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CHAPTER

Bioterrorism, an Emerging Threat

7

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Chapter outline

Abstract

Various books such as *Handbook of Viral Bioterrorism and Biodefense* (Clercq and Kern, 2003), *Biosecurity and Bioterrorism: Containing and Preventing Biological Threats* (Ryan and Glarum, 2008), and *Bioterrorism: Threats and Deterrents* (Çankaya and Kibaroğlu, 2010) have discussed threats, causes, and effects of bioterrosim in different parts of the world. The chapter on "Bioterrorism, an Emerging Threat in Pakistan" focuses on the current situation of bioterrorism in Pakistan. Several examples from all around the world have been quoted to highlight different incidents of bioterrorism across the world. After addressing vicious epidemics, several laboratory methods for detection and surveillance for bioterrorism have been elaborated. The case studies of bioterrorism in terms of warfare highlight use of bioweapons at political fronts. Similarly, the success story of controlling bird flu and advent and persistence of dengue show the status of bioterrorism and Pakistan's preparedness to deal with this menace. Pakistan has strengthened itself to deal with bioterrorism by adopting different national and global tools for governance. However, the rapid decline in environmental quality leads to an increase in biohazards. It

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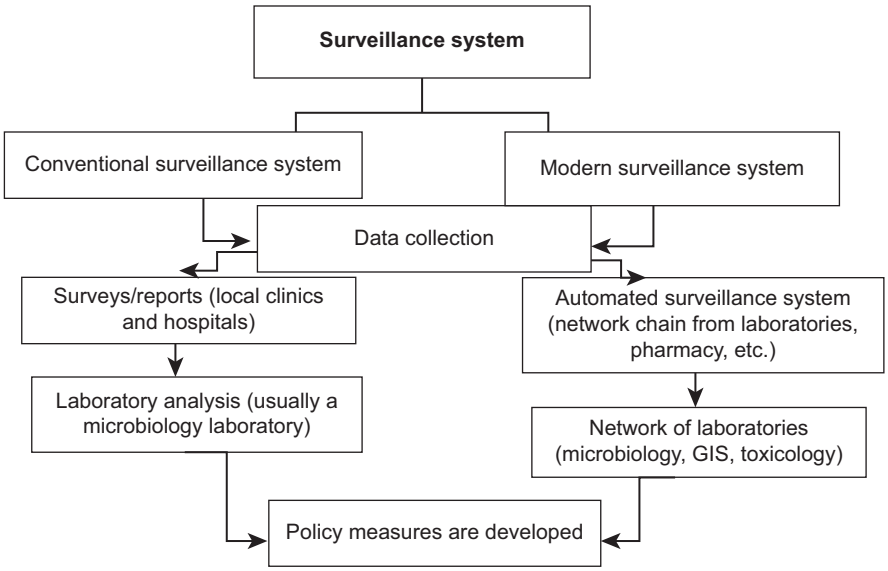
is important to address bioterrorism at every forum so that sustainable solutions can be devised to tackle environmental deteriorations.

Keywords: Biohazards; Bioterrorism; Environment; Pakistan; Warfare.

Graphical Abstract



7.1 Introduction

Bioterrorism, bioweapons, or biowarfare is a term used to describe the intentional or deliberate use, spread/release, dissemination or production of living organisms, toxins, and chemicals of animal or plant origin to produce such diseases that can harm or cause death of humans, animals, plants, and even the overall environment. The terrorist can spread it via air, water, soil, and food, and they can take few hours to several days to cause the effect. It is a very broad subject that includes diverse range of organisms (bacteria, pathogens, and viruses) and chemical toxins which are used to spread terror, danger, risk, and threat. This can be performed by an individual having vested interests or for retaliation, but it can also be sponsored by some government as part of a political agenda. In earlier days, anthrax and small pox diseases were used as a source of bioterrorism in the West and even recently, anthrax is a very commonly used agent for bioterrorism. This form of

terrorism is the easiest because the agents are available easily, do not cause sound or blast (unless it involves chemicals), can cause harm across borders, and are widespread mostly as it can wipe out entire population (Khadori, 2006). There are three broad categories which specify the term bioterrorism. The categories are based on the threat ranging from highest to moderate and eventually to gradual (A, B, and C) (Table 7.1).

Category A consists of those disease-causing agents which can be easily released and can spread from one person to another. They can become a public health problem and result in socioeconomic impact because people can become ill and do not go to jobs, schools or handle business which ultimately results in social impact. Some examples are bacteria such as *Bacillus anthracis* (anthrax-causing bacteria) and *Yersinia pestis* (plague-causing specie), viruses such as filoviruses (cause Ebola), and toxins such as *Clostridium botulinus* (botulism-causing toxin).

Category B includes those agents that are moderately easily transmitted and do not cause deaths, but some people are affected. For instance, bacteria specie such as *Salmonella* (food contaminant) and virus such as alphaviruses (cause encephalitis).

Category C includes those pathogens that are being genetically engineered to cause effect in future and they have a potential to result in high death toll. For example, *Naegleria* and Nipah viruses.

Historically, bioterrorism has been termed as the earliest form of terrorism to be practiced since pre-Christian era when wars were common and technology was not evolved as it is today. However, world was making advancements in science and methods were being invented to take over the world and crush the enemy in a shorter time. So the easiest way to do it was to spread diseases that can weaken the enemy. It is usually believed that the plague epidemic in Europe was caused by some sailor who carried the disease from the enemy country (Riedel, 2004). Similarly, there has been

Table 7.1 Distinction between categories of bioterrorism.

	Category A	**Category B**	**Category C**
Level	Highest	Moderate	Gradual (future use)
Impact	Large population	Small population	Potential to effect large population
Examples	Bacteria (*Bacillus anthracis)* Virus (filoviruses)	Bacteria (*Salmonella)* virus (alphaviruses)	Virus (Nipah virus)

incidences when during election, a poisonous dose of bacterial agent was mixed in the salads of local restaurants so that the voters turn out will be less and the competitors will lose (Barras and Greub, 2014). Then later, it became common to use bioterrorism during world wars, when it assumed the shape of chemical warfare. Mustard gas was used to blind the enemy, poison used to be sprayed in the freshwater sources to kill the population, food used to be poisoned, viruses were spread through prostitution, and so on. Recently, Ebola virus, bird flu, rota virus, H1N1, influenza, Naegleria, dengue fever, and many other forms of diseases are being spread among those countries where population is not getting controlled such as African and some Asian countries. Also, in Syria, recently the President Bashar al-Assad bombed the civilians with chemicals which resulted in huge casualties of children. It has been reported that after the onset of Gulf War, many countries sent agents in African countries to acquire such viruses and bacterial agents such as Ebola and botulinum to cause harm to either the enemy or the groups that were engaged in uprising against the tyrannical governments. Even such chemical gases like nerve gases are available in all European countries to counter the war threat (Handerson, 1998). Some examples of bioterrorism from history are enlisted in Table 7.2.

7.2 Laboratory detection and surveillance methods for bioterrorism

Globally, there are laboratories established to address bioterrorism. According to the Centers for Disease Control and Prevention (CDC), there should be a laboratory response network which should include clinical microbiology laboratories that are responsible for identifying, detecting, and reporting bioterrorism. In addition, they must suggest the measures that can be adopted to remedy the effects. Moreover, the laboratory response network can be grouped category wise, dealing with the issue, like a category A laboratory can be a primary laboratory that can help detect such agents which can likely cause bioterrorism effects and so they should be equipped to conduct primary analysis. The B category laboratories can help to isolate and identify the exact agent responsible for bioterrorism and work for its remedial measures and design such strategies. Similarly, the category C laboratories should work to identify those agents that can cause potential damage as a bioterrorism agent in future; they all must act as public health laboratories. Mostly, microbiologists are capable enough to work out the effects and remedies for bioterrorism and the population suffering or at risk to suffer from its

Table 7.2 List of biodiseases around the world.

Diseases	Year	Origin/ country	Reported causalities	Source
Black death pandemic	13–15th century	Europe	25 million reported deaths	Shinwari et al. (2014)
Smallpox virus	1600s	North America	400,000 causalities	Riedel (2004)
Severe acute respiratory syndrome (SARS)	2002–03	Hong Kong/ China	298	Mikes (2009)
Avian influenzas	2006	Azerbaijan, Cambodia, China, Egypt, Djibouti, Indonesia, Iraq, Laos, Thailand, Turkey, Nigeria, and Vietnam	150 million affected birds resulted in 335 confirmed cases	Brooks (2007)
Equine influenza	2007			
Swine flu	2009/ 2014	Worldwide	203,000 deaths	Gholipour (2013)
Tuberculosis	2016	Worldwide	10.4 million affected people	CDC (2018)

impacts. However, toxicologists also have a significant role to offer in this regard, as they are the ones who can identify the toxins from food, air, water, and even soil sources that can have an impact on the entire population and pose a risk to the overall public health (Lim et al., 2005). Usually, blood samples are taken from humans and animals for the identification of the cause, while water, crop, soil, and air sampling is also performed to identify the source. Ideal sampling techniques have been recommended by CDC which should be adopted globally as a standard procedure. Some common globally used laboratory techniques to detect bioterrorism agents include centrifugation, filtration for the separation of microorganism on cellular level, dielectrophoresis, immune-magnetic separation; and mostly polymerase chain reaction is also utilized by laboratory experts to identify biowarfare agents that can have impacts on genes and at molecular level (Bravata et al., 2004).

Before the laboratory work begins, there is a surveillance system that includes collection of data either through observation or surveys and later reporting it to the laboratories. The data should be collected from local clinics and hospital reports because bioterrorism is a public health issue, so a nation-wide surveillance system should be devised to monitor and manage the issue. This kind of surveillance system is also termed as conventional or traditional surveillance; however, modern surveillance system has also been adopted by many countries in the world to counter bioterrorism which include nation-wide automated surveillance for disease-related syndromes, analysis of routinely collected clinical, administrative, pharmacy, and laboratory data. Another important thing that should be considered for surveillance is the cost, social barriers, and environmental ethics. So, it does not matter which surveillance type is adopted as it depends upon the country's environmental, economic, and social conditions. Furthermore, there has to be a system of proper management and chain of command which should be supervised and regulated under the government as it is a concern for entire population. A regulatory body should be established to further remove the bias that can be questioned later (Hutwanger et al., 2003). However, problems can still exist because it is not easy to identify the culprit who release or transmit agents because the recipes to spread such kind of terror are easily available and accessible through the Internet. Also, the environment ethics is the subject being ignored the most specifically by the scientists who are engaged in performing experiments on viruses and bacteria, genetic modifications, etc. and is becoming a reason for the wide spread of bioterrorism in the world (Fig. 7.1).

7.3 Bioterrorism and its impacts on environment of Pakistan

Biosafety is a well-established concept which gained fame after the incident of 9/11. Similarly, despite Pakistan striving to survive in the global dynamics, climate change, however, is one of the biggest forms of bioterrorism in Pakistan. Massive desertification in agricultural plains, diverge droughts in Thar, massive flooding in arid and semiarid regions and irregular pattern of monsoon are the results of climate change (Nazar, 2016). Gayari Sector avalanche resulted in the death of 121 Pakistani soldiers. Pakistan witnessed its worst history of floods in 2010 which caused damage to over 20 million people, killed more than 2000 people alone, and resulted in huge economic loss to the country (Jaspal, 2010). Flash floods caused by torrential monsoon

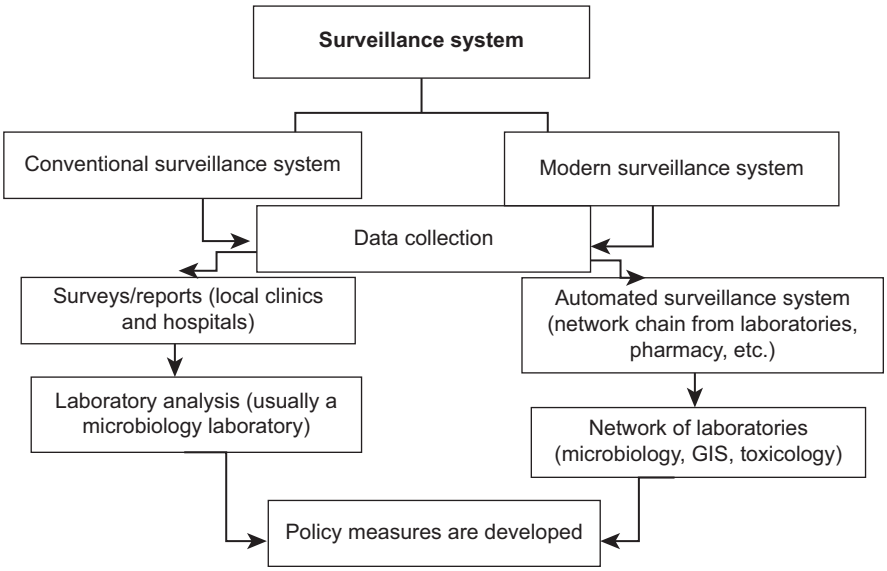


FIGURE 7.1 Steps involved in investigation of bioterrorism.

rains damaged crops in 2015. Pakistan can be beleaguered with biological weapons on the pillars of economy such as food, agriculture, human resource, and livestock (Shinwari et al., 2014).

7.3.1 Bioterrorism in health sector—case studies from Pakistan

Use of biological weapons has been widely debated over the years. World in the 21st century is more prone to bioweapons than nukes. Gleick (2006) reported cases of bioterrorism in Pakistan. Since then, numerous cases have been reported confirming the presence of evidence and traces of bioweapons, which show that specialized knowledge has been applied to make them cheap and spread to masses. Table 7.3 provides insight in the history of bioterrorism in Pakistan.

Mosquito-borne diseases have greatly affected the agricultural sector of Pakistan. Floods of 2010 and 2011 resulted in major outbreaks of waterborne diseases. According to World Health organization (WHO), 50 million dengue infections are reported each year. Dengue was first reported in 1994 in Pakistan, and till now 4.5 million cases of malaria are reported each year in Pakistan (Khan, 2016). In 2014, 1218 cases of cholera were reported

Table 7.3 List of legal parameters adopted to counter bioterrorism in Pakistan (Khalil et al., 2015).

Legal parameters	Year	Features
Biological toxic Weapons Convention (BTWC)	1972	Pakistan became a party to this convention by recognizing its obligation to prevent the use of toxic agents.
Plant Quarantine Act	1976	Pakistan is committed to regulate the entry, spread, and distribution of exotic insects and plants.
Animal Quarantine Act	1979	Pakistan is committed to regulate the entry, spread, distribution, and export of harmful animals and animal products.
Cartagena Protocol on Biosafety	1992	Being a secretary of Convention on Biological Diversity (CBD), Cartagena Protocol on Biosafety ensures safe and protected transboundary movement of biologically modified organisms.
Sanitary and Phytosanitary Agreement (committed under WHO)	1995	Pakistan is obliged to sanitary and phytosanitary agreement which coerces it not to import or export toxins which can be misused for terrorism against plants or animals.
Pakistan Environmental Protection Act (PEPA)	1997	Section 13 of PEPA prohibits the import of hazardous substances in Pakistan.
Pakistan Export Control Act	2004	Pakistan is committed to regulate, control, and prevent the spread of bioweapons. The list of such goods and technologies was prepared and revised in 2016 (confirm from the document)
National Biosafety Guidelines	2005	These guidelines were developed to regulate the possible undesirable effects of laboratory work on Genetically Modified Organisms (GMOs). These guidelines also contributed to formation of the following regulatory bodies: • Institutional Biosafety Committee (IBC) • Ministerial Biosafety Committee (MBC) • National Biosafety Committee (NBC)
International Health Regulations (committed under WHO)	2005	Pakistan is committed to regulate spread of infectious materials at inter region and intraregional level by adopting better public health response.
National Internal Security Policy (NISP)	2014	This policy addresses both internal and external threats to the country including use of biological or chemical agents for terrorism in the future.

(The Statistics portal, 2014). Each year in Pakistan, 115.2 million cases of diarrhea are reported (Sultan and Memon, 2017).

7.3.2 Pakistan's stance on countering bioterrorism

Pakistan has been a victim of bioterrorism from a very long period. Despite having no recognition in *Anti-Terrorism Act 1997* and *National Counter Terrorism Act 2013*, bioterrorism is one of the highly debated issues of Pakistan. Biosafety and bioterrorism are two parallel concepts as improvement in biosafety can help to combat bioterrorism and vice versa. Pakistan still needs to work in public health sector by developing effective response mechanisms to address bioterrorism. Up-to-date vaccine availability, clean environment, and improved health standards can be ensured by public-private partnership and joint ventures by researchers, physicians, policy makers, and common people. Various research institutes are working to protect it from this menace. A list of some initiatives from the past is given in the following section.

7.4 Bioterrorism in terms of warfare

Use of infectious materials for warfare can be traced to 600 BC to physically weaken the enemy. Use of filth, cadavers, contagion, pollutants in water reservoirs of the opposing army was a common strategy which has been followed till 21st century (Riedel, 2004). Evidence has indicated the presence of biological warfare program in Germany during World War I when Germans were accused for shipping horses and cattle inoculated with anthrax and glanders to neighboring countries (Huge-Jones, 1992). More countries invested in biological weapons during World War II. Japan conducted biological weapons research program "Unit 731" which consisted of 150 buildings, 5 satellite camps, and more than 3000 scientists (Baskin and Brewer, 1997).

State and nonstate actors have been reported to be indulged in chemical weapons programs as a prologue of terrorism in the 21st century (Rapoport, 2014). In recent era, almost 30 states have chemical weapons. Iraq used them against Iran, Libya against Chad, and Egypt used them against Yemen (Maloney, 2008). Such chemical weapons have more tactical effects than strategic ones (Bruck and Flowerree, 1991). Syrian biochemical attack is the most brutal form of bioterrorism in the recent age. Syrian government used similar weapons in 2015 and 2016 as well claiming lives of 1500 people. Thousands of people were wounded, and the blame was transferred to the rebels. In 2017, a war plane dropped a bomb in *Khan Sheikhoun*, a small area

occupied by protesters. More than 70 deaths and more than 350 injuries were reported. Victims reported experiences including redness of eyes, constricted pupils, blue derma and lips, and shortness of breath. The organization for the prevention of chemical weapons collected medical samples from three victims, which indicated the presence of banned compound sarin, which is diisopropyl methylphosphonate (Syrian Civil War, 2017). This incident was a cruel decision against civilians demonstrating might is right in religious violence as well.

7.5 Case studies of bioterrorism in Pakistan

Various research studies imply that many of the diseases have been introduced as a consequence of bioterrorism in the country. Table 7.4 shows the list of distribution of deadly diseases in Pakistan (Fig. 7.2).

7.5.1 Bioterrorism in terms of health nuisance in Pakistan

Dengue fever has been identified as the worst form of epidemic across the world. Pakistan, like other developing counties, is largely affected by it due to lack of proper sanitation, unsafe access to drinking and freshwater reservoirs, larger refugees, and overcrowded cities. Its origin can be traced to import of used tires in the country. Morbidity by dengue fever has been increasing since it was first reported in 1994 (Jahan, 2011). In 2012, Government of Punjab launched anti-dengue campaign in different schools, universities, and departments. Punjab Municipal Development Fund

Table 7.4 Reported cases of bioterrorism in Pakistan.

City	Disease	Year
Lahore	Swine flu	2015
Islamabad	Crimean-Congo hemorrhagic fever	2015
Karachi	*Naegleria fowleri* (brain-eating bacteria)	2015
Noorpur Thal	Mysterious infection in 500 camels	2015
Punjab	Dengue	2011–present
Punjab	Anthrax	2004
Country wide	198 cases of polio	2011

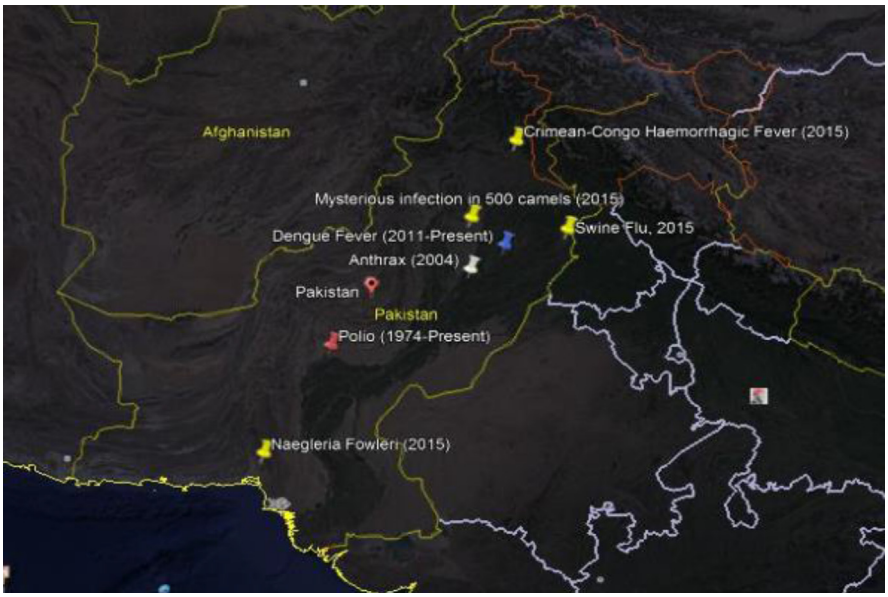


FIGURE 7.2 Highlights of the reported cases of bioterrorism in Pakistan.

Company (PMCFC) was given the responsibility to strengthen Tehsil Municipal Authorities in combating dengue. Digital maps were prepared by using geographical information system, and hotspots of dengue were identified. 520 shoulder foggers, 1600 spray pumps, and safety gears were provided to the teams who visit homes for sprays and site inspection. Various training sessions are arranged for capacity building of the staff (PMDFC, 2018). Despite numerous initiatives, dengue returns each year with larger number of cases. Lack of involvement of public, open drains, and insufficient access to sanitation can be major causes of the wide spread of this epidemic. Media has played effective role in spreading awareness about this menace; however, there are still gaps in community involvement in this sector.

7.5.2 Bird flu

Bird flu, also known as fowl plague, avian flu, or chicken Ebola, is the most fatal disease which results in 100% mortality rate in domesticated birds (Dhama et al., 2013). H5N1 or etiological agent avian influenza virus (AIV) has global impacts and spreads beyond geographical boundaries (Dhama et al., 2012). Therefore, disease outbreak should be reported immediately so that trained veterinarians and professionals can deal with

biohazard of fowl birds. The symptoms of bird flu in fowls include edema in wattles, diarrhea, soft-shelled or misshaped eggs, lack of coordination in birds, swelling of birds, lack of appetite or energy, ruffled feathers, and nasal discharge (Bentoli, 2018). In 2003, human to human transmission of avian influenza was observed before which it was considered to affect birds only (Peiris et al., 2004).

The poultry sector of Pakistan also witnessed episodes of H5N1, which resulted in great challenges to this industry due to highly pathogenic Asian influenza (HPAI) during 2003−06 (Ghafoor et al., 2010). Avian influenza was first recorded in 2006 in Pakistan in Charsadda, Abbottabad, Pindi Bhatian, Attock, Sehala, and Tarlai areas of Islamabad. Nearly 100,000 birds were culled, and Rs. 100 million was spent as compensation. The surveillance system established nationwide helped stakeholders to prevent disasters from this disease (Hussain et al., 2008). CDC advises the travelers and people who deal it to take prevention measures (Khan et al., 2008). Pakistan gained the bird flu free status in 2007 (Poultry News, 2011).

7.6 Conclusion

Bioterrorism is real, evident, and persistent in the modern era. Unfortunately, Pakistan faces bioterrorism in all categories. Our natural resources are being polluted at irreversible rate. Many indigenous species are at the verge of extinction. Evidence shows that state and nonstate actors are contributing to biosafety and security issues. Therefore, it is important to revise and review the legal structure pertaining bioterrorism. Government must ensure the construction of strong institutions which can carefully implement those legislations. The source of category A and B is localized; therefore strengthening of provincial Environmental Protection Agencies (EPA), implementation of self-monitoring programs by the industries, and legislations such as "polluter pays" principle can help to protect our natural resources. Research is the backbone of policies. Therefore, private sector should be encouraged to invest in research in this field.

References

Barras, V., Greub, G., 2014. History of biological warfare and bioterrorism. Clinical Microbiology and Infections 20 (6), 497−502.

Baskin, S.I., Brewer, T.G., 1997. In: Sidell, F., Takafuji, E.T., Franz, D.R. (Eds.), Medical Aspects of Chemical and Biological Warfare, vol. 10. TMM Publication, Washington, DC, p. 271.

Bentoli, 2018. How to Identify Bird Flu Symptoms in Chicken. https://bentoli.com/bird-flu-symptoms-in-chickens/.

Bravata, D.M., McDonald, K.M., Smith, W.M., Rydzak, C., Szeto, H., Buckeridge, D.L., Haberland, C., Owens, D.K., 2004. Systematic review: surveillance systems for early detection of bioterrorism-related diseases. Annals of Internal Medicine 140 (11), 910–922.

Brooks, P., 2007. Bird Flu (Avian Flu). http://www.netdoctor.co.uk/healthy-living/a5566/bird-flu-avian-flu/.

Burck, G.M., Flowerree, C.C., 1991. International Handbook on Chemical Weapons Proliferation, p. 105. New York.

Çankaya, S., Kibaroğlu, M., 2010. Bioterrorism. IOS Press, Amsterdam.

CDC, 2018. Data and Statistics about Tuberculosis Around the World. https://cdc.gov/tb/statistics/default.htm/.

Clercq, E., Kern, E., 2003. Handbook of Viral Bioterrorism and Biodefence. Elsevier, Amsterdam..

Dhama, K., Chakraborty, S., Tiwari, R., Kumar, A., Rahal, A., Latheef, S.K., Latheef, Wani, M.,Y., Kapoor, S., 2013. Avian/bird flu virus: poultry pathogen having zoonotic and pandemic threats—a review. Journal of Medical Science 13 (5), 301–315.

Dhama, K., Tiwari, R., Singh, S.D., 2012. Biosecurity measures at poultry farms and thumb rules to avoid developing a serious zoonotic illness from birds. Poultry Punch 28 (3), 30–51.

Ghafoor, A., Badar, H., Hussain, M., Tariq, N., 2010. An empirical estimation of the factors affecting demand and supply of poultry meat. Pakistan Veterinary Journal 30 (3), 172–174.

Gholipour, B., 2013. 2009 Swine-Flu Death Toll 10 Times Higher than Thought. https://www.livescience.com/41539-2009-swine-flu-death-toll-higher.html.

Gleick, P.H., 2006. Water and terrorism. Water Policy 8 (6), 481–503.

Henderson, D.A., 1998. Bioterrorism as a public health threat. Emerging Infectious Diseases 4 (3), 488–495.

Hugh-Jones, M., 1992. Wickham Steed and German biological warfare research. Intelligence and National Security 7 (4), 379–402.

Hussain, M., Irshad, H., Khan, M.Q., 2008. Laboratory diagnosis of transboundary animal diseases in Pakistan. Transboundary and Emerging Diseases 55 (5-6), 190–195.

Hutwagner, L., Thompson, W., Seeman, G.M., Treadwell, T., 2003. The bioterrorism preparedness and response early aberration reporting system (EARS). Journal of Urban Health 80 (1), i89–i96.

Jahan, F., 2011. Dengue fever (DF) in Pakistan. Asia Pacific Family Medicine 10 (1), 1.

Jaspal, Z.N., 2010. Biosecurity and Pakistan: A Critical Appraisal.

Khalil, A., Tanveer, F., Shinwari, Z.K., 2015. Pakistan's bio-preparedness with regard to biosecurity, biodefense strategies and policy measures. Journal of Bioterrorism & Biodefense 6 (132), 2.

Khan, S., 2016. Malaria in Pakistan. Pakistan Observer. https://pakobserver.net/malaria-in-pakistan/.

Khan, S.A., Hashmi, I., Ranjha, A.N., Yosufzai, M.K., Hashmi, K., Anjum, Q., 2008. Students' corner-awareness of bird flu amongst young college students. The Journal of the Pakistan Medical Association 58 (8), 466.

Khardori, N., 2006. Bioterrorism and bioterrorism preparedness: historical perspective and overview. Infectious Disease Clinics 20 (2), 179–211.

Lim, D.V., Simpson, J.M., Kearns, E.A., Kramer, M.F., 2005. Current and developing technologies for monitoring agents of bioterrorism and biowarfare. Clinical Microbiology Reviews 18 (4), 583–607.

Maloney, S., 2008. Iran's Long Reach: Iran as a Pivotal State in the Muslim World. US Institute of Peace Press.

Mikes, J., 2009. Bioterrorism in Asia. The Diplomat. https://thediplomat.com/2009/05/bioterrorism-in-asia/.

Nazar, S., 2016. Pakistan's Big Threat Isn't Terrorism-It's Climate Change. The South Asian Channel. http://foreignpolicy.com/2016/03/04/pakistans-big-threat-isnt-terrorism-its-climate-change/.

Peiris, J.S.M., Yu, W.C., Leung, C.W., Cheung, C.Y., Ng, W.F., Nicholls, J.A., Path, T.,N., Chan, K., Lim, W., Yuen, K., Guan, Y., 2004. Re-emergence of fatal human influenza A subtype H5N1 disease. The Lancet 363 (9409), 617–619.

PMDFC, 2018. Anti-Dengue Campaign. http://pmdfc.punjab.gov.pk/anti_dengue_campaign/.

Rapoport, D.C., 2014. Terrorism and weapons of the apocalypse. In: Twenty-first Century Weapons Proliferation. Routledge, pp. 32–50.

Riedel, S., 2004. Biological warfare and bioterrorism: a historical review. In: Baylor University Medical Center Proceedings, vol. 17, No. 4. Taylor & Francis, pp. 400–406.

Ryan, J., Glarum, J., 2008. Biosecurity and Bioterrorism. Butterworth-Heinemann.

Shinwari, Z.K., Khalil, A.T., Nasim, A., 2014. Natural or deliberate outbreak in Pakistan: how to prevent or detect and trace its origin: biosecurity, surveillance, forensics. Archivum Immunologiae et Therapiae Experimentalis 62 (4), 263–275.

Sultan, M.A., Memon, I., 2017. 5th Initiative against Diarrheal and Enteric Diseases in Asia. http://www.cholera-network.org/wp-content/uploads/2017/05/ashraf-sultan.pdf/.

Syrian Civil War, 2017. Syrian Chemical Attack: What We Know. http://www.bbc.com/news/world-middle-east-39500947/.

The Poultry Site, 2011. Vigilance & Prevention Keep Pakistan Bird Flu- Free. http://www.thepoultrysite.com/poultrynews/22942/vigilance-prevention-keep-pakistan-bird-flundashfree/.

The Statistical Portal, 2014. Number of Reported Cases of Cholera in Pakistan. https://www.statista.com/statistics/701551/pakistan-number-of-reported-cases-of-cholera/.