

10.3.9 Bioterrorism 1718

10.3.9 Bioterrorism 1718

SECTION 10 Environmental medicine, occupational medicine, and poisoning 1718 a substantial difference to the health and economic impacts of these severe events. Post-disaster relief Most traumatic deaths in sudden-onset disasters will happen before outside aid arrives, and so building local resilience and the capacity to react to disaster is essential. However, relief teams from outside a disrupted region or country may find that they have an important role in restoring roads and bridges, bringing in potable water, water purification, ensuring solid waste management, food protection, vector control, and sanitation. Attendances at medical facilities may return to normal within a few days of the disaster onset, and restoration of primary care then becomes the priority rather than emergency treatment. However, the earthquakes in Pakistan (2005) and Nepal (2015) already mentioned in this chapter caused widespread destruction in remote, mountainous regions of the countries, and the damage to roads reduced accessibility even further, so the treatment of many casualties was inevitably delayed. In Nepal, WHO working with the Ministry of Health and Population coordinated the national and international humanitarian aid, sending foreign medical teams that had registered with them to deliver healthcare in the affected districts. Epidemiology has an important role in post-disaster assessment and health surveillance, particularly when large populations have been relocated, as well as investigating the causes of mortality and morbidity in disasters, such as mental ill health and long-term physical health consequences. The evidence base for the effectiveness of health-directed interventions in humanitarian crises, including natural disasters, needs strengthening and this is at last being acknowledged by research grant awarding bodies and nongovernment organizations. Similarly, scientific evaluation of disaster relief efforts, in particular the knee-jerk response of sending aid—any type of aid, instead of aid matched to need, in the mistaken and even patronizing belief that the affected population is too shocked and helpless to take responsibility—has incentivized governmental relief organizations to review their practices. Indiscriminate aid can actually hinder the efforts of countries already fully under strain—the examples are legion. Many donated medicines are out of date or simply inappropriate, food supplies are not tailored to requirements, international relief teams being sent without the right expertise or capable of being self-sufficient, including uninvited individuals or medical doctors inexperienced in disaster response, and who might consequently do more harm than good. Infectious disease epidemics are still mistakenly and widely held to inevitably follow in the wake of mass fatalities and the disposal of corpses, with the result that local healthcare workers, already in short supply, might be diverted into undertaking mass immunization campaigns and mass burials without good reason. Inevitably, the pressing priorities in most disaster settings are not conducive to undertaking well-conducted evaluations of relief practice. The medical literature on natural disasters is relatively small and in recent decades the global challenge has focused on

improving preparedness and risk reduction, but progress has been lamentably slow. This global overview of progress over the last decade may not be as encouraging as many of us would like to read, but the need for effective health sector participation in both planning for and responding to natural disasters has never been greater. FURTHER READING Cash RA, et al. (2013) Reducing the health effect of natural hazards in Bangladesh. *Lancet*, 382, 2094–103. Fink S (2013). Five days at memorial: life and death in a storm ravaged hospital. Atlantic Books, London. Hasegawa A, et al. (2015). Health effects of radiation and other health problems in the aftermath of nuclear accidents, with an emphasis on Fukushima. *Lancet*, 386, 479–88. Katz JM (2013). The big truck that went by: how the world came to save Haiti and left behind a disaster. Palgrave Macmillan, New York, NY. Koenig KL, Schultz CH (2016). Disaster medicine. Cambridge University Press, Cambridge. Websites Centre for Research on the Epidemiology of Disasters (CRED). <http://www.cred.be> Pan American Health Organization (WHO) Emergency Preparedness and Disaster Relief.

<http://www.paho.org/disasters> UN International Strategy for Disaster Risk Reduction. <https://www.unisdr.org/> 10.3.9 Bioterrorism Manfred S. Green ESSENTIALS Bioterrorism is the deliberate use of biological agents to cause illness, death, and fear for ideological or personal purposes. Most potential bioterrorism agents occur naturally as known pathogens and are classified by the United States Centers for Disease Control as follows: (1) Category A, with greatest risk to the public and national security This comprises (a) infectious and contagious diseases—smallpox, plague, and viral haemorrhagic fevers; (b) infectious but not contagious diseases—anthrax, and tularaemia and (c) toxins—botulism; (2) Category B, with intermediate risk This comprises those causative agents that are relatively easy to spread and produce diseases with moderately high death rates; (3) Category C—emerging infectious diseases that could be engineered to spread and cause high rates of morbidity and mortality. The agents might be disseminated through aerosolization, food, human carriers, infected insects, or water. The incubation periods of these agents can vary from hours to weeks, with early symptoms mimicking many other infectious diseases. The diagnosis might not be suspected unless cases occur in clusters. Early identification of outbreaks will depend largely on the ability of primary care and emergency room physicians to identify and promptly report cases to the public health authorities. A major concern is that diagnosis of these extremely uncommon diseases might not be considered by physicians who have

10.3.9 Bioterrorism 1719 rarely, if ever, seen such cases. Specific treatment (if available) of affected individuals will depend on the pathogen, and for contagious diseases such as smallpox and plague, isolation of patients and their contacts, barrier nursing, quarantine, and restriction of the movements and social interactions of people are important control measures. Decontamination is relevant mainly for anthrax and smallpox, in the environment of an aerosol attack and at places where patients were treated. Public education and effective risk communication are essential in managing a bioterrorism attack: (1) clinicians and public health personnel need access to up-to-date information; (2) the general public requires nontechnical descriptions of the diseases and simple instructions on how to act in an emergency situation. Primary prevention should include addressing the root causes of terrorism, developing comprehensive preparedness programmes, and educating health professionals to deal with an outbreak. Introduction The potential public health threat posed by bioterrorism could make exceptional demands on clinicians. Rapid diagnosis will have implications far beyond the individual patient. It will initiate a process of preventive actions, which could impact on the lives of thousands. Clinicians might have to treat infectious disease casualties en masse under emergency situations, while ensuring the protection of healthcare workers and other patients. Clinical presentations might be atypical because of the

nature of the exposure and the possibility that the organism might have been genetically mutated. Antibiotic resistance and vaccine failure could be encountered and laboratories are likely to be overburdened. Public panic could exacerbate ethical dilemmas in the triage for specialized care in limited facilities. Historical perspective The use of biological agents as weapons inspires a special abhor- rence and dread. International agreements, such as the Geneva Protocol in 1925 and the Biological Weapons Convention in 1972, banned their use and production. However, in the early 1990s, it was revealed that anthrax spores were accidentally released from a military facility in Russia in 1979, causing an outbreak of respira- tory anthrax. Evidence emerged that the former Soviet Union had continued a bioweapons programme, generating concerns that bioweapon agents and the expertise for their production might reach terrorist groups. Biological weapons Almost all potential bioterrorism agents occur naturally as known pathogens, although many are zoonoses, not normally affecting humans. The United States Centers for Disease Control and Prevention (CDC) classified potential bioterrorism agents into three categories (Box 10.3.9.1). Category A agents have the highest priority since they are considered the greatest risk to the public and national security. These can be subclassified into agents that are in- fectious and contagious, those that are infectious but not usually contagious, and toxins. Category B includes diseases that are con- sidered an intermediate risk to the public since the causative agents are relatively easy to spread and the diseases result in moderately high death rates. Category C agents include emerging pathogens, which could be engineered to spread and cause high rates of mor- bidity and mortality. Since the category A biological agents have been weaponized in past programmes, they are currently of greatest concern. Here they are briefly described but more details about their clinical aspects are provided in Section 8. Diseases that are both infectious and contagious Smallpox (Chapter 8.5.4) is the prototype of potential bioterrorism agents that are both infectious and contagious. Although eradicated in 1978, it is believed to have been weaponized by the Soviet Union. Universal vaccination was phased out in the 1970s and since the case fatality in unvaccinated subjects is around 30%, smallpox is one of the most feared bioterrorism threats. Secondary cases can occur through droplet spread, direct contact with skin lesions or body fluids, and rarely through airborne transmission. The plague bacillus (*Yersinia pestis*) (Chapter 8.6.16) was in- cluded in the bioweapons programmes of both the United States of America and the Soviet Union. Untreated pneumonic plague has a case fatality approaching 100%. The organism can spread from person to person through droplets, causing several generations of the disease. Box 10.3.9.1 Examples of bioterrorism agents by category Category A Infectious and contagious diseases • Smallpox (*Variola major*) • Plague (*Yersinia pestis*) • Viral haemorrhagic fevers (filoviruses, e.g. Ebola, Marburg, and arena- viruses, e.g. Lassa, Machupo) Infectious but not contagious diseases • Anthrax (*Bacillus anthracis*) • Tularemia (*Francisella tularensis*) Toxins • Botulism (*Clostridium botulinum* toxin) Category B • Brucellosis (*Brucella* spp.) • Epsilon toxin of *Clostridium perfringens* • Food safety threats (*Salmonella*, *Escherichia coli* 0157, *Shigella*) • Glanders (*Burkholderia mallei*) • Melioidosis (*Burkholderia pseudomallei*) • Psittacosis (*Chlamidia psittaci*) • Q fever (*Coxiella burnetii*) • Ricin from *Ricinus communis* (castor bean) • Staphylococcal enterotoxin b • Typhus fever (*Rickettsia prowazekii*) • Viral encephalitis (alphavirus, e.g. Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis) • Water- safety threats (e.g. *Vibrio cholerae*, *Cryptosporidium parvum*) Category C • Emerging infectious diseases such as Nipah virus and hantavirus Source: <http://www.bt.cdc.gov/agent/agentlist-category.asp>

SECTION 10 Environmental medicine, occupational medicine, and poisoning 1720

Viral haemorrhagic fevers caused by the filoviruses (Chapter 8.5.17) and arenaviruses (Chapter 8.5.18) may have been weaponized by the former Soviet Union, Russia, and the United States. The Soviet Union is reported to have produced quantities of Marburg, Lassa, Ebola, Junin, and Machupo viruses. Second and later generations of disease can occur through direct contact with body fluids of the patients. Healthcare workers are at greatest risk. Infectious but not contagious diseases

Anthrax spores (Chapter 8.6.21) were among the leading agents in biological weapons programmes, since they are highly stable, virulent, resistant to drying, and easily disseminated. Aerosolized spores cause inhalation anthrax, which has an untreated case fatality approaching 100%. The spores can survive in the environment for many years, although once on the ground, they will tend to produce cutaneous anthrax. The spore-forming coccobacillus *Francisella tularensis* (Chapter 8.6.20), has been weaponized in biowarfare programmes. The untreated case fatality could be 30–60%. There is no secondary person-to-person spread. Toxins Botulinum toxin, produced by *Clostridium botulinum* (Chapter 8.6.25), is one of the most potent neurotoxins known and has been weaponized. In a bioterrorist incident, it could be disseminated either through food or by aerosol. The untreated case fatality approaches 100%. Ricin is a protein cytotoxin produced from the castor bean *Ricinus communis*. There is no antidote. Patients affected by toxins are not contagious at any stage of the disease. Dissemination of bioweapons Biological agents might be disseminated through aerosols, food, human carriers, infected insects, or water. Aerosolization maximizes the number of people exposed, causing the most damage. Release of contagious agents at different sites could greatly amplify the outbreak. Since most potential agents are not normally aerosol transmitted, the resulting illnesses could occur with shorter incubation periods and atypical clinical manifestations. Clinical effects are likely to depend on the dose. Epidemiology Documented contemporary attempts at planning or occasionally attempting bioterrorism have employed *Salmonella typhimurium*, botulinum toxin, anthrax spores, Q fever bacteria, Ebola virus, and ricin. In 1978, a Bulgarian dissident was assassinated in London by a pellet, probably of ricin, that was implanted into his leg. In 2001, six envelopes contaminated with powdered anthrax spores were mailed in the United States and infected 22 people. Half suffered from inhalation anthrax and the others from cutaneous anthrax. Thousands of workers received prophylactic therapy, and a large-scale decontamination programme was implemented (Fig. 10.3.9.1.)

Radiological and chemical terrorism are also potential threats. The only documented incident of radiological terrorism occurred in 2006, when a former officer in the Russian security services was assassinated by exposure to α -emitting polonium-210 (^{210}Po), in a public place in London. Although no other cases were detected, others could have been exposed through ingestion of the material from contamination of their hands. The initial symptoms could be confused with an infectious disease. In 2018 in the UK a nerve agent, novichok, was used in an attempt to assassinate a former Russian agent and his daughter. Some weeks later a UK citizen died from exposure to the same agent following contact with the presumed liquid containing novichok that had been left near the scene. Prevention Prevention of bioterrorism includes addressing the causes of terrorism and developing appropriate preparedness strategies. In addition to international condemnation of the development of bioweapons, access to production capabilities must be controlled. Effective preparedness is in itself a deterrent and requires coordination between agencies and specialists from multiple disciplines. Food supplies must be protected from deliberate contamination.

1 0 0 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 30 31 32 33 2 3 4 5 6 7 8 9 10

Day Per cent

Fig. 10.3.9.1 Simulated epidemic curve for a point-source outbreak of inhalation anthrax without intervention. Reproduced from Scheulen J, Latimer C,

Brown J (2006). Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS). Johns Hopkins University. Internet <http://www.hopkins-cepar.org/EMCAPS/EMCAPS> accessed July 14, 2007.

10.3.9 Bioterrorism 1721 Although water is an unlikely vehicle for bioterrorism, drinking- water sources require special security measures. Preparedness programmes include training and, where indicated, pre-exposure vaccination of 'first responders'. The infrastructure to deal with the impact of different biological agents will require increased clinical surge capacity and patient isolation facilities. Children, pregnant women, and the immunocompromised might have special needs. Dead patients need to be handled using the same barrier precautions as for live patients. Antivirals and immunoglobulins are currently considered only for treatment and not for prophylaxis. At present, vaccines are relevant only for smallpox and anthrax. In most countries, more than 50% of the population has never been vaccinated against smallpox. Antibody titres have been shown to decline markedly 5–10 years following vaccination, although residual immunity might persist for many years. However, previously vaccinated, milder cases in the community could increase the risk of spread. Several countries have carried out vaccination programmes against smallpox for military personnel and first responders. Anthrax vaccine is given routinely in some military populations. Some countries have established national stockpiles of pharmaceuticals and vaccines for use in the event of biological or chemical attacks. The global inventory of smallpox vaccine, together with the possibility of diluting vaccine, exceeds three billion doses. Preparedness for a potential bioterrorism incident remains a high public health priority in most countries, but there are important logistic issues regarding stockpiling and mass administration of vaccines against potential bioterrorism agents, both prior to and during incidents. A dual vaccine has recently been developed against both smallpox and anthrax by integrating immune-enhancing cytokine IL-15 and the protective antigen of *B. anthracis* into the Wyeth vaccinia virus. This has been proven to be efficacious against both smallpox and anthrax in laboratory animals. If human trials of safety and efficacy are successful, such a vaccine will have several important advantages. First, it will be a combined vaccine against two diseases. Second, as a vaccinia-based vaccine it can be lyophilized without loss of potency and so will not be dependent on the cold-chain, which will greatly simplify storage, stockpiling, and field delivery. Thirdly, it is likely to reduce the number of doses necessary to achieve protection against anthrax. Hence, in practice it could be an extremely important advance for mass vaccination in general and for vaccinating first responders in particular. The recent Ebola epidemic in West Africa has stimulated the development of effective vaccines and treatment for Ebola virus disease. Secondary prevention depends on comprehensive surveillance and clinical awareness, both for detecting and characterizing the event. This will facilitate prompt implementation of treatment and, where appropriate, postexposure prophylaxis. Rapid implementation of measures such as vaccination, isolation of patients, and quarantine of contacts can ameliorate the spread. Tertiary prevention includes early treatment and rehabilitation of those people who contract the disease and public information campaigns to reduce the long-term psychological impact of the incident. Clinical features The incubation periods of potential bioterrorism agents can vary from as little as several hours to weeks. The incubation period for smallpox is between 7 and 14 days, but could be less following exposure to aerosol. Pneumonic plague is likely to develop within 24 h to 2 days after aerosol exposure. Inhalation anthrax has an incubation period of 1–6 days, but is probably dose-related, and could be longer than 40 days. For inhaled botulinum toxin, the incubation period is estimated to be between 12 and 80 h and for ricin, perhaps even less. Diseases such as anthrax, smallpox, and tularemia usually present early

on with influenza-like illnesses, but if exposure is by aerosol, the symptoms might differ from the naturally occurring diseases. Diseases like plague and tularemia can present as pneumonia. Agents such as smallpox will subsequently develop a typical rash. In the later stages, both anthrax and smallpox commonly develop neurological symptoms. The haemorrhagic fevers are characterized initially by high fever and bleeding tendencies. Inhaled botulinum toxin causes acute, afebrile, descending flaccid paralysis starting with ptosis and muscles innervated by cranial nerves. Inhaled ricin causes fever, chest tightness, dyspnoea, nausea, and arthralgia, within 4–8 h, followed by acute respiratory distress syndrome and death within 18–24 h. Differential diagnosis The early symptoms of diseases caused by potential bioterrorism agents can mimic a large spectrum of diseases since influenza-like illness is a common presentation for many. Since diseases such as plague and tularemia can present with pneumonia, cases might not be suspected unless they occur in clusters. Even with the classical sign of widened mediastinum which frequently characterizes inhalation anthrax, it might not be simple to distinguish from other severe pneumonias. Early identification of deliberately caused outbreaks will depend largely on the ability of primary care and emergency room physicians to identify and promptly report cases to the public health authorities. A major concern is that diagnosis of these uncommon diseases will not be considered by physicians who have rarely, if ever, seen such cases. Many of the biological agents can be identified by hospital laboratories. However, some require more specialized laboratories and international collaboration. New techniques, especially those based on polymerase chain reaction, are being developed to accelerate specific diagnosis. The safety of laboratory workers must be protected. Surveillance and early detection The objectives of surveillance for bioterrorism incidents are twofold. Firstly, early detection of cases can facilitate prompt treatment, identification of the exposure source, rapid introduction of prophylaxis and, where necessary, isolation of cases and imposition of quarantine. Secondly, surveillance systems have a major role in monitoring the progress of an outbreak to support decisions on upgrading and redistributing health services and provide reliable and timely information to the media and the public. Traditional surveillance, based on routine physicians' reports, could have serious limitations in a bioterrorism incident. Early cases might be missed due to a failure to suspect unusual diseases. Thus, there might be considerable delays in alerting public health

SECTION 10 Environmental medicine, occupational medicine, and poisoning 1722 authorities due to the lag time between the initial symptoms and definitive diagnosis. Furthermore, access to timely, processed information during the epidemic might be seriously limited. Recognizing these limitations, surveillance for symptoms and signs, known as 'syndromic surveillance', has been proposed as a more sensitive method for early detection of an outbreak. Although theoretically appealing, in practice, syndrome surveillance is likely to be most useful to complement early detection and reporting of the index cases by alert physicians. Sources of data for syndromic surveillance are usually recorded visits to primary care physicians and emergency rooms and use of prescription and nonprescription medication. Computer analysis of the data allows temporal and geographical trends to be identified. Clusters in families or in age groups will be useful in locating the exposure source. Surveillance systems must include clear procedures to be followed when a suspected incident is reported. Although syndromic surveillance systems are highly sensitive, they tend to have both low specificity and positive predictive value. Abundant false positive reports could desensitize and paralyse the system. Despite the limitations of syndromic surveillance, once an outbreak has been confirmed, such systems will provide timely data on the location, nature, and evolution of the outbreak. Electronic data systems will, however, be important for confirming

and tracking the outbreak, and they can reduce delays in reporting and reliance on reports from individual physicians. They can play a critical role in the control of the epidemic by providing information for 'situational awareness'. Epidemiological investigation The main objectives of the investigation are to identify and characterize the outbreak and predict its course. For bioterrorism incidents, the investigators should have specialized knowledge of the possible biological agents and the natural history of the diseases. Close collaboration with the police, public health authorities, and the media is essential. Patient details should include the date and time when symptoms started, signs and symptoms and, when smallpox is suspected, the vaccination history. It is important to establish which public places patients have visited in the incubation period of the suspected agent. Those patients reported to have similar symptoms and contacts should be interviewed. It is important to document the natural history of the disease for each patient. When investigating potential bioterrorism outbreaks, there is a need to identify the source of the implicated pathogen. This was typified in the investigation of the anthrax letters incident in the United States in 2001. Recently the investigators in that outbreak used comparative genome analysis and demonstrated that the genotypes detected in the *B. anthracis* morphotypes isolated for the letters were different from the Ames strain common in the environment. This study has provided support for the added value of whole-genome sequencing, and comparative genomics for potential bioterrorism outbreak investigations. Postexposure prophylaxis Postexposure prophylaxis is appropriate for some, but not all, bioterrorism agents. Vaccination against smallpox, within 3–4 days of exposure, appears to provide protection against clinical disease. However, since the incubation period is usually longer than 4 days, the lag time for recognizing index cases might render postexposure vaccination effective only for contacts of those initially exposed. 'Ring vaccination' involves intensive tracing and vaccination of all primary contacts, followed by vaccination of the secondary contacts as opposed to mass vaccination immediately following diagnosis of the first cases. Ring vaccination accompanied by vaccination in affected regions, followed by countrywide mass vaccination, is likely to be the most effective strategy. This approach has now also been proposed for the control of Ebola virus disease epidemics. For some agents, postexposure prophylaxis with antimicrobials has a role. Ciprofloxacin, doxycycline, and ampicillin are used for postexposure prophylaxis against anthrax and plague. In the case of anthrax, it should be combined with vaccination. Results of animal studies suggest that postexposure antivirals could be effective in a smallpox outbreak. Ribavirin might have some efficacy in postexposure prophylaxis of RNA viral haemorrhagic fevers such as arenaviruses. Isolation and quarantine For contagious diseases, such as smallpox and plague, isolation of patients, barrier nursing, quarantine of contacts, and restriction of the movements and social interactions of people are important control measures. Results of modelling studies suggest that closing schools and reducing crowding and the use of public transport would be effective in limiting the spread of an epidemic. For contagious diseases, there are specific guidelines for the use of masks by healthcare personnel and emergency workers. Surgical masks might be adequate for droplet spread, whereas N95-type masks would be necessary to protect against aerosols. However, they are more expensive, require special fitting, and cannot be worn for long periods. The efficacy and practicability of the use of masks by the general public are less clear. Public education and risk communication The novel and largely unpredictable effects of biological weapons are likely to increase the uncertainty surrounding a bioterrorism incident. Public education and effective risk communication are essential in order to bolster public confidence and improve cooperation with the authorities. Clinicians and public health personnel should have access to up-to-date information. The general public should be provided with nontechnical descriptions of the diseases and simple instructions on

how to act in an emergency situation. Risk communication associated with a bioterrorist event can be divided into five stages: prior to the event, on suspicion of an event, on confirmation of the event, during the event, and following the event. At each stage, the public is likely to ask questions relevant to that stage. Since the authorities may possess very little factual information, the public might suspect that information is being withheld, resulting in hostility. Thus, it is important that the public messages be reassuring while sharing uncertainties. Overreaction or panic should be anticipated. This can be exacerbated by rumours

10.3.9 Bioterrorism 1723 or unsubstantiated statements by professionals or laypeople not involved in managing the outbreak. A variety of problems should be anticipated during an outbreak, including atypical presentations of cases and varying responses to treatment and prophylaxis. Side effects of the medications and vaccines might be reported. Discovery of new exposure foci and reports of disease in apparently unexposed people could cause disquiet and mistrust. There might be inadequate isolation of patients and a breakdown of the implementation of quarantine. Untried new treatments might be proposed by unauthorized professionals or lay people. Following a bioterrorist incident, residual public fear and anxiety is likely to persist. Inevitably, there will be questions about the extent to which the authorities were able to control the incident, criticism of actions taken or not taken, and general recriminations. Public messages should be broadcast about the lessons learned from the incident and actions that will be taken to address deficiencies. It is essential that the authorities maintain transparency in order to strengthen public trust.

Decontamination Decontamination is relevant, mainly for anthrax and smallpox, in the environment of an aerosol attack and at places where patients were treated. Sodium hypochlorite solution is effective in most settings. Bedding and clothing of patients should be sterilized or disposed of where indicated. Low humidity and temperature prolong survival of the smallpox virus in the environment, and on scab material; it can remain viable for months. Legal and ethical aspects Bioterrorism preparedness requires the necessary legislation to enable the public health authorities to carry out measures with adequate legal backing. Laws that are of particular importance relate to closing buildings, taking over hospitals, ordering isolation and quarantine, and active surveillance of presumed infected individuals and their contacts. Ethical issues might arise in the triage of patients for admission to overburdened hospital wards and intensive care units.

Areas of uncertainty or controversy Bioterrorism incidents have so far been very rare, and preparedness is based on an assumption that the potential risk is both real and severe. There are some concerns that the investment of large resources in bioterrorism preparedness could come at the expense of other essential public health activities. Research should be encouraged to assess the risks, costs, and benefits of the preparedness activities, in order to strike a reasonable balance. New surveillance systems, particularly those based on syndromic surveillance, might be insufficiently specific and too much of a burden on the health services to be sustainable for long. Uncertainty remains about the efficacy of vaccines and antimicrobial therapy in the event of an outbreak. Renewed assessment of conventional approaches is particularly appropriate now, in the light of the experience gained during the recent Ebola virus disease epidemic in West Africa. Likely future developments The threat of bioterrorism is likely to increase, demanding greater resources to deter attacks and improve surveillance, vaccines, and medications. Conclusions Bioterrorism is a low-risk but high-impact public health emergency. Deterrence remains the prime goal. Reducing the motivation for terror and banning internationally the use of biological weapons should be promoted at all levels. Sensible preparedness for bioterrorist incidents is a deterrent in itself and ensures that public health systems and society will deal effectively with an incident. Risk communication

needs to be strengthened. Such measures will also improve general emergency preparedness and the control of infectious diseases. FURTHER READING Adalja AA, Toner E, Inglesby TV (2015). Clinical management of potential bioterrorism-related conditions. *New England Journal of Medicine*, 372, 954–62. Armengaud J (2017). Striking against bioterrorism with advanced proteomics and reference methods. *Proteomics*, 17, (1–2). Arnon SS, Schechter R, Ingelsby TV, et al (2001). Botulism toxin as a biological weapon. Medical and public health management. *Journal of the American Medical Association*, 285, 1059–70. Banada PP, Deshpande S, Chakravorty S, et al (2016). Sensitive detection of *Francisella tularensis* directly from whole blood by use of the GeneXpert System. *Journal of Clinical Microbiology* 55, 291–301. Banada PP, Deshpande S, Russo R, et al (2017). Rapid Detection of *Bacillus anthracis* bloodstream infections by use of a novel assay in the GeneXpert System. *Journal of Clinical Microbiology* 55, 2964–71. Bonin S (2007). In A Wegner, V Mauer, M Dunn, series ed. *International Biodefense Handbook. An inventory of national and international biodefense practices and policies*; Center for Security Studies at ETH Zurich. Borio L, Ingelsby T, Peters CJ, et al (2002). Hemorrhagic fever viruses as biological weapons. *Journal of the American Medical Association*, 287, 2391–405. Bozzette SA, Boer R, Bhatnagar V, et al (2003). A model for a smallpox vaccination policy. *New England Journal Medicine*, 348, 416–25. Covello VT, Peters RG, Wojtecki JG, Hyde RC (2001). Risk communication, the West Nile virus epidemic, and bioterrorism: responding to the communication challenges posed by the intentional or unintentional release of a pathogen in an urban setting. *Journal of Urban Health*, 78, 382–91. Darsow U, Sbornik M, Rombold S, et al (2016). Long-term safety of replication-defective smallpox vaccine (MVA-BN) in atopic eczema and allergic rhinitis. *Journal of European Academy of Dermatology and Venereology*, 30, 1971–7.

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