terrorists because of the ease of acquisition, ease and economy of production, low visibility, and the ease and stealth of delivery. Consequently, executing a bioterror attack requires much less sophistication compared to chemical or nuclear terror attack.

Bioterrorism is intentional and deliberate release of pathogenic biological agents (bacteria, viruses, or toxins) to cause mass illness or death of people, animals, or plants. Inspired by ideological, religious or political beliefs, state-sponsored or non-state actors’ sponsored bioterrorism predominantly aims to create casualties, immense affright and unimaginable fear, societal disruption, or economic loss and enhance the power base of the organization that undertakes such an operation.

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Present address: <sup>1</sup>Principal Scientist (VPH) (neerajrana.icar@nic.in), Agricultural Education Division.

A major reason that may be attributed to spread of bioterrorism is globalization and the population growth that ultimately increases mass migration, thereby accelerating commerce and travel. Approximately, 1.8 million airline passengers cross international borders daily that may provide a free route of radiating infectious biological materials around the world within hours (Drexler 2010). Poverty, that is increasing continuously with the climate change, population growth as well as sick agricultural policies (Reuveny 2007) are also the contributing factors to the growth of bioterrorism. Other climatic changes such as water scarcity, land degradation, droughts, deforestation, floods, storms and famines also hamper agriculture and trigger more migrations which lead to a hostile atmosphere (Meinhart 2005). Growing slums at the outskirts of developed cities are a potential source of infectious diseases, as these habitats lack clean water, proper sanitation and education. Some of these diseases are caused by dangerous pathogens and are a subject of legitimate study in government, academic, and industrial labs, thereby catering to an easy accessibility to the terrorists. Some anti-social elements use such settings for production of malevolent bioweapons, as genomic data of the pathogens is easily available either on the internet and open scientific literature or through these legitimate research laboratories and pharmaceutical manufacturing sites.

### *Historical aspects of biological warfare*

Bioterrorism is not a novel phenomenon and its history goes back to antiquity. However, for the sake of discussion, it would be convenient to classify the historical use of

biological warfare under two categories, viz. Pre-modern biological warfare (Ancient era) and Twentieth century biological warfare (Modern era).

#### *Pre-modern biological warfare (Ancient era)*

The use of biological weapons dates back to the sixth century BC when Assyrians (inhabitants of biblical Middle East and comprising modern day Iraq, Syria, Jordan and Lebanon) allegedly resorted to contamination of water supply with the fungus *Claviceps purpurea* that grows in place of the grain and forms a horny mass called ergot (rye ergot). The fungus caused convulsions, muscle spasms and hallucination upon ingestion among their Israeli enemies. In 1155, the German Holy Emperor Frederick I Hohenstaufen “Barbarossa” poisoned water wells with human corpse during the battle of Tortona, Italy. In 1346, plague broke out in the Tatar (Mongol) army during its siege of Caffa, a well-fortified Genoese (Italian merchants from Genoa) controlled seaport (now Feodosia, Ukraine) in Crimea. The Mongols, in desperation, catapulted the corpses of slain soldiers over the city walls. The epidemic that followed forced the Genoese forces to surrender. Infected people who left Caffa started the Black Death pandemic throughout the Europe, probably the most devastating public health disaster in recorded history, killing more than 25 million Europeans. During the Bohemian battle of Carolstein (Karlstein) in 1422, Lithuanian soldiers, under Prince Coribat, catapulted the bodies of their slain comrades along with 2,000 cartloads of excrement over the castle walls into the ranks of the enemy, breaking out the deadly fevers. In 1495, Spanish mixed wine with blood of leprosy patients to sell to their French foes in Naples, Italy. A strategy similar to the one used by Tatar army, using cadavers of plague victims, was utilized in 1710 during the battle between Russian troops and Swedish forces in Reval. In the eighteenth century (1754–1767), during the French–Indian war, Sir Jeffrey Amherst, the commander of the British forces in North America, suggested to diminish the native Indian population, hostile to British, by giving blankets (as a gesture of goodwill) used by smallpox patients. Captain Ecuyer, one of Amherst’s subordinate officers, gave the native Americans smallpox-laden blankets, resulting in large outbreak of smallpox and high mortality as high as 50% in some tribes of Ohio River Valley (Christopher *et al.* 1997). In 1797, Napoleon flooded the plains around Mantua, Italy, to enhance the spread of malaria and in 1863, Confederates sold clothing from yellow fever and smallpox patients to Union troops during the US Civil War (Riedel 2004).

#### *Twentieth century biological warfare (Modern era)*

##### *World War era*

With the advent of modern microbiology during the 19<sup>th</sup> century, the isolation and production of stocks of specific pathogens became possible, thereby imparting sophistication to the art of biological warfare (Robertson and Robertson 1995). The role played by some major

powers in the biological warfare during the world wars is discussed below.

*Japan:* Japan was actively engaged in biological weapons research for nearly 13 years until the end of World War II. The centre of the Japanese biowarfare program, “Unit 731” was located near the town of Pingfanin Manchuria. Japanese carried out research on *B. anthracis*, *Neisseria meningitidis*, *Vibrio cholerae*, *Shigella* spp., and *Yersinia pestis*. Between 1932 and 1945, more than 10,000 prisoners were believed to have died as a result of experimental infection. At least 3,000 of these victims were prisoners of war, including Korean, Chinese, Mongolian, Soviet, American, British, and Australian soldiers. Later on, Japanese officials considered these experiments to be “most regrettable from the humanity point of view” (Riedel 2004).

In addition to the experiments conducted on prisoners in the camps of Unit 731, the Japanese military developed plague as a biological weapon by allowing laboratory fleas to feed on plague infected rats. On several occasions, the fleas were released from aircrafts over Chinese cities to initiate plague epidemics. However, the Japanese had not adequately prepared, trained, or equipped their own military personnel for the hazards of biological weapons. A biowarfare attack on the city of Changteh in 1941 reportedly led to approximately 10,000 casualties. During this incident, 1,700 deaths were reported among Japanese troops which eventually led them to terminate “field trials” in 1942 (Riedel 2004).

*Germany:* Germans allegedly shipped horses and cattle inoculated with disease-producing bacteria, such as *Bacillus anthracis* (anthrax) and *Pseudomonas pseudomallei* (glanders), to the USA and other countries. These agents were also used to infect Romanian sheep to be used for export to Russia. Germans were also accused of spreading cholera in Italy and plague in St. Petersburg in Russia (Hugh Jones 1992; SIPRI 1971). Germany, however, denied all these allegations, including the accusation that biological bombs were dropped by it over British positions (Riedel 2004).

Hitler was alleged to have issued orders prohibiting the development of biological weapons, in view of his own devastating experience with the effects of chemical agents used during World War I. However, with the support of other high-ranking Nazi officials, German scientists had started research on biological weapons (Harris 1992). Nevertheless, a German offensive biological weapons programme could never see light of the day.

*Great Britain:* German officials, on the other hand, accused the Allies of using biological weapons: Joseph Goebbels accused the British of attempting to introduce yellow fever into India by importing infected mosquitoes from West Africa (Eitzen and Takafuji 1997). This was in fact believable by many, as the British had actually been experimenting with at least one organism of biological warfare, i.e. *B. anthracis*. Bomb experiments of weaponized spores of *B. anthracis* were conducted on Gruinard Island

near the coast of Scotland (Manchee and Stewart 1988). These experiments led to heavy contamination of the island with persistence of viable spores. The island was finally decontaminated in 1986 using formaldehyde and seawater.

*United States:* Ricin (*Ricinus communis*) toxin was used by US as a bioweapon against Germany in World War I in the form of coating for bullets and shrapnel or as powder in order to be inhaled into the lungs (Smart 1997). The offensive biological warfare programme began in US in 1942 under the direction of a civilian agency, the War Reserve Service (Eitzen and Takafuji 1997). About 5,000 bombs filled with *B. anthracis* spores were produced at Camp Detrick, Maryland [renamed Fort Detrick in 1956 and presently known as the US Army Medical Research Institute of Infectious Diseases (USAMRIID)]. However, the production facility lacked adequate engineering safety measures, precluding a large-scale production of biological weapons during World War II (Robertson and Robertson 1995, Christopher *et al.* 1997).

#### *Post-World War era*

The allegations levelled by different countries against one another continued during the post-World War II period (SIPRI 1971). The Eastern European press stated that Great Britain had used biological weapons in Oman in 1957. The Chinese alleged that the USA caused a cholera epidemic in Hong Kong in 1961. In July 1964, the Soviet newspaper Pravda asserted that the US Military Commission in Columbia and Colombian troops had used biological agents against peasants in Colombia and Bolivia. In 1969, Egypt accused the “imperialistic aggressors” of using biological weapons in the Middle East, specifically causing an epidemic of cholera in Iraq in 1966.

At the end of 1969, likely prompted by Vietnam War protests, President Richard Nixon terminated the offensive biological warfare program and ordered all stockpiled weapons destroyed. In 1972, the US and more than 100 nations signed the Biological and Toxin Weapons Convention, the world’s first treaty banning an entire class of weapons. However, no clear mechanisms to enforce the treaty existed and just after signing the treaty, the Soviet Union launched its offensive program. In 1979, a rare outbreak of anthrax killed nearly 70 people in the city of Sverdlovsk. The Soviet government publicly blamed contaminated meat, but US intelligence sources suspected the outbreak to be a fallout of a secret bioweapon work at a nearby army lab. In 1992, Russia permitted a US team to visit Sverdlovsk. The team’s investigation concluded that the victims died from inhalational anthrax, likely caused by the accidental release of aerosolized anthrax spores from the military base (Meselson *et al.* 1994).

Iraq had launched its own bioweapons program around 1985 but initially lacked the expertise to develop sophisticated arms. As the Soviet Union’s bioweapon programme began to crumble in the 1990s, and scientists’ salaries dwindled, some bioweapons experts possibly got lured by Iraq. By the time of the Gulf War cease-fire in

1991, Iraq had weaponized anthrax, botulinum toxin, and aflatoxin and had several other lethal agents in development. Inspectors from the U.N. Special Commission (UNSCOM) spent frustrating years chasing down evidence of the program, which Iraq repeatedly repudiated. The UNSCOM team found that Iraq’s stockpile included Scud missiles loaded to deliver pathogens (Langford 2004).

In addition to these state-sponsored and military-related biowarfare programs, private and civilian groups have made political attempts of bioterrorism to develop, distribute, and use biological and chemical weapons to attain their vested interests or spread terror among the general public. Some of these groups (Tucker 1999) are mentioned below:

*Weather Underground:* In 1970, Weather Underground, a revolutionary group in United States, founded in the University of Michigan, planned to use biological/chemical agents in urban water in American cities. The movement opposed to American imperialism and the Vietnam war wished to demonstrate the impotence of the federal government. Their conspiracy was, however, foiled.

*RISE:* In 1972, RISE, a group of college students influenced by eco-terrorist ideology and 1960’s drug culture planned attack with pathogens causing typhoid, diphtheria, dysentery and meningitis in five American cities around Chicago. The attack was, however, aborted by timely detection of microbe cultures.

*Rajneeshee cult:* The Rajneeshee sect that moved from India to the United States in 1984 was trying to take over political control in Oregon where it lived. They had a licensed medical facility on their commune which had legitimate access to *Salmonella* bacteria. During late September that year, the cult members, with the motive to incapacitate many voters to win local elections, polluted salad bars in 10 restaurants in Dallas, Oregon with *Salmonella* Typhimurium (Christopher *et al.* 1997). The incident resulted in community outbreak of Salmonellosis involving 751 patients and at least 45 hospitalizations but fortunately with no fatality. Although the Rajneeshees were suspected, the extensive research and investigation conducted by the Oregon Health Department and the Centers for Disease Control could not conclusively identify the origin of the epidemic. However, in 1985, a member of the cult confirmed the attack and identified the epidemic as a deliberate biological attack (Caudle 1997).

*Red Army Faction:* In the mid 1990s, large amount of botulinum toxin meant for attack against West German officials and business leaders was found in a laboratory in a safe house of the Red Army Faction, a Marxist revolutionary ideology group, in Paris, France. The toxin, apparently, was never used (Caudle 1997).

*Aum Shinrikyo:* Followers of Shoko Asahara, who were members of Aum Shinrikyo, the new age Doomsday cult, made at least 10 attempts to use anthrax, botulinum toxin, Q fever agent and ebola virus in aerosol form on different occasions in Japan. The sect with an ulterior motive to establish a theocratic state made an effort to start an apocalyptic war to eventually emerge as ruler of Japan, and

possibly even the world. The same group on March 18, 1995 launched attack on Tokyo underground/subway with nerve gas sarin, resulting in death of 12 and injuries to 5500 people.

*Liberation Tigers of Tamil Eelam (LTTE)*: The Tamil militant group, LTTE, issued a communiqué in 1987 that threatened to make use of biological agents in their struggle for independence against Sri Lanka. In the communiqué, the group threatened to poison the water supplies and spread bilharziasis/onchocerciasis (river blindness) and “yellow fever” among human populations of Sri Lanka. They also threatened to attack rubber and tea plantations with leaf curl and rust diseases, respectively (Carus 2001).

*Al Qaeda*: In 2002, the Pentagon reported finding traces of anthrax at suspected Al Qaeda biological weapons’ site along with equipment used in biological warfare programme in Kandahar, Afghanistan (Larssen 2010).

*Unknown individuals/Groups*: In 1996, laboratory workers at a large medical centre in Dallas, Texas, received an email for partake of muffins and donuts in break room. Twelve individuals later developed severe diarrhoea, 8 of whom tested positive for *Shigella dysenteriae* type 2. In 1998, Larry Wayne Harris, a microbiologist and white supremacist, allegedly threatened to release “military grade anthrax” in Las Vegas, Nevada. He obtained plague and anthrax (vaccine strains) and repeatedly isolated several other bacteria. He made vague threats against US federal officials on behalf of right wing “patriot” groups, but was arrested later when he talked openly about bioweapon terrorism. In October 2001, intentional dissemination of anthrax spores was done through the US postal system, leading to 5 deaths, 22 hospitalizations and contamination of several government buildings (Teshome 2016). Five letters were sent through the mail to high-profile individuals using the highly virulent ‘Ames strain’ of anthrax. Bruce Edwards Ivins, a senior biodefense researcher at the United States Army Medical Research Institute of Infectious Diseases, was believed to be responsible for the attack.

It is widely speculated that the deadly severe adult respiratory syndrome (SARS) pandemic, which claimed several lives worldwide originated as a bioweapon. According to a report, between 01 November 2002 to 31 July 2003, more than 8,000 people were affected with 774 deaths in 29 countries (WHO 2003).

#### *Types of bioterror agents*

Historically, biowarfare (BW) agents of concern have constituted a selective group of pathogens and toxins. These may be the products of microbial metabolism that kill or incapacitate the targeted host. These include biological toxins, as well as substances that interfere with normal behaviour, such as hormones, neuropeptides and cytokines (Arora *et al.* 2002).

Based on the ability and extent of damage that can be caused, the CDC, USA, basically classifies bioterrorism diseases/agents into following three types (<https://emergency.cdc.gov/agent/agentlist-category.asp>, accessed

6 November, 2017):

*Priority category A*: High-priority agents that pose the risk to national security as they can result in high mortality rates and have potential for a major public health impact. The intensity and speed of impact can trigger public panic and social disruption requiring special action for public health preparedness.

*Priority category B*: Moderate-priority agents that are moderately easy to disseminate, resulting in moderate morbidity and low mortality. These require specific enhancements of diagnostic capabilities and enhanced disease surveillance.

*Priority category C*: Low-priority agents that are emerging pathogens, readily available and can thus be easily mutated or engineered to cause high morbidity and mortality in a short span of time due to ease of availability, production and dissemination. These have a potential for high morbidity, mortality rates and major health impact. Examples of the above three categories are shown in Table 1.

#### *Key characteristics/features of bioterrorism agents*

Biological weapons are very attractive to the terrorists because of several characteristics. It is estimated that the cost to produce a bioweapon would be about 0.05% the cost of a conventional weapon to produce similar numbers of mass casualties per square kilometre (Hawley and Eitzen 2001). Some of the features of bioterrorism agents (Borio *et al.* 2002) are as under:

- Cause high morbidity and mortality
- Potential for person-to-person spread
- Being 600–2000 times cheaper than other weapons of mass destruction, suited for mass production
- Suitable for storage until delivery without loss of pathogenic potential
- Low infective dose and highly infectious by aerosol that is invisible, silent, odourless and tasteless
- Lack of rapid diagnostic capability
- Lack of universally available effective vaccine in a short time
- Potential to cause anxiety
- Easy availability of pathogen and feasibility of production
- Environmental stability of the pathogen
- Database of prior research and development
- Potential for weaponization, i.e. ability to be modified for greater virulence and for dispersal with available weapon delivery systems

#### *Epidemiologic clues of a biological warfare*

It is very difficult to differentiate between a naturally occurring epidemic and an alleged or attempted biological warfare attack. However, some of the features that may help differentiate bioterror attack from natural outbreak (Pinto 2013) are as under:

- The occurrence of an epidemic with a similar disease or syndrome, especially in a discrete population

Table 1. Bioterrorism Agents/Diseases

Category-A	Category-B	Category-C
<i>Bacillus anthracis</i> (Anthrax)	<i>Brucella</i> species (Brucellosis)	Hanta virus
<i>Clostridium botulinum</i> toxin (Botulism)	Ricin toxin from <i>Ricinus communis</i> (Castor beans)	Nipah virus
<i>Francisella tularensis</i> (Tularemia)	<i>Coxiella burnetii</i> (Q fever)	
<i>Variola major</i> (Smallpox)	Food safety threats ( <i>E.coli</i> O157:H7, <i>Salmonella</i> spp., <i>Shigella</i> )	
<i>Yersinia pestis</i> (Plague)	Water safety threats ( <i>Vibrio cholera</i> , <i>Cryptosporidium parvum</i> )	
Filoviruses like Ebola virus (Ebola haemorrhagic fever), Marburg virus (Marburg haemorrhagic fever)	<i>Burkholderia mallei</i> (Glanders)	
Arenaviruses like Lassa virus, Machupo	<i>Burkholderia pseudomallei</i> (Meliodiosis)	
	Venezuelan equine encephalitis, eastern and western equine encephalitis	
	Staphylococcal enterotoxin B	
	<i>Rickettsia prowazeki</i> (Typhus fever)	
	Epsilon toxin of <i>Clostridium perfringens</i>	
	<i>Chlamydia psittaci</i> (Psittacosis)	

- Several cases of unexplained diseases or deaths
- A point-source outbreak with all cases clustering around a single time period
- More severe disease than is usually expected for a specific pathogen or failure to respond to standard therapy
- Unusual route of exposure for a pathogen, such as the inhalational route for diseases that normally occur by exposure through other routes
- An unusual temporal or geographic pattern of the disease
- Occurrence of disease transmitted by a vector that is usually not present in the local area
- Multiple simultaneous or serial epidemics of different diseases in the same population
- A single case of disease by an uncommon agent (smallpox, some viral hemorrhagic fever)
- An unusual age distribution for common diseases
- Unusual strains or variants of organisms, or antimicrobial resistance patterns different from those circulating in the area
- Similar genotype of the agents isolated from distinct sources at different times or locations
- Higher attack rates in those exposed in certain areas, e.g. inside a building (if released indoors), or lower rates in those inside a sealed building (if released outside)
- A disease outbreak with zoonotic impact
- Intelligence of a potential attack, claims by a terrorist or aggressor of a release, and discovery of munitions or tampering
- Multiple disease entities in one patient, indicating that mixed agents have been used in the event

#### Disadvantages of biowarfare agents

- Difficulty of protecting the workers at all stages of production, transportation, loading of delivery systems and final delivery (Harris 1992).
- Difficulty in maintaining quality control and sufficient containment during growth and harvesting of agents

- After 15 years of denial, in 1992. President Boris Yeltsin admitted to the accidental release of anthrax spores from a military microbiology test facility in Sverdlovsk (now Ekaterinburg) during 1979 that claimed over 200 lives (Jeena 2007).
- Effective delivery problems
- Most biological materials, including spores, are destroyed by exposure to Ultra Violet light and drying. Agents released in the air are likely to disperse in unexpected ways due to the vulgarities of wind patterns (Harris 1992, Jeena 2007)
- Poor storage survival
- Many biological weapons require storage under special conditions to maintain efficacy. They are often difficult to maintain in a weapons - delivery state, e.g. loaded and ready to be fired in a rocket (Bhardwaj *et al.* 2009).
- Difficult to control once released
- Detection or interdiction of groups intending to use BW is next to impossible

Table 2. Effective dose of bioterrorism agents

Biological agent	Effective dosage/person
Anthrax	8000-15000 spores
Plague	100-500 organisms
Small pox	< 10-100 organisms
Tularemia	10-50 organisms
Q. Fever	1-10 organisms
Ricin	3-5 mg/kg body weight
Botulism	0.00001 mg/kg body weight

#### Effective dose of bioterrorism agents

The effective dose per person of different biological agents (Kar *et al.* 2012) is given in Table 2.

#### Impact of a hypothetical biological attack

The estimates given by WHO (1970) for causalities in the event of a hypothetical attack due to potential bioterrorism agents are presented in Table 3.

Table 3. Estimates of casualties produced by a hypothetical attack

Agent	Downwind reach (km)	Number killed	Number incapacitated
Rift Valley fever	1	400	35,000
Tickborne encephalitis	1	9500	35,000
Typhus	5	19,000	85,000
Brucellosis	10	500	125,000
Q-fever	>20	150	125,000
Tularemia	>20	30,000	125,000
Anthrax	>20	95,000	125,000

\*Release of 50 kg of agent (aerosolized) by aircraft along a 2 km line upwind of a population center of 500,000. *Source:* \*Modified from WHO (1970)

#### Potential methods for dispersal of bioterrorism agents

The biological weapons system predominantly comprises of four components: a payload, munition, delivery system and dispersion system. The payload is the biological agent itself. The munition protects and carries the payload to maintain its potency during delivery. The delivery system can be a missile, vehicle (aircraft, boat, automobile or truck), or an artillery shell. The dispersion system ensures dissemination of payload at the target site. Some of the potential methods of dispersion (Kar *et al.* 2012, Klietmann and Ruoff 2001) are as under:

*Inhalational exposure:* Such systems may include mail/packages, commercially available spray devices/crop duster, fire extinguisher, air conditioning systems, smoke generator and street air fresheners. Motor vehicle/car may also be used to cruise through the streets of a city while emitting a fine spray of biological warfare— aerosol through a fake tailpipe or other small vent (Poupard and Miller 1992).

*Food and water supply contamination:* The terrorists may either use individual consumption items or food chain contamination mode to infect a vast population.

*Injection:* Contaminated needles or some projectiles/contaminated shrapnel may be used for dispersal of infectious agents. Umbrella weapon, that consists of a projectile weapon disguised as an umbrella, shoots tiny pellets having a hole drilled through it and filled with the toxin 'ricin'. The hole is covered with wax that melts when the projectile enters the body due to the body heat. Bulgarian dissident writer Georgi Markov was assassinated on a London street in 1978 using ricin-filled pellet infected with a spring-loaded device disguised as an umbrella.

*Military munitions:* Military munitions like radio-controlled, infra-red guided/electro-optical, laser/satellite guided weapons may also be used to quickly produce a mass effect.

*Suicide coughers:* Human "Suicide Coughers" may get self-inoculated with lethal strains of anthrax and smallpox and go into public gatherings to spread the diseases, causing mass fatalities.

*Remote controlled devices:* Solar powered robotic delivery systems can be used to release material periodically over several days depending on the direction of the wind

(Bhardwaj *et al.* 2009). Unmanned Aerial Vehicles or "Drones" are being used nowadays for a range of activities, such as delivering packages for Amazon, monitoring poachers of endangered animals on African reserves, and even for herding sheep in Ireland. Difficulty with detection methods, coupled with the advent of low-cost drones, could make transporting liquid agents or dispersing airborne pathogens fairly easy.

#### Impact of advancement in biotechnology on development of biowarfare agents

Ever-evolving advances in biotechnology research hold promise for a revolution in biowarfare development and may thus offer opportunity to technologically proficient rogue nations and sophisticated terrorist organizations to expand their capabilities for attack. For the sake of discussion, impact of biotechnology on the development of biological agents can be considered as under:

*Genetically modified agents:* With the advent of recombinant DNA technology, it has become quite easier to alter the genetic makeup of an organism for producing bio-warfare agents. Some of the potential modifications that may be exploited to effect these alterations include antibiotic resistance, increased aerosol stability, or enhanced virulence. The genetic modifications may specifically be used to alter epitopes or sequences used for detection and diagnostics, thereby necessitating the incorporation of multiple points of reference into these systems to ensure security regarding bio-detection strategies (Kumar *et al.* 2011).

*Advanced biological warfare agents:* Development of technologies in biological sciences has helped biowarfare agent developers to identify biochemical pathways critical for physiological processes and engineer specific advanced biowarfare agents to exploit vulnerabilities in the biological system. Emerging biotechnologies thus might lead to a paradigm shift in biowarfare agent development with future biological agents capable to target specific human biological systems at the molecular level (Kumar *et al.* 2011).

#### New biowarfare use options

There is a wide array of effects that can be introduced by the bioterrorists into novel biowarfare agents.

Agents could be tailored to target a specific population and race sensitive bio-weapons may be designed to selectively attack people according to their genetic or cultural traits, e.g. "Designer" substances may be created (Arora *et al.* 2002) that can be specifically targeted to a particular cell-type in an enemy, such as people with blonde hair and blue eyes. Similarly, sterilizing, oncogenic, or debilitating agents could be created for use as a strategic weapon against a target population for long-term effects.

The white South Africa apartheid government had once considered trying to develop methods to reduce the population of blacks. Research on birth control methods, through 'Project Coast', to reduce the birth rate in black population was one such development (BBC News 1998).

A rumour once surfaced in the English Press that Israel was working on a bioweapon that would specifically harm Arabs carrying certain genes (Mahnaimi and Colvin 1998).

#### *Is the bioterrorism threat realistic?*

The threat of bioterrorism is no more restricted to realms of imagination as can be discerned from the following points:

- As evident from the past and present cases of bioweapons, nations/dissidents/groups exist with the motive and necessary skills to develop and disperse biological agents (Hamburg 2002).
- The former Soviet Union's bioweapons facility that was used to produce weaponized infectious diseases, such as plague and anthrax, has missing stockpiles of its bioweapons. Stockpiles were allegedly sold on the black-market to Middle Eastern countries. Furthermore, the scientists who worked in the offensive biological weapons program until the early 1990s have moved to other countries, such as North Korea and other Middle Eastern countries and are suspected to be collaborating with those governments in their clandestine bioweapons programs (Fong and Alibek 2010).
- Efforts have been made by terrorist networks, such as Al Qaida, to recruit scientists capable of creating bioweapons, thereby posing security concerns (Anonymous 2011).
- >800 terrorist modules have been operating in India (Narayanan 2008).
- Exponential increase in computational power combined with the accessibility of genetic information and biological tools to the general public and lack of governmental regulation has raised concerns about the threat of biowarfare arising from outside the military (Kay 2003).
- Individuals with basic biology and engineering training could develop effective weapons at little cost.
- Overall, bioweapons are relatively inexpensive, easy to produce, conceal and transport, and can cause considerable damage without elaborate weaponization, thus making them an ideal candidate to use as a weapon.

The fear of bioterrorism and its implication on public health is already being perceived in certain countries around the world. In the United States for example, after the discovery of human anthrax cases in 2001, the Illinois Department of Public Health received over a thousand human samples of potential anthrax, all of which were negative. This data of increased volume of submissions to a local public health laboratory demonstrates the fear of bioterrorism in the general population (Department of Health and Human Services Public Health Service 2012).

#### *What makes India vulnerable?*

Precarious security environment in South Asia, rapid rise in fundamentalism, extremist implosion of Pakistan, civil

war in Afghanistan and emergence of ISIS have accentuated the threat of bioterror attacks in India (Abrol 2016). Links of Al Qaeda with four terrorist groups in India, viz. Lashkar-e-Taiba, Jaish-e-Mohammad, Harkat-ul-Jihad-ul-Islami and Harkat-ul-Mujahideen are well-established. All these groups, like Al Qaeda, specialize in suicide bombings and pose a real danger of biological attack in India in future. Possibility of Al-Qaeda taking help of organized crime syndicates in launching biological attacks cannot be ruled out. Domestic groups such as the LTTE or global groups such as Al Qaeda have not indulged in agro-bioterrorism so far. However, according to press reports, Al Qaeda does have such ambitions (Bannerjee 2007). According to the Ministry of Agriculture, India is particularly vulnerable to agriculture attacks (Anonymous 2010). High population density, growing mobility of India's middle class and vast international movements, coupled with weak public health and agricultural infrastructure, are some of the factors conducive to an imminent threat. Co-existence of an advanced biotechnology industry and large bio-medical research community that may be a potential source of biological agents, also adds to this danger. Prime Minister Manmohan Singh had once remarked—"Intelligence on terror strikes will remain with the concerned central security agencies, while a recently formed expert group could formulate a plan to deal with exigencies in case of biological or chemical warfare" (Jeena 2007). This was published in response to a report by Indian intelligence agencies, warning the Ministry of Home Affairs (MHA) of possible biological attacks on the country. The PM had suggested setting up a high-level policymaking body capable of providing advice and assistance to states during times of disaster. Advances in the biotech sector and shifting terrorist tactics that focus on disrupting India's social cohesion and economic prosperity oblige the GoI to look at the possibility of terror groups using biological agents as weapons of mass destruction. Moreover, lack of communication, coordination, and cooperation among key stakeholders from different sectors will continue to remain a major impediment to the GoI's capacity to respond to a bioterrorism attack. All these indicators and developments warrant that the country gets equipped adequately to pose suitable counter measures in the event of a bioterror attack.

#### *Bioscare in India*

Though India has faced terror attacks on several occasions, yet no bio-terrorist strike has been recorded in India to date. This may, however, be due to very low levels of suspicion and lack of definitive investigative procedures (Sharma 2001).

Several incidents in the past suspected to have been the acts of bioterrorism in India are listed in Table 4.

The real threats, however, seem to have been reduced to a prank. Following 9/11 events in US, incidents of bioscare were reported from several parts of the country and the postal workers had started wearing rubber gloves and surgical masks before leaving for work in the metropolitan

Table 4. Suspected acts of Bioterrorism in India

Year	Biological agent attack	Place
1965	Scrub typhus outbreak	North-eastern India during Indo-Pakistan war
1994	Pneumonic and bubonic plague*	Surat and Beed, Gujarat, respectively
1996	Dengue hemorrhagic fever	Delhi (10252 cases, 423 deaths)
1999	Anthrax	Midnapore, West Bengal
2001	Mystery 'encephalitis'	Siliguri, West Bengal (66 cases, 45 deaths)

\*Plague strains were suspected to be genetically engineered as both outbreaks were from a unique 'unknown strain', a firm called Viva, Almaty, Kazakhstan was known to possess several strains of the plague microbes for sale during the same period (Press Trust of India 1995).

cities like Delhi, Mumbai and Kolkata, etc. Anthrax scare was faced by Rashtrapati Bhavan, MHA and Russian Embassy in New Delhi. The victims ranged from L.K. Advani, Union Home Minister; Buddhadev Bhattacharya, Chief Minister of West Bengal; Manohar Parikkar, Chief Minister of Goa; Vilasrao Deshmukh, Chief Minister of Maharashtra; Motilal Naik, Hyderabad High Court Judge; Harjinder Kaur, Chandigarh Mayor; A.R. Nanda, Family Welfare Secretary; Milind Shete, Editor of the Vishwa Hindu Parishad (VHP) weekly Sanskritik Vartapatra in Pune to villagers in remote areas.

#### *Biodefence preparedness and constraints*

A strong public health infrastructure is a prerequisite to effectively handle the threat of bioterror attack in India. India spends just 1% of its gross domestic product (GDP) on public health, which is amongst the world's lowest (Abrol 2016). However, as per the recently unveiled National Health Policy, it has been decided to raise public expenditure for healthcare sector to 2.5% of GDP (Anonymous 2017a). The various components of the public health system such as surveillance, assessment, medical management, information and education, etc. need to be strengthened. Weaknesses in the disease surveillance systems, lack of well-established collection of baseline epidemiological information/data (naturally occurring disease burden) are likely to pose difficulty to the country in differentiating between a natural outbreak and deliberate introduction in the event of attack. Integrated Disease Surveillance Project (IDSP) created with the objective to strengthen/maintain decentralized laboratory-based IT enabled disease surveillance system for epidemic prone diseases to monitor disease trends and to detect and respond to outbreaks in early rising phase through trained Rapid Response Team (RRTs) has poor grass root penetrability and lacks international networking with generic or disease-specific networks like FluNet and Dengue Net (Abrol 2016).

Though India had established a National Institute for Disaster Management (NDMA) in 2003, it lacks a specific agenda directed to bioterrorism and its mitigation. National

Guidelines on Biological Disasters were also comprehensively framed in India by NDMA in 2008, however, not much progress has taken place on the ground. Though, the Indian National Crisis Management Committee (NCCM) constituted under the co-ordinating command of MHA had approved a model of standard operating procedures (SOP) for preventing and responding to a bioterrorism attack in March 2007, yet primary responsibility for responding to attacks lies with the State governments (Sharma *et al.* 2016).

The 'Defence Research and Development Establishment' (DRDE), Gwalior, under the 'Defence Research and Development Organization' (DRDO), Ministry of Defence (MoD), is India's primary biodefence laboratory. It is mainly involved in the development of defence against malicious biological, chemical as well as toxicological materials. Some DRDO labs have developed the protective systems and equipments for protection of Indian troops against the nuclear, biological and chemical warfare. Four battalions of National Disaster Response Force (NDRF), the multi-disciplinary force for specialized response to natural and man-made disasters, have been trained to deal with chemical, biological, radiological, and nuclear (CBRN) threats. However, focus of both NDMA and NDRF is on post-disaster response to natural calamities (Abrol 2016).

High containment laboratories (Bio-safety level-4, BSL-4) having ultra-modern facilities for safe handling and rapid diagnosis of all the classified bioterror agents constitute the first line of defence. These are also responsible for storage of such agents under secure custody for developing vaccines for use in the event of an emergency. Sensu stricto, there are only two BSL-3 plus laboratories in India, one at ICAR-National Institute of High Security Animal Diseases at Bhopal (the OIE Reference Laboratory for Avian Influenza), actively engaged in diagnosis and control of exotic animal diseases, and the other at the Microbial Containment Complex (MCC), National Institute of Virology, Pune.

Clearly, GoI is currently ill-equipped to prepare for or respond to a bioterrorism attack as no central nodal govt. agency exists to holistically address different facets of bioterrorism with no definitive legal backstopping to address this issue. A comprehensive National Bioterrorism Disaster Management Plan involving MoD (armed forces as first responders), MHA (nodal ministry for countering terrorism), Ministry of Agriculture & Farmers' Welfare, MoAFW (epidemics in animals and crops), Ministry of Health & Family Welfare, MoH&FW (epidemics in humans) and concerned scientific institutes/laboratories across the country needs to be prepared.

Revised International Health Regulations, 2005 which require that epidemic outbreaks on international concern are detected, investigated and contained promptly are also not being pursued vigorously. A comprehensive planning that focuses on local preparedness and response capacity integrating the role of regional, state and central government is also strongly warranted.

The draft Public Health (Prevention, Control and Management of Epidemics, Bio-Terrorism and Disasters) Bill, 2017 was recently uploaded for seeking comments of the stakeholders by the MoH&FW. The National Centre for Disease Control (NCDC) and the Directorate General of Health Services (DGHS) jointly prepared the Bill keeping in mind the need to empower local government bodies during emergency situations. It incorporates provisions to give more teeth to the government machinery so that they are able to tackle any emergency swiftly. The Bill seeks to provide for the prevention, control and management of epidemics, public health consequences of disasters, and acts of bio-terrorism or threats and repeal the Epidemic Diseases Act, 1897. Though the bill gives emphasis on curbing bioterrorism, but the larger picture is merely visionary. On ground, there is a scarcity and crisis of public health institutes, universities and hospitals which are efficient enough and well-equipped to tackle the concerns of bioterrorism. We rather need a comprehensive Public Health Act with more clarity and precision. The powers and duties should be clearly revealed at community, local, state and central levels for its better implementation. Besides other facts, massive research and development and training of public health cadres like field epidemiologists, disease control specialists and public health administrators is needed before formulating such a bill (Anonymous 2017b).

Veterinarians are at the front line for education regarding zoonotic diseases and are the experts on zoonotic category A, B, and C agents. Veterinarians and veterinary diagnostic laboratories should become a part of nationwide active surveillance for category A, B, and C agents and diseases, as well as for new and emerging bioterrorism agents. If the war against bioterrorism and emerging diseases is expected to be remotely winnable, integration of practitioners and veterinary diagnostic laboratories into public health and disease-reporting systems and establishment of means for rapid communication and dissemination of information to these stakeholders is imperative (Pal *et al.* 2017).

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