

# 4. PUBLIC HEALTH PREPAREDNESS AND RESPONSE

## 4.1 Background

The initial response to a deliberate release of infective or toxic agents targeted against civilian populations is largely a local responsibility in many parts of the world. Local authorities are in the best position to deal with such events, and will generally be held accountable should the incident be mishandled. While national and international resources will be important in the long term, it is the responsibility of local officials to ensure that response systems and plans are in place before an incident actually occurs.

This chapter provides a framework that local and national authorities can use in planning the response to incidents in which biological or chemical agents may have been released deliberately. It is not intended to provide an in-depth review of all the technologies and other matters involved, or a manual for use in training. The goal is rather to demonstrate that the standard principles of risk management are as applicable to biological or chemical incidents as they are to other emergencies or disasters (1). These principles, which are outlined in Appendix 4.1 below, can be used to identify areas needing particular attention when biological or chemical agents are involved. They are described further in a recent WHO publication (2). The chapter thus provides an outline of the matters that will need to be considered. Further sources of detailed information are given in Annex 6.

As far as chemical attacks are concerned, States Parties to the CWC, which have thereby become Member States of the OPCW, have access to international aid in their preparedness activities. Assistance in assessing needs and specific training can be obtained by contacting the International Cooperation and Assistance Division of the OPCW Technical Secretariat. For biological attacks, Article VII of the BWC makes some provision for assistance if a State Party is exposed to danger as a result of a violation of the Convention. For further infor-

mation on this and other sources of international assistance, including WHO, see Chapter 6.

Preparedness also needs to cover situations in which a threat has been made that biological or chemical agents are to be released. While such a threat may be a hoax, the authorities concerned need to be able to allay public fears as well as to take appropriate action to locate and neutralize any suspect device.

There may be a close relationship between the public health preparedness that is to be discussed in this chapter and the preparedness of military forces to protect their capabilities and operations against biological or chemical warfare. While it may be possible, however, for some countries adequately to warn, encapsulate and otherwise protect the disciplined, centrally commanded, healthy adults who make up combat forces in an active theatre of war, the protection of a civilian population, especially in peacetime, is an altogether different matter. Indeed, there may be danger in holding out a prospect of adequate civil protection that is actually unrealistic, for it may detract from efforts at prevention.

The first to respond to an attack with a toxic substance having immediate effects are likely to be the police, fire departments and emergency medical personnel on or near the scene. In contrast, the first to respond to an initially undetected attack with an infective or toxic agent having only delayed effects are more likely to be regular health-care providers, including nurses, physicians and hospital accident and emergency personnel, who may be located in widely separated places.

While chemical weapons can place a great burden on public safety personnel, and biological weapons on the public health infrastructure, they can both place an extraordinary burden on the local health-care delivery system.

Because victims of a chemical attack may be affected immediately, a rapid response will be required, in which the main emphasis will be on evacuation, contamination control and early medical treatment.

Emergency personnel will have to locate and identify the contaminated area immediately (the “hot zone”) and may have to act within minutes if lives are to be saved. On the other hand, a covert release of a biological agent will be more likely to become apparent over a longer period of time, e.g. days or even weeks, and will probably take the form of the appearance of cases of infectious disease. Because some victims are likely to move around in the symptom-free incubation period after exposure, cases of the disease may appear in different locations, even distant ones, and the full picture may become evident only after information, medical reports and surveillance data from many areas have been combined. Biological agents that are transmissible from person to person can also generate clusters of secondary outbreaks. Depending on the nature of the organism involved and the normal pattern of infectious disease in the locality concerned, the attack might initially appear to be a natural outbreak of disease.

These differences need to be borne in mind in planning public health preparedness for biological and chemical incidents. However, in the early phases of an incident, it may not be clear whether the causative agent is biological or chemical, or possibly a mixture of the two. As a result, first responders may find themselves needing to manage both types of incident before the relevant specialists for biological or chemical incidents become involved.

In order to prepare for biological or chemical attack, the authorities concerned should be encouraged to make maximum use of existing emergency-response resources, and to adopt an approach that is consistent with the principles on which the management of any other type of public health emergency is based. While attacks with biological and chemical agents will have some special features, they do not necessarily require the formation of completely new and independent response systems. A well designed public health and emergency-response system is quite capable of responding to a limited biological or chemical attack and can take the measures necessary to mitigate its effects. A sizeable attack with a chemical agent will be very similar to a major hazardous-materials accident. A community’s existing capability to respond to such an accident is therefore an essential component of preparedness for such an attack. A biological agent

attack will generally have the characteristics of a disease outbreak, so that city, state and regional public health authorities must be involved in the response, which will have much in common with the infection-control strategies used in any outbreak of disease.

Routine sensitive and near-real-time disease-surveillance systems are thus essential in both disease outbreaks and those caused by biological agents. Such systems should be in place well in advance of an attack, so that the background disease prevalence in the area concerned is known. The performance of a surveillance system in terms of the timeliness of its response to naturally occurring outbreaks of disease provides an indication of its probable contribution during deliberately caused outbreaks. A national centre can detect a national outbreak not noticed in any individual region and it can also economically provide epidemiological expertise for investigating the causes and sources of outbreaks. Further, it can contribute to both biological and chemical defence, as the epidemiological techniques used in the investigation of both types of attack are similar (although possibly more often relevant in biological attacks). Establishing mechanisms for the routine exchange of information between the public health and veterinary sectors is very important as many biological agents are zoonotic.

A greater role in disseminating information on disease outbreaks and other health events is now being played by the media and certain interest groups, notably the Program for Monitoring Emerging Diseases (ProMed)<sup>6</sup> now run by the International Society for Infectious Diseases in the United States. WHO collects, verifies and disseminates information on outbreaks of diseases of international public health concern, and this information is available on a restricted basis to WHO's partners in the Global Outbreak Alert and Response Network and Member States weekly; once officially notified, the information is published electronically through the World Wide Web and in printed form in the *Weekly Epidemiological Record* (3).

Functioning and efficient poisons centres have proved to be invaluable for authorities charged with the management of accidents involving chemicals or individual cases of poisoning. The immediate availability of chemical and toxicological information and expertise will be equally valuable in managing a chemical incident.

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<sup>6</sup> See <http://www.promedmail.org>

Confirming that a covert release has taken place may be a particularly difficult task. Routine emergency-call monitoring systems (which continually track the frequency, nature and location of emergency calls) are a useful management tool, and may be of great value in drawing attention to an unusual pattern of symptoms, possibly indicating a deliberate release of biological or chemical agents.

The danger of making the response to biological and chemical incidents the task solely of dedicated specialized response units is that the relative infrequency of call-out could lead to the deterioration of skills. More seriously, excessive centralization may risk increasing the time taken to react. Mobilization of a specialized biological and chemical unit throughout a region can never match the 24-hour availability and general emergency-management experience of existing response and public health services. It is true, however, that certain activities will need to be carried out by specialists (e.g. sampling and analysis for the definitive identification of the agent involved). This suggests that a readiness and response strategy should aim at enabling the local public health, emergency-response and other authorities (fire and ambulance services, police force and civil defence) to respond to, and manage the incident scene in its early phases, specialized functions being performed later by a dedicated mobile biological and chemical response unit. Exceptionally, the pre-positioning of special response units may be necessary for highly visible events (e.g. the Olympic Games) that might be a target for terrorists.

The ability to respond to biological or chemical incidents depends on *preparedness* (what needs to be considered long before an incident takes place) and *response* (what needs to happen after a warning of a pending release is received, or after the release has actually occurred).

## 4.2 Preparedness

### 4.2.1 Threat analysis

Threat analysis is a multidisciplinary activity, with inputs from the country's law-enforcement, intelligence, and medical and scientific communities. It is aimed at identifying those who may wish to use

biological or chemical weapons against the population, the agents that may be used, and the circumstances under which they may be used. This is an exercise that is broad in its scope, and requires active liaison between law-enforcement, security and health agencies (typically centralized state institutions) with the local authorities. It will only rarely be possible to identify the likelihood or precise nature of the threat, and general preparedness measures will therefore usually be required. Judgements may need to be made on the basis of a general appraisal of national or local circumstances.

Even if specific biological or chemical hazards cannot be identified, general improvements in public health will automatically improve a population's ability to manage biological incidents. The ability to manage industrial chemical accidents will provide resources that can be diverted, if needed, to managing a chemical incident.

If specific potential hazards can be identified, the probability of an incident occurring and its consequences must be evaluated. Justified and well-motivated decisions on resource allocation can be made only after this has been done. Chapter 3 has identified a group of agents representative of those that may be of particular concern.

The level of threat that exists is also a function of the potential vulnerability of the community concerned. Vulnerability analysis will identify potential scenarios as well as weaknesses in the system that may be exposed to biological or chemical hazards, and will determine the current ability to respond to and manage the emergency (4). This, in turn, requires an assessment of needs and capability. When potential scenarios have been identified in the preceding steps, it will be possible to determine the resources required to respond to such incidents. Response requirements must be determined for each of the actions identified below in respect of biological and chemical incidents. When identified needs are measured against currently available resources, in what is called "gap analysis", certain deficiencies will be revealed. It is then that a country inexperienced in defence against biological and chemical weapons is most likely to need international assistance (see Chapter 6 for sources of such assistance).

### 4.2.2 *Pre-emption of attack*

The establishment of a biological and chemical response system is in itself a pre-emptive risk-reduction strategy. Historical precedent suggests that the risk of biological or chemical attack in war is considerably reduced by the mere existence of effective ability to respond to and manage an incident. If an aggressor knows that an attack will be quickly and effectively dealt with, the incentive to perpetrate such an attack will be considerably diminished. A balance needs to be struck between the level of visibility that such a vigilance and response system needs in order to serve as a deterrent, and the potentially negative results that the demonstration of concern about possible vulnerabilities could produce. Ill-considered publicity given to the perceived threat of biological or chemical terrorism might have the opposite effect to that desired.

Pre-emption of terrorist use of biological or chemical agents presupposes, first and foremost, accurate and up-to-date intelligence about terrorist groups and their activities. As the agents may be manufactured using dual-use equipment, and as the equipment required for manufacture need not be large or particularly distinctive (as seen from outside the facility), technical means of acquiring intelligence, such as reconnaissance satellites, are of little use. Intelligence on terrorism, therefore, relies heavily on human sources. While large-scale national development and production programmes and facilities for the manufacture of biological and chemical weapons are relatively easy to identify, terrorist activities may be much less conspicuous and therefore more difficult to detect.

An important prerequisite for pre-emption is the existence of national legislation that renders the development, production, possession, transfer or use of biological or chemical weapons a crime, and that empowers law-enforcement agencies to act where such activities are suspected before an actual event occurs. For details of how this is dealt with in the CWC and BWC, see Chapter 5.

Pre-emption of attacks will be aided by concerted national and international efforts to monitor and control dual-use technology and equipment as, in the case of chemical and toxin attacks, by full implementation of the CWC, including its general purpose criterion. The

international norm that has been established by the majority of countries by their acceptance of the principles of the BWC and the CWC may be a decisive factor in deterring would-be users of biological or chemical weapons.

#### *4.2.3 Preparing to respond*

Pre-emptory efforts notwithstanding, the risk of a biological or chemical attack cannot be eliminated completely, and could have serious consequences if it occurred. Accordingly, a preparedness programme may be necessary, and this will require the acquisition of equipment and supplies, the development of appropriate procedures, and training. Communities will need to examine their existing hazardous-materials protocols, public-health plans, and the current training of the police, firefighters, emergency medical service personnel and public health personnel, including physicians, epidemiologists, veterinarians and laboratory staff. These will have to be adapted in the light of the features unique to deliberately released biological or chemical agents.

Most civilian health-care providers have little or no experience of illnesses caused by biological and chemical weapons, and may therefore not suspect, especially in the early phases of an incident, that a patient's symptoms could be due to such weapons. There is therefore a need to train health-care workers in the recognition and initial management of both biological and chemical casualties, and for a rapid communication system that allows sharing of information immediately an unusual incident is suspected. Education and training must cover the general characteristics of biological and chemical agents; the clinical presentation, diagnosis, prophylaxis and treatment of diseases that may be caused by deliberate agent-release; and sample handling, decontamination and barrier nursing. Training, planning and drills should be directed at physicians and staff for the management of mass casualties, providing respiratory support to large numbers of patients, the large-scale distribution of medication, and supporting the local authorities in vaccination programmes. Providing the necessary education and training is expensive and may also be manpower-intensive, yet may be the most cost-effective method of medical preparation for biological attack. Such training will also be the cornerstone of an approach to prevent anxiety and fear in health-care workers, something that might

be expected after a bioweapons event and that could disrupt the provision of health-care services.

Because early diagnosis of both biological and chemical exposure will be important in the choice of treatment and response, preparation should include the establishment of a reference laboratory (or a network of laboratories in large areas) in which potential agents can be identified. In addition to the need for diagnosis for purposes of medical treatment, samples obtained from a delivery system or the environment, or from patients, will require forensic analysis. Earlier diagnosis will be facilitated if regional laboratories have the necessary equipment and staff for that purpose. New diagnostic technologies mean that biological agents can be identified quickly, perhaps even at the attack site. Such state-of-the-art techniques may not, however, be available everywhere.

Failure adequately to prepare the health-care system and its staff for biological attack may not only result in late detection of an outbreak, but may also facilitate the spread of an outbreak caused by an agent transmitted by person-to-person contact. Should the local health-care facilities and personnel be perceived as unable to manage the outbreak and the clinical cases, the population, including potentially infectious patients, may travel long distances to seek treatment, thus contributing to spread of the disease.

Where a particular need for equipment, antidotes, antibiotics or vaccines has been identified, pre-attack stockpiling and planning of distribution systems, or designation of sources of rapid supply, to make them available to the exposed population will be necessary. The financial cost of such stockpiles, depending on the items chosen and the quantities stockpiled, may then be very high indeed. Spending such large sums exclusively on responding to possible attack with biological or chemical weapons can be justified only when there is an extremely unusual and very specific threat. In high-risk situations, the supply to each person or family of protective equipment (e.g. respiratory protection), antidotes (e.g. syringes loaded with antidotes for self-injection) or antibiotics can be considered. The cost and logistic burden of this type of preparation may be prohibitive, however, and may not be feasible in poor countries or those in which large numbers of people will need protection. In such cases, and depending on the agent involved,

selective protective measures may still be considered for high-risk groups (e.g. prophylactic antibiotics for those most likely to be, or having been, exposed).

It is vital not to make the mistake of assuming that availability of equipment is synonymous with the ability to respond, or that a community without all the latest equipment is doomed to failure. Furthermore, ensuring the availability of specialized equipment is generally a more important part of preparation for chemical attack than for biological attack. The use of biological and chemical protective equipment requires special training, and the adaptation of existing procedures for emergency management. Without careful development of the necessary procedures and intensive training, the introduction of such equipment can hamper the ability to respond, and can even be dangerous. Some of the problems associated with the use of protective equipment are described in Annex 4.

#### *4.2.4. Preparing public information and communication packages*

If it is to have any chance of success, a plan for providing information to the public and thus demystifying the subject of biological and chemical weapons needs to be drawn up well before an incident occurs. If this is to be effective, the public needs to know how they are expected to act if an attack takes place, long before any such attack occurs. The communication plan may include radio and television broadcasts, or the distribution of brochures to the public describing the potential threat in plain, unemotional language. Clear advice should be given on how the alarm will be raised, and what to do if that happens. Excellent examples of such communication packages are available, e.g. references (5–6). A well-constructed media plan is essential, both as part of the pre-incident education process, and to avoid overreaction after an incident. It must contain explicit and exhaustive instructions on channels of communication and clearance procedures for potentially sensitive information. Of course, any public preparedness or information programme needs to be evaluated in the context of the specific local circumstances, including the possibility that too much information may be counterproductive, or even dangerous.

#### 4.2.5 *Validation of response capabilities*

As with preparation for any high-consequence but low-frequency incident, it is a major challenge to prove and validate response capabilities if they are not being constantly practised or used. Realistic training simulations are a useful tool (7–8), and must be evaluated critically to identify areas that can be improved.

In addition, careful analysis of actual incidents, wherever they occur, should provide valuable information that could help the international community to respond, and the lessons learned should be incorporated into future planning. Since the first edition of this report was published, a serious incident of terrorist attack on civilians in which chemical weapons were used occurred in Japan. This incident warrants careful analysis, as many lessons on the nature of, and response to, civilian attacks with chemicals can be learned. For example, the fact that most of the victims went to hospitals on their own initiative, using their own transport, has important implications for the distribution of triage and decontamination facilities. Further information on this incident is given in Appendix 4.2 below.

The deliberate use of biological agents to cause harm has fortunately been rare. In 1984, and apparently with a view to influencing a local electoral process, a religious cult known as the Rajneeshees caused 751 people in a small town in Oregon, United States, to become ill by using cultures of *Salmonella enterica typhimurium* bacteria to contaminate the salad bars of 10 restaurants over a period of some two months (9–10). More recently, and with far more media exposure, letters containing *Bacillus anthracis* spores were distributed in the United States postal system. This incident is described in Appendix 4.3 below.

### 4.3 Response

#### 4.3.1 *Response before any overt release of a biological or chemical agent*

If a warning of an impending release of biological or chemical agents is received, a number of activities can and should be carried out before

the release, if any, actually happens. The sequence in which these activities are performed will depend on the particular circumstances of the incident. The first indication of an incident may be a warning, or the finding of an unusual device or unusual materials as a result of normal activities within the community such as the response to a fire or the discovery of a strange package. One or more of the following may then be required:

**Analysis of the available information.** All the information available needs to be assessed by an appropriate group including the police, the intelligence services and technical experts who should have been trained to work together to analyse such information by means of realistic and credible exercises. Such a small group of analysts and experts will be able to evaluate the threat or the information on the incident and advise on appropriate action and the mobilization of specialist assistance, and may also help to avoid inappropriate responses to hoaxes.

**Initiation of a search procedure.** If sufficient information was given in the warning and the analysis warrants such action, it may be appropriate to search for a suspect device at a particular location. It may also be appropriate to search for those responsible for the warning or for witnesses who may have seen them.

**Establishment of a cordon.** Again depending on the circumstances and the information available, it may be appropriate to evacuate people from the area at risk and to establish an exclusion zone.

**Early identification of the nature of the hazard.** If a device or unusual package is found, it will be important to decide as soon as possible whether the impending hazard is chemical or biological in character (or even a mixture of the two). The presence of explosives, either as the primary hazard or as the disseminating charge for a toxic/infective agent, must also be considered, together with the possibility of the device containing a radioactive hazard. The appropriate specialists can then be called in to help in managing the incident, and the appropriate protective equipment selected. For example, an oronasal mask may provide adequate protection against a particulate biological hazard

while a respirator and full protective clothing may be required to protect against a persistent chemical agent.

**Risk reduction and/or neutralization.** Depending on the nature of the device, the possibility of reducing the risk, or neutralizing the potential hazard, through containment or other mitigation and neutralization approaches should be considered. Whether it should be managed on-site or moved to a specialized facility would be a decision for specialists (equipment is available that allows on-site controlled and contained detonation of devices, together with decontamination of toxic/infective contents). Wherever possible, sampling for analytical and forensic purposes should be accomplished before destructive neutralization.

#### *4.3.2 Distinguishing features of biological and chemical incidents*

In the earliest phases of a release (and particularly if it is covert), it may be difficult to distinguish between a biological and a chemical attack. As a general rule, chemical attacks are more likely to produce simultaneous and similar symptoms in a relatively restricted area near the point of release relatively soon after release. Biological attacks are more likely to result in the appearance of ill individuals at medical centres and/or doctors' surgeries over a longer period of time and a much larger area. Symptoms resulting from exposure to chemicals with delayed effects will obviously be much more difficult to distinguish from those of an infectious disease. While there are no definitive and invariable distinguishing features, the indicators shown in Table 4.1 may help in deciding whether a biological or chemical attack has taken place. The differentiation of deliberate releases from natural morbidity is discussed in Annex 3.

Table 4.1 Differentiation of biological and chemical attack

Indicator	Chemical attack	Biological attack
Epidemiological features	<p>Unusual numbers of patients with very similar symptoms seeking care virtually simultaneously (especially with respiratory, ocular, cutaneous or neurological symptoms, e.g. nausea, headache, eye pain or irritation, disorientation, difficulty with breathing, convulsions and even sudden death)</p> <p>Clusters of patients arriving from a single locality</p> <p>Definite pattern of symptoms clearly evident</p>	<p>Rapidly increasing disease incidence (over hours or days) in a normally healthy population</p> <p>Unusual increase in people seeking care, especially with fever, respiratory, or gastrointestinal complaints</p> <p>Endemic disease rapidly emerging at an unusual time or in an unusual pattern</p> <p>Unusual numbers of patients with rapidly fatal illness (agent-dependent)</p> <p>Patients with a relatively uncommon disease that has bioterrorism potential (particularly those listed in Annex 3)</p>
Animal indicators	Sick or dying animals	Sick or dying animals
Devices, unusual liquid spray or vapour	<p>Suspicious devices or packages</p> <p>Droplets, oily film</p> <p>Unexplained odour</p> <p>Low clouds or fog unrelated to weather</p>	Suspicious devices or packages

Source: Adapted from references 11 and 12.

### 4.3.3 Response to biological incidents

Table 4.2 summarizes the major activities involved in responding to biological incidents. The sequence of events is based on application of the internationally accepted principles of risk analysis (see Appendix 4.1 for more detail on risk analysis).

Table 4.2 **Major response activities for biological attack**

<b>Assess the risks</b>	<p>Determine that a release has occurred or an outbreak is taking place</p> <p>Identify the nature of the agent involved (hazard identification) and develop a case definition</p> <p>Evaluate the potential outbreak spread and assess current and delayed case-management requirements, having regard to the possibility that the infection may be contagious (risk characterization)</p>
<b>Manage the risks</b> (introduction of risk-reduction/control measures)	<p>Protect responders and health-care workers</p> <p>Introduce infection-prevention and control procedures</p> <p>Conduct case triage</p> <p>Ensure medical care of infected cases</p>
<b>Monitor all activities</b>	<p>Decide whether local and national resources are adequate or whether international assistance should be sought</p> <p>Implement active surveillance to monitor the effectiveness of the prevention and control procedures, follow up the distribution of cases (time, place and person), and adjust response activities as needed</p> <p>Repeat the risk-assessment/management process as required</p> <p>Implement longer term follow-up activities</p>
<b>Communicate the risks</b>	<p>Implement a risk-communication programme for the affected population that conveys information and instructions as needed</p>

**The following discussion summarizes some of the most important considerations in the activities listed in Table 4.2. Sources of more detailed information that may be needed by response planners are given in Annex 6. Since responses to both natural and intentionally caused outbreaks will follow similar lines, the information given below focuses specifically on the problems posed by outbreaks that have been caused deliberately. Information on public health action in emergencies caused by epidemics is available in a WHO publication (13).**

### **Determination that a release has occurred or an outbreak is taking place**

All outbreaks of infectious disease should be considered natural events unless there is good reason to suppose otherwise (see Annex 3). Initiating a response to an intentional outbreak thus requires prior confirmation that a release has actually occurred or the suspicion that an outbreak has been caused deliberately. Many factors will influence the decision to initiate such a response, particularly whether the release was overt or covert. A covert release, just like any other outbreak of disease, will be detected only when patients begin to present at medical facilities. The existing surveillance system should be able to detect the outbreak and an epidemiological investigation will then be triggered. The results of the investigation, coupled with clinical, laboratory or environmental data, may indicate that the outbreak could have been the result of a deliberate release. The importance of routine surveillance and the prompt investigation of all outbreaks so that warning can be given that an unusual outbreak may be under way have been discussed in section 4.1 above. A threatened or overt release will generate response requirements more akin to those in the early stages of a chemical release, described below. While it is probable that signs and symptoms in people and animals will provide confirmation that a release has taken place, the sampling and detection of biological agents in environmental substrates may also be required.

### **Identification of the agent involved**

Prompt identification of the agent involved is required to ensure that the appropriate preventive and medical measures are taken. Because some agents may cause a contagious infection, it may not be advisable to wait for laboratory confirmation of the identity of the agent. It may then be necessary to introduce risk-reduction strategies soon after starting the investigation of the outbreak.

The development of sensitive and rapid methods of detecting and identifying biological agents in the environment will be difficult because of the large number of potential agents. Significant advances will have to be made in technology before such methods can be made widely accessible, and they may therefore not be available for some time.

The extent to which laboratory support will be able to aid initial diagnosis and treatment will depend on both the level of pre-incident preparation, and the availability of a network of diagnostic laboratories. The nature of the biological sample required, and the specific laboratory techniques required for agent identification, will vary according to the nature of the organism suspected. Definitive identification of a biological agent used in a deliberate attack will also be forensically important. Detailed analysis of the organism and its properties may allow it to be traced to a source laboratory. This is a highly specialized activity, distinct from the basic diagnostic procedures needed in outbreak management, and is often outside the immediate interests and responsibility of the public health sector.

Biological hoaxes may be difficult to evaluate or confirm immediately because of the long incubation periods of biological agents. One proven method of increasing the likelihood of identifying a hoax accurately is to establish a small on-call committee of experts who have trained together and are able to evaluate the situation quickly and efficiently by telephone conference or computer link at very short notice (see also section 4.3.1). The committee should include a biologist and a physician who are familiar with the classification of threat agents, representatives of law-enforcement agencies and possibly the military, a forensic psychologist, a representative of the public health community, and the on-scene authorities. A group such as this, furnished with all the information available at the time, can make the best decision possible on the steps to be taken.

Once the agent is identified, it is important to develop an initial hypothesis as to the exposure that is causing disease (source of the agent and mode of transmission). This hypothesis should be tested with clinical, laboratory or environmental data, field investigations and application of analytical epidemiology tools in comparing subgroups of the population

### **Evaluation of potential spread**

If the incident involves the release of a biological aerosol, computer modelling may help to predict the spread of the aerosol particles. The first steps must, however, be to gather information on the wind direction

and speed and on possible sources of the aerosol. With an ongoing outbreak, retrospective analysis may indicate that cases originate from specific areas, and may be a valuable indicator of an up-wind site of original release. For example, investigators of the accidental release of anthrax spores in 1979 from the military biological facility in Sverdlovsk, the former Soviet Union, were able to use aerosol spread analysis to show the striking occurrence of cases of pulmonary anthrax in persons located within specific isopleths originating from the point of suspected release (14–15).

If the release involves an agent that has potential for person-to-person transmission, an epidemic is likely to spread through secondary outbreaks. Standard epidemiological methods should then be used to predict the probable spread of the disease, and medical resources mobilized and deployed accordingly.

### **Protection of responders and health-care workers**

The protection of responders and health-care workers is obviously essential. In addition to compromising the ability to manage the incident, the occurrence of infection in health-care workers may lead to the perception among the population that health centres and hospitals themselves constitute a high-risk source of infection. This may discourage potentially infected persons from seeking treatment from the local health-care providers, and lead them to travel to other health-care facilities, thereby increasing the risk of secondary transmission if the infection is contagious.

During the spread of a biological aerosol, the primary route of exposure will be via the airways and respiratory tract. Respiratory protection will then be the most important component of physical protection. Particulate filters are generally adequate for biological agents (in contrast to the activated-charcoal or similar filters that will be needed for the filtration of air contaminated with chemical vapour).

Most of the agents of special concern do not cause contagious disease, but some do, and if these become established in the population, the spread of aerosol droplets, contact between infected body fluids and mucous membranes or broken skin, and even ingestion may all be

involved in the secondary spread of the agent. Universal precautions for dealing with potentially infective materials should therefore always be taken. The protection of responders should be based on the standard principles of barrier nursing and infection control (12, 16–17).

Vaccination or prophylactic antibiotic treatment of those involved in response may have to be considered. This is more likely to be useful in the management of any secondary spread of the infection than for the primary manifestations of the attack. Pre-attack vaccination of health-care providers may be considered if appropriate vaccines are widely available (e.g. for smallpox, plague and possibly anthrax).

### **Infection control**

If agents of transmissible (contagious) diseases are released, basic hygiene and infection-control measures, e.g. washing hands after contact, avoiding direct contact with secretions from infected individuals, keeping exposed persons away from public places, and isolating suspected or symptomatic cases, may be essential in limiting secondary spread. The dissemination of such basic information on the precautions necessary, not only to health-care providers but also to the general public, will be an important step in infection control. The population should be told what signs and symptoms to watch out for and whom to call or where to go if they appear. Lack of specificity in such advice to the public may result in local health facilities becoming overwhelmed by uninfected patients.

Large-scale evacuation as a preventive measure is not likely to form part of the response to biological incidents. Where contagious disease is involved, it may aggravate the situation by increasing both the spread of infection and the number of secondary outbreaks. Movement of patients should be restricted to the minimum necessary to provide treatment and care.

Special measures may be required to limit the nosocomial spread of such diseases as the viral haemorrhagic fevers (e.g. Ebola or Marburg), plague and smallpox. The frequent suggestion that special rooms under negative pressure should be provided is impractical because of the sheer number of probable cases. Provision may be made to care for

patients at sites other than health-care centres, such as gymnasias, sports arenas or at home.

Immediate decontamination for people who may be exposed to biological attack is not so critical as it is for chemical casualties, since biological agents are non-volatile, are difficult to re-aerosolize and leave little residue on skin or surfaces. Many pathogens deposited on surfaces will rapidly die, though some may survive for longer periods (18). However, it would be prudent to be prepared to decontaminate both materials and persons, particularly if a site of release can be identified. Defining a “hot zone” (as in hazardous-materials incidents) may be extremely difficult or impossible, and it may not be possible to define the contaminated zone until the outbreak has been characterized. At or near the release point of a biological agent, where large particles may have been deposited, area decontamination (or whole-body decontamination of persons who were present in the area) may be appropriate. Decontamination solutions used for chemical decontamination will usually also be suitable for biological decontamination. Hypochlorite is the recommended disinfectant for use in outbreak response. An all-purpose disinfectant should have a concentration of 0.05% (i.e. 1 g/litre) of available chlorine, a stronger solution with a concentration of 0.5% (i.e. 10 g/litre) available chlorine being used, for example, in suspected outbreaks of Lassa and Ebola virus diseases. The use of the solution with 0.5% available chlorine is recommended for disinfecting excreta, cadavers, and spills of blood and body fluids, and that of the solution with 0.05% available chlorine for disinfecting gloved or bare hands and skin, floors, clothing, equipment and bedding (19). Most experts now agree that water, or soap and water, may be adequate, and probably safer, for the removal of most biological agents from human skin. Buildings can be decontaminated by means of chlorine-based liquid sprays, formaldehyde vapour produced by heating paraformaldehyde, or other disinfecting fumigants. Because of the lack of other effective tools, the decontamination of a building may be psychologically beneficial. It may, however, be extremely difficult to certify that a building is clean after an agent release. In addition to the standard principles of barrier nursing referred to above for highly transmissible agents, the disposal of waste materials, safe burial practices, and cleaning or disinfection of patients’ clothing should be considered (20).

Where transmissible-disease agents are involved, quarantine of the affected area via the establishment of a sanitary cordon may need to be considered. The coordinated efforts of several public service groups will be required to inform the people affected, control water and food supplies, regulate the movement of people into and out of the area, and establish medical services.

In addition, where there is a danger of the international spread of human diseases, the provisions of the International Health Regulations (IHR) (21), currently under revision, should be borne in mind. The IHR provide an essential global regulatory framework to prevent the international spread of diseases through permanent preventive measures for travellers and cargo, and at border crossing points.

### **Triage**

Any suspected or actual dissemination of biological agents is likely to lead to large numbers of people seeking care. The development of scientifically sound case definition(s) suitable for the local circumstances and the definition of the population at risk of becoming ill are very important for triage (the initial reception, assessment and prioritization of casualties). Such information can generally be gathered from the epidemiological description of the outbreak, or sometimes from more specific surveys. Fear and panic can be expected in genuinely symptomatic patients, the public and the health-care providers involved. All health-care facilities will need to plan in advance for dealing with overwhelming numbers of people seeking care or advice simultaneously, and to ensure that resources are used to help those who are most likely to benefit. Both psychological support and active treatment of anxiety will play an important part in the triage process.

### **Medical care**

The specific medical treatment of exposed individuals will depend entirely on the nature of the organism involved (see Annex 3).

Immunization or prophylactic antibiotic treatment of certain segments of the population (contacts, health-care personnel and first responders) against potential biological agents may be warranted. This treatment

will depend on the availability of such treatment and its effectiveness against the agent involved, e.g. immunization will be an important means of controlling an outbreak of smallpox or plague, and all those who enter hospitals where patients are housed and treated should be immunized against these diseases.

Because immunity generally takes several weeks to develop fully after vaccination, drugs (antibiotics) and symptomatic care may be the mainstay of management. Immune serum may be used to confer passive immunity.

If stockpiles of antibiotics or vaccines have been prepared or identified, plans for their distribution must be activated. In essence, the choice is either to take the drug to the potentially exposed person or for the person to come to the drug. The latter option generally requires fewer personnel. The stocks should be larger than needed to treat only those exposed because it may be difficult to distinguish between those who have actually been exposed and those who simply believe themselves to have been exposed. Cases may be much greater in number than the total number of available hospital beds and additional care facilities may need to be established.

### **International assistance**

The management of a large-scale outbreak, whether of natural, accidental or intentional origin, will be beyond the resources of many countries. An early decision to enlist the assistance of international aid (see Chapter 6) may save many lives. WHO is able to offer public health assistance to countries experiencing outbreaks of infectious disease, and such aid will be available regardless of the source of the outbreak.

### **Monitoring the outbreak**

Because of the delay in the onset of symptoms, the movement of exposed individuals during the incubation period and the possibility that a transmissible disease agent has been used, outbreaks may affect a large area. Efficient and coordinated collection of national data will therefore be necessary to track the outbreak, and to direct resources to the areas most in need. Again, good public health and near-real-

time surveillance programmes will be essential in monitoring, irrespective of whether the causative agent has appeared naturally or been spread deliberately.

### **Follow-up activities**

The sequelae of a biological attack may be present for many years after the incident. Careful case identification, record keeping and monitored follow-up will be required both from the practical viewpoint of comprehensive medical care and because of the need to study such incidents and improve preventive and response measures. Outside the medical field, follow-up forensic or arms-control activities may also be appropriate.

### **Risk communication and distribution of information**

Because of the potential for widespread fear and panic following a biological incident, the provision of clear and accurate information on the risks to the public is essential. People must be told that medical evaluation and treatment are available and how to obtain them. If preventive measures are available to minimize the chance of exposure and infection, the public must be clearly and rapidly informed.

If the incident involves the release of a potential airborne agent from a specific point, and if there is time to issue a warning, an appropriately prepared room or building may possibly provide some protection from a biological agent cloud for those living nearby. A sealed area may be improvised by moving into a single room and sealing openings with adhesive tape. Wet towels or clothing can also be pressed into gaps to make a seal. Such improvisation, however, needs to be accompanied by an understanding of its limitations, including its potential dangers. Thus, simulations have shown that improvised shelter within buildings may only be beneficial initially, and that the total dose of the substance indoors may eventually approach or even exceed that receivable outdoors. People should therefore leave the shelter as soon as the cloud has passed, but this will not be easy to determine in the absence of agent detectors. If improvised protection is to be recommended, it must be well considered, communicated, understood and practised before any release actually occurs.

It is unlikely that military or approved industrial masks will be widely available (or, indeed, appropriate) for the local population. If respiratory protection is considered appropriate, oronasal particulate or smog masks, or even improvised multilayer cloth filters, will provide some degree of protection.

### **Command, control and communication**

The response mechanisms described for biological incidents may involve a large number of different groups. Effective coordination and training are essential if such a multidisciplinary response is to be successful. The person who will be in overall command at each level of responsibility must therefore be identified in advance and must be an individual who is able to exert the necessary authority over the various parties involved in the response. This requirement may be in conflict with other considerations, e.g. the law-enforcement officers who usually take overall responsibility for the response in criminal incidents may not have the necessary background and expertise to deal with biological or chemical incidents. A high-level, authoritative overall command, directly supported by appropriate trained technical and specialist advisers who will ensure that the specific features of the incident are given appropriate consideration, must therefore be established.

#### *4.3.4 Response to chemical incidents*

The activities required in response to a chemical attack can be identified, as described above for biological incidents, by following the steps of the risk analysis process. This process is described in more detail in Appendix 4.1.

Table 4.3 **Major response activities for chemical attack**

<b>Assess the risks</b>	<p>Use rapid chemical detection and identification techniques to determine the causative chemical agent (hazard identification)</p> <p>Recruit the aid of specialists for definitive identification, needed for forensic and legal purposes</p> <p>With initial response initiated (see below), activate more detailed assessments regarding dose–response relationships, exposure assessment and risk characterizations (see Appendix 4.1)</p>
<b>Manage the risks</b> (introduction of risk-reduction/control measures)	<p>Protect responders</p> <p>Control contamination: establish “hot-zone” scene control to limit contamination spread; conduct immediate operational decontamination onsite, and decontamination of all persons leaving the “hot-zone”</p> <p>Conduct casualty triage</p> <p>Ensure medical care and evacuation of casualties</p> <p>Conduct definitive decontamination of the site</p>
<b>Monitor all activities</b>	<p>Decide whether local and national resources are adequate, and whether international assistance should be sought</p> <p>Continuously monitor the residual hazard level on the site, and adjust response activities as needed</p> <p>Repeat the risk-assessment/management process as required</p> <p>Implement follow-up activities (e.g. of long-term injuries and rehabilitation)</p>
<b>Communicate the risks</b>	<p>Implement a risk-communication programme for the affected population that conveys information and instructions as needed</p>

The following discussion summarizes some of the most important considerations in the activities listed in Table 4.3. Sources of more detailed information that may be needed by response planners are given in Annex 6.

### **Hazard identification**

Detection and identification are necessary to determine the nature of the chemical hazard being confronted, if any. It begins with the reasoned and logical application of observation skills, including the analysis of all the

available information, the appearance and function of delivery devices, the appearance and odour of the substance itself (if it is an overt release), and the signs and symptoms of those who have been exposed. It is instructive to note that, after the terrorist chemical attacks in Japan, the recognition of characteristic symptoms by emergency medical personnel provided the first indication that nerve gas had been released. This clinical diagnosis guided response activities for some time before analysis confirmed the nature of the chemical used (see Appendix 4.2).

Detection strategies may include the use of a variety of devices that can provide an early indication of the agent involved. This is needed to guide initial operational response activities. A large variety of devices are available, ranging from simple colour-changing paper to sophisticated electronic contamination monitors. The choice of detection equipment must be guided by the preparedness phase risk assessment, and specific local requirements. Detection strategies must be linked to warning or alert mechanisms that will be used to activate response, whether by primary responders, specialist responders or the population. Decisions are needed on the basic philosophy of response activation. The approach whereby all suspicious incidents are treated as chemical attacks until proved otherwise may be warranted in high-risk scenarios (as exemplified by the Israeli attitude towards Scud missiles during the Gulf War). Lower-risk scenarios may be more efficiently dealt with by an approach calling for further response only if chemical detection tests are positive.

Definitive identification of chemicals used will involve a longer-term forensically based analytical process, requiring the use of sophisticated laboratory facilities. Such identification will be needed both as evidence and to determine the appropriate strategic response. As with other crimes, chemical attacks require the integration of the forensic investigation with rescue and medical operations. Response personnel must operate without disturbing the integrity of the crime scene, while forensic investigators need to allow rescue efforts to proceed effectively. For example, responders must be careful to maintain chain of custody procedures with clothes and personal effects that may be removed as part of the decontamination process. This will allow later use of such objects in an international investigation or a criminal trial.

Under the provisions of the CWC, Member States of OPCW can initiate an “investigation of alleged use”, whereby an international inspection team will undertake a complete investigation of an incident, including sampling followed by analysis, making use of a worldwide network of laboratories accredited specifically for this purpose. Such investigative procedures have been practised but not yet invoked.

In an overt chemical release, an important component of exposure assessment is the prediction of the spread of the agent cloud. This will be useful in deciding where to focus protective and incident-management procedures. A variety of computerized prediction models are available to assist with this process. Depending on their sophistication, they take account to a varying degree of agent characteristics, nature of release (point or line source, instantaneous or continuous), initial concentration, wind and weather conditions, and topography to produce predictions of spread. Isopleths indicate the position of expected concentrations over time, and can be used to indicate where effects are likely to be greatest and to direct the deployment of resources.

Where high-risk areas have been identified during the pre-incident preparedness phase, it is possible to use computerized models that take into account the specific local topography and population distribution. This enables more precise information to be generated on the numbers of casualties that may result as the cloud spreads, and the available resources to be deployed to appropriate sites.

While such models may be useful as planning tools, their limitations must also be appreciated. Results tend to be more accurate when wind speeds are higher, wind speed and direction are constant, and local topography is relatively flat. Wide and commonly occurring variations in these and other relevant variables, however, often reduce the accuracy of predictions to the level of generalized estimates.

### **Protection of responders**

Individual protective equipment (IPE) must be available to responders and must allow them to carry out a wide range of activities in a contaminated area without becoming casualties themselves. Many types of IPE are available, ranging from simple aprons and half-mask

respiratory protection to fully encapsulating self-contained impermeable ensembles. The types that are stockpiled, and the choice of IPE for particular incidents, will depend on the risk assessment and the nature of the chemicals involved. In areas where the threat is significant, it may be necessary to make collective protection facilities available, i.e. large protected areas supplied with filtered air where people can shelter without the need for IPE. An outstanding example of this approach can be found in Switzerland, where threat assessments during the Cold War era led to the construction of a network of public and private collective protection facilities capable of sheltering the majority of the population in times of need. A more detailed discussion of the issues surrounding protection can be found in Annex 4.

### **Contamination control**

The most distinctive element of disaster management for chemical incidents is contamination control, which requires:

- the rapid establishment of a well demarcated “hot zone” (with clearly visible “clean” and “dirty” areas);
- the limitation of contamination spread by means of strictly controlled entry and exit procedures;
- on-site decontamination procedures, ensuring that all persons or items leaving the dirty areas are cleaned and monitored before entering the clean environment.

Patients should be decontaminated as soon as possible, and before transport to specialized facilities (to avoid the contamination of vehicles and overburdened accident and emergency departments). However, the nature of human response to mass casualty incidents is such that many patients are likely to arrive at medical centres on vehicles other than those of the emergency services, bypassing on-site decontamination facilities. For this reason, triage at casualty reception centres should also incorporate decontamination.

### **Triage**

Triage will need to include casualty-reception procedures suitable for contamination control purposes, since conventional triage techniques will

not be adequate during a chemical incident. Normally, medical personnel separate the triage and treatment phases of a response, but because of the rapidity of onset of effects with some chemical agents, responders to a chemical incident may be required to triage and administer antidotes simultaneously. As with any mass casualty situation, it will be necessary to ensure that potentially limited resources are used to help those who are most likely to benefit from them. This can lead to difficult triage decisions, requiring the attention of the most experienced clinical personnel available. Depending on the casualty load, it may be necessary to activate additional accident and emergency departments and hospital beds to handle the sudden influx. It must be expected that many more will seek treatment than were actually exposed. Psychological support teams should be available to provide assistance, thereby reducing the number of people occupying hospital beds.

### **Medical care and evacuation of casualties**

Medical care includes prophylaxis (pre-exposure treatment measures for high-risk personnel to prevent or minimize the effects of exposure), diagnosis and treatment.

There are not many examples of true prophylaxis, but certain medications (e.g. pyridostigmine bromide) can improve the response to treatment of those affected by nerve agents. However, such medications can have adverse side-effects, and case-by-case decisions on their use will be needed. They will normally be used only by military personnel in wartime or by emergency responders who must be able to work in a high-risk area known to be contaminated with liquid nerve agent.

Specific diagnostic aids may be required for detecting exposure to chemical warfare agents, ranging from established techniques, such as the observation of typical symptoms and the measurement of acetylcholinesterase activity (after nerve agent exposure), to newer advanced techniques, such as the detection of specific DNA adducts (after mustard gas exposure).

Initial prehospital treatment will provide symptomatic and life-saving support to allow decontamination and transport to medical centres. If the nature of the substance is known, specific treatment protocols may

be required for on-site emergency antidote administration (possibly using auto-injectors), and definitive treatment of the medium- and long-term effects of exposure. As for all response measures, detailed discussion of medical protocols is outside the scope of this publication, but references to the relevant literature can be found in Annex 6.

### **Definitive decontamination**

The decontamination strategies described above are aimed at meeting immediate operational needs, and minimizing the spread of contamination during response activities. Once the immediate manifestations of the incident have been dealt with, a final decontamination of the site will be required. This is a specialized activity and will usually need to be handled by specialist response units.

### **International assistance**

National authorities will have to decide at an early stage whether to seek international assistance, either for the management of the incident or in order to draw international attention to it. As for many other aspects of the response to a chemical incident, Member States of OPCW have access to a carefully considered package of international assistance measures (see Chapter 6). Because of the instability of some chemicals and the transient nature of their effects, this assistance must be mobilized as quickly as possible.

### **Monitoring of the residual hazard**

There will be an ongoing need to evaluate the hazard remaining in the contaminated area, the risk it poses to response activities, and when the area can be reopened to the public without further risk. Monitoring must continue until the “all clear” has been sounded, i.e. after definitive decontamination and certification of the removal of all residual hazard. This will be the task of specialists in the management of hazardous-materials incidents.

### **Follow-up**

While the immediate problem after a chemical attack will be the management of the acute effects of exposure, some chemical agents

have long-term effects that may appear over a period of many years (see section 3.6.2). Well-organized and well-administered follow-up programmes are therefore required, not only for the benefit of the patients, but also for the advancement of medical science in this area. An outstanding example of what may be required is the extensive patient follow-up programme still being implemented by Iranian public health authorities, many years after the exposure of individuals to chemical weapons during the war between Iraq and the Islamic Republic of Iran in the 1980s (22–23).

### **Risk communication and distribution of information**

If it is suspected that the hazard may spread to affect the downwind population (as predicted in the hazard evaluation step above), a warning and public address system will need to be activated. This may provide evacuation instructions, or information on what people should do to protect themselves against the potential spread of the hazard. Even if the hazard is not expected to spread, a large-scale incident is likely to generate widespread fear and public reaction. Rapid distribution of accurate and helpful information is essential if panic is to be avoided.

Depending on circumstances, it may be considered advisable for the population to stay indoors and to close all windows and doors. A sealed area might be improvised (as described in section 4.3.3 on pages 75–76 above for sealed areas for protection from biological agents, and with the same limitations).

### **Command, control, and communication**

The response mechanisms described above may involve a large number of different groups. Effective coordination of this multidisciplinary response is essential for successful results. As mentioned in the preceding discussion, response is likely to involve the usual primary responders (ambulance teams, firefighters, police, etc.), specialist responders (such as military chemical defence units) and the public. Overall site command must be assigned to an authority able to exercise the control required to limit the hazard and to achieve the required coordination of all the groups involved.

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## APPENDIX 4.1: PRINCIPLES OF RISK ANALYSIS

Responding to biological or chemical attacks is a multidisciplinary and complex task. With an array of issues and questions, a means of ordering and prioritizing an approach to response is needed. The requisite response activities, and a logically ordered sequence for their implementation, can be identified using the risk analysis approach. This is an organized way in which to identify and evaluate hazardous conditions, and to take actions to eliminate, reduce or control the risk(s) posed by such conditions. These steps can be used to structure planning, and to identify areas needing attention during both the pre-attack “preparedness” phase, and the post-warning or post-attack “response” phase (and is the way in which the preceding chapter was structured). Although some detailed considerations for biological and chemical agents may differ (e.g. population vulnerability may be a more important consideration for biological than for chemical agents), the basic principles of approach remain the same.

The risk analysis approach is generally accepted to consist of risk assessment, risk management and risk communication. In this Appendix, risk assessment and risk management are further described inasmuch as they are applicable to chemical incidents. Risk communication has been detailed in the chapter itself.

### **Risk assessment**

Risk assessment includes hazard identification, hazard characterization (dose–response), exposure and consequence assessment, and risk characterization.

The first, and perhaps most difficult step in the process is to identify all hazardous conditions. Risk cannot be controlled unless hazardous conditions are recognized before they cause injury, damage to equipment or other accident. Once a hazardous condition is recognized it must be evaluated to determine the threat or risk it presents. The level of risk is a function of the probability of exposure to the hazard and the severity of the potential harm that would be caused by that exposure. Some hazards may present very little risk to people or equipment (e.g. a toxic chemical well enclosed in a strong container). Other hazards may

cause death or serious injury if not controlled (e.g. a toxic chemical that has spilled into a busy workspace). In these two examples, the former situation carries a much lower probability of exposure than the latter. Even though the hazardous chemical may be the same substance, and the harm caused by exposure would be similar, the lower probability of exposure in the first situation results in a lower risk.

Chemicals generally can be divided into two groups: (i) chemicals causing toxic effects for which it is generally considered that there is a dose, exposure or concentration below which adverse effects will not occur (e.g. a chemical causing organ-specific, neurological/behavioural, immunological, non-genotoxic carcinogenesis, reproductive or developmental effects); and (ii) chemicals causing other types of effect, for which it is assumed that there is some probability of harm at any level of exposure – this currently applies primarily for mutagenesis and carcinogenesis. Many chemicals have been evaluated and the literature offers guidance values of levels of exposure below which it is believed that there are no adverse effects (i.e. threshold substances) and risks per unit exposure for those chemicals for which it is believed that there is a risk for health at any level of exposure (i.e. non-threshold substances).

Exposure or precursors of exposure such as concentrations in air, water or food can be measured and/or modelled. Transport and fate of chemical agents depends on their physico-chemical properties and can vary dramatically. During the risk-assessment phase of an incident, it is important to measure and/or model actual or future concentration/exposure/dose, as well as the spread of the causative chemical agent.

Risk characterization aims to provide a synthesis of the intrinsic (eco)toxicological properties of the causative chemical derived from hazard identification and dose–response relationship assessment with the actual or prognostic exposure. It takes into account uncertainties and provides the major input for making risk-management decisions. The process involves comparison of the outcome of the dose–response relationship assessment with the outcome of the risk assessment in order to characterize the risk with which populations are faced so as to recognize potential adverse health outcomes (e.g. there is a high, moderate or low risk).

## **Risk management**

Risk management encompasses all those activities required to reach and implement decisions on risk reduction or elimination. Once a risk has been characterized, an informed decision can be made as to what control measures, if any, are needed to reduce the risks or eliminate the hazard. Control measures can consist of any action for risk reduction or elimination. Usually, however, control measures involve reducing the probability of occurrence or the severity of an incident. When toxic chemicals or infectious organisms are involved, control measures usually include administrative measures, engineering controls or physical protection. There is more detailed discussion of these measures in Annex 4. Control measures must be implemented before personnel or equipment are exposed to the hazardous condition. When controls are implemented, care must be taken to ensure that new hazardous conditions are not introduced as a result of the control measures.

There is no such thing as “no risk”. It may not always be possible to control all hazardous conditions completely. When some risk remains, a conscious decision must be made at the proper level as to whether the remaining risk is an “acceptable risk”. The concept of “acceptable risk” should not be unfamiliar as it is part of daily life. Everyone accepts a certain degree of risk in order to accomplish something beneficial. There is risk associated with flying on a commercial aeroplane. Most people (but not all) will accept the very small chance of an aeroplane accident in exchange for being able to reach their destination quickly.

The potential benefit to be gained from accepting a risk must always be worth the potential consequences of the risk itself. In some cases, a high potential benefit may justify acceptance of a risk that would normally be unacceptable. Unnecessary risk, risk taken without a potential benefit, or risk taken without an appropriate risk assessment must not be accepted. The decision to accept risk must always be made at the proper level. If the evaluated worst-case result of an accident during a particular activity was, for example a minor injury, it might be appropriate for an on-site supervisor or area manager to accept the risk and to proceed without further hazard control measures. At the other end of the spectrum, a decision that could place the lives of many people in jeopardy should be made only at the highest level of

authority. Of course, one never plans for an injury. Risk-reduction measures are always applied. What is referred to here is the consequence of an unexpected occurrence of an accident, despite taking reasonable precautions. If the residual risk is still assessed as being too high, the risk-control process needs to be repeated to lower the probability of occurrence or consequence of exposure even further.

A fundamental principle must always be observed when addressing “acceptable risk”. The number of personnel exposed to a hazardous condition, the amount of time for which they are exposed, and the level/concentration of hazard to which they are exposed must always be kept to the absolute minimum required to accomplish the task.

When applying the concept of “acceptable risk” to the possibility of chemical or biological attack, the level of residual risk that can be accepted will depend on the circumstances of the region concerned. One country may need to address a significant risk of terrorist use of biological or chemical agents by devoting considerable resources to response. In a different part of the world, the assessed low risk of biological or chemical incidents will not justify major expenditure, and acceptance of a reduced ability to respond may be justified. Such decisions are clearly extremely difficult to take and will be influenced by political factors as well as by practical considerations.

When a risk management process is being implemented, it is crucial that the control measures should be evaluated and monitored continuously to ensure that they are working as planned. If it is found that the control measures are not effective, they must be changed or modified immediately. Effective control measures should be recorded for use in controlling similar hazardous conditions in the future. Lessons should be learned by studying simulation exercises, or similar hazards or incidents in other areas/countries, and adapting one’s own risk-management programme accordingly.

## APPENDIX 4.2: THE SARIN INCIDENTS IN JAPAN

On 20 March 1995, a terrorist group launched a coordinated attack with the nerve gas sarin on commuters on the Tokyo subway system. This highly publicized attack killed 12 people and caused more than 5000 to seek care. Without the prompt and massive emergency response by the Japanese authorities, and some fortunate mistakes by the terrorist group, the incident could have been much more devastating. While this is the most widely publicized incident of this type, it is not the first nerve-gas attack in Japan. In June 1994, 7 people were killed and more than 300 injured in an attack by the same group on a residential apartment building in Matsumoto. In December 1994, an opponent of the group was murdered by the skin application of VX.

This Appendix provides a brief summary of the background and features of these incidents and the lessons learned from them. It draws heavily on a number of excellent and comprehensive reviews that have appeared in the international literature (1–6).

### **Background**

The Aum Shinrikyo sect was the brainchild of Chizuo Matsumoto, whose childhood aspirations apparently included the leadership of Japan. In 1984, he started a small publishing house and yoga school, which gradually developed into a cult. He renamed himself Shoko Asahara (“Bright Light”), embarked on a course of cult expansion, with increasingly bizarre teachings and rituals for devotees, and ultimately subversion with the aim of achieving supremacy for his followers in Japan. The group attracted a surprisingly large international membership, numbering in the tens of thousands, and actively recruited graduate scientists and technicians to develop armament programmes that were highly ambitious in their scope. Plans included the development and use of biological and chemical weapons.

Aum Shinrikyo’s chemical weapons made worldwide news after the Tokyo subway attack in 1995, but a quest for biological weapons actually pre-dated the chemical programme. Despite the expenditure of large sums of money and great efforts to acquire the means to develop and disseminate biological agents, attempted attacks (with botulinum toxin

in April 1990 and anthrax in 1993) failed, fortunately causing no noticeable effects on the target population of Tokyo.

The cult had more success with its chemical programme, which was launched in 1993 and reportedly cost around US\$ 30 million. After experiments with VX, tabun, soman, mustard gas, hydrogen cyanide and phosgene, the cult's final choice was the nerve gas sarin, and a plan was developed for the production of about 70 tonnes of this substance at Aum Shinrikyo's facilities in Kamikuisiki, at the foot of Mount Fuji.

### **The Matsumoto incident**

During 1994, Aum Shinrikyo was involved in legal proceedings concerning a land purchase, and a gas attack on the overnight premises of the three judges involved was planned for 27 June of that year, apparently to pre-empt an unfavourable ruling. An improvised sarin-dissemination system was used, consisting of a heater, fan and drip system, sarin vapour being vented from the window of a disguised delivery van. After a 20-minute release period, the gas spread over an elliptical area measuring about 800 by 570 metres (most effects occurring within a smaller area of 400 by 300 metres). While the judges survived, 7 unfortunate residents died as a result of the attack, there were 54 other hospital admissions, and 253 persons sought care at outpatient facilities. In the absence of formal identification of the toxic substance, doctors could rely only on what they observed to guide treatment, namely clinical symptomatology consistent with organophosphate poisoning. On 4 July, an official report revealed that the cause of the poisoning had been the chemical warfare agent sarin, which had been identified by gas chromatography-mass spectrometry (GC-MS) in a water specimen taken from a pond in the affected area. No evidence found at that time incriminated Aum Shinrikyo.

### **The Tokyo incident**

The Japanese authorities were collecting increasing evidence suggestive of Aum Shinrikyo's interest in chemical weapons. Ironically, they had been unable to prevent the suspected acquisition or production of chemical weapons' since such activities were not illegal at that time. The pretext for a raid on the suspected production plant was provided when evidence

linked an Aum member to a suspected kidnapping, but cult members employed by the authorities warned Asahara of the imminent raid, for which the police were being trained in chemical defence. In an apparent attempt to dissuade the police from making the raid, an attack on the Tokyo subway system was hastily planned. On the morning of 20 March 1995, five two-man teams carried out the attack, each team consisting of one getaway driver and one subway rider. Four subway riders carried two double-layered plastic bags and one rider carried three, each bag containing about half a litre of sarin. The sarin was only about 30% pure because it had been hastily produced for use in the attack. Five subway lines converging on the station of Kasumigaseki (where many Japanese government buildings and the Tokyo Metropolitan Police Department are located) had been selected. At around 08:00, i.e. during peak commuting time, the five assailants placed their sarin-filled bags on the train floor, pierced them with sharpened umbrella tips,<sup>7</sup> and left the trains several stations away from Kasumigaseki.

The first emergency call was received by the Tokyo fire department at 08:09, and the emergency services were soon inundated with calls for aid from the numerous subway stations where affected passengers were disembarking and seeking medical help. A total of 131 ambulances and 1364 emergency medical technicians were dispatched, and 688 people were transported to hospital by the emergency medical and fire services. More than 4000 people found their own way to hospitals and doctors using taxis and private cars or on foot. The lack of emergency decontamination facilities and protective equipment resulted in the secondary exposure of medical staff (135 ambulance staff and 110 staff in the main receiving hospital reported symptoms).

Having initially been misinformed that a gas explosion had caused burns and carbon monoxide poisoning, medical centres began treating for organophosphate exposure based on the typical symptomatology encountered, supported by the results of tests indicating depressed acetylcholinesterase activity in symptomatic victims (see Annex 1). An official announcement by the police that sarin had been identified reached the hospitals, via the television news, about three hours after the release.

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<sup>7</sup> Of the 11 bags, only 8 were actually ruptured: 3 were subsequently recovered intact. It is estimated that around 4.5 kg of sarin were released.

Overall, 12 heavily exposed commuters died, and around 980 were mildly to moderately affected, while about 500 required hospital admission. More than 5000 people sought medical assistance.

### **Observations**

Much can be learned from the analysis of these attacks, at both the general level (i.e. in terms of the international threat), and at the specific level (i.e. in terms of the immediate effect and response).

- **Magnitude of the event.** While the human consequences of the attack should not be underestimated, they should also not be exaggerated. The frequently encountered casualty toll of “over 5000” must be seen in its true perspective. The attack was serious – 12 people died, 54 were severely injured, and around 980 were mildly to moderately affected. The majority of the 5000 seeking help, many of them with psychogenic symptoms, were (understandably) worried that they might have been exposed. This demonstrates the value of rapid information dissemination via the media in reassuring the public. It also shows the importance of effective triage at receiving centres in ensuring that medical resources are reserved for those who really have been exposed. Before this attack is taken as evidence of the effectiveness of toxic chemicals in the hands of terrorists, however, the figure of 12 dead should be compared with the death tolls of recent terrorist attacks using conventional explosives, such as the bombing of the United States embassies in Nairobi and Dar es Salaam (257), the Federal Building in Oklahoma City, USA (168), and the United States Marine barracks in Lebanon (241). These, in turn, must now be regarded as relatively slight in comparison with what happened on 11 September 2001, when hijacked long-haul passenger aircraft were flown into the Pentagon outside Washington, DC, and into each of the twin towers of the World Trade Center in New York City, killing, it is now believed, more than 3100 people. Equally, it should be realized that the sarin casualty figures might have been many times worse.

- **The utility of chemical weapons in achieving terrorist objectives.** While many reports (particularly in the media) have touted the sarin incidents as evidence of a frightening new era in terrorist methodology, a sober assessment of the actual results shows otherwise. It is true that,

before 11 September 2001, this was one of the most highly publicized terrorist attacks in history. The result for Aum Shinrikyo, however, can hardly be judged a success. The immediate objective of the attack was the disruption of an anticipated raid on cult premises and, on a broader level, the incitement of social upheaval. In fact, the raid was delayed for only 48 hours, the Japanese Government remained firmly in power, and most of the cult's senior members are now in prison.

• **The ease of acquisition and use of biological and chemical weapons.**

Despite its ample financial resources, equipment and expertise, and years in which to develop its weapons, Aum Shinrikyo attempted but failed to use biological agents effectively (7–9) and achieved only relatively limited success with its chemical programme. Aspirant terrorists thinking of using biological or chemical weapons may well find these results a deterrent, not an encouragement.

• **The importance of national legislation on chemical weapons.**

Despite compelling evidence of the cult's growing interest in chemical agents, which started well before the Tokyo subway attack, no Japanese laws prohibited its activities at the time, and pre-emptive action could therefore not be taken. Since the entry into force of the CWC in 1997, however, all Member States (including Japan) have been able to share their experiences and planning concepts to fulfil their obligation to enact and implement legislation forbidding persons on their territory, or under their jurisdiction, from undertaking any activities that are prohibited to the State Party itself.<sup>8</sup> When such legislation has been introduced, pre-emptive action against terrorist groups developing or using chemical weapons can be taken. Likewise, the entry into force of the BWC in 1975 has obliged all its States Parties (including Japan) to take the measures necessary for its implementation

• **The importance of detection and identification abilities.** In both the Matsumoto and Tokyo incidents, medical staff had to rely on clinical observation to guide their initial treatment of victims. If portable detection apparatus had been available to emergency-response personnel, this would have facilitated the earlier identification of the nature of the event. The follow-up forensic and legal process was considerably aided by the laboratory identification of sarin using

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<sup>8</sup> See also Appendix 5.2.

sophisticated GC-MS techniques available to the police forensic toxicologists (10). In an interesting development of new biomedical testing methods, scientists in the Netherlands were later able to retrieve sarin from the stored blood samples of 10 out of 11 of the victims of the Tokyo incident, and from 2 out of 7 samples from the Matsumoto incident – unequivocal evidence of exposure to sarin (11).

- **The importance of decontamination abilities and protection.**

About 10% of the ambulance staff who responded to the incident reported symptoms of exposure, as did 110 members of the staff at the major receiving hospital (although these symptoms were generally mild). A contributing factor was the lack of decontamination facilities on site and of protective equipment for initial responders and hospital staff. Before this is taken to mean that high-level protection is always required, it should be remembered that the figure of 10% reporting mild effects also means that at least 90% were not affected at all. A reasonable conclusion is that the availability of protective equipment would have been of considerable benefit to responders. However, an approach based on graded protection appropriate to the level of contamination is required to prevent the unnecessary immobilization of helpers as a result of the ergonomic problems of wearing protective clothing (see Annex 4). Rapidly deployable decontamination equipment is needed both on site (to avoid secondary contamination of emergency transport) and at receiving facilities. However, it is important to remember that the majority of people who sought medical help did so on their own initiative and using their own transport. This would have effectively negated much of the utility of on-site decontamination systems, even had they been available, as they would generally be used for victims being treated in the course of evacuation by the emergency services.

- **The importance of command, control and communication.**

Communication channels available to emergency-response personnel were not able to cope with the flood of calls that the attack precipitated. In particular, overload prevented effective communications between the on-site and mobile emergency medical technicians and their supervising hospital-based doctors, whether to seek medical instructions or to determine which hospitals could receive patients. As a result, a number of patients did not benefit from interventions such as airway support,

intubation or intravenous therapy until after they arrived at hospitals. The timely provision of accurate information to responders is crucial to their own safety and to their ability to provide appropriate assistance. Pre-planned systems for tapping the expert knowledge of experienced toxicologists, poison information centres and chemical warfare specialists would have been of major assistance to the receiving medical facilities. A single responsible local authority with the ability to communicate with, and coordinate the activities of, the various response elements would have been a considerable advantage. Complicated formalities and the need for high-level approval prevented the rapid mobilization of the specialists in chemical defence within the Japanese military.

• **The readiness of medical personnel to handle chemical casualties.** The majority of the Tokyo hospital staff, like medical personnel in most parts of the world, were untrained in the care of casualties caused by chemical weapons and had no immediate access to treatment protocols for the victims of such weapons. This is not something that can be left to military specialists, as it is the local hospitals that will be the first to receive the casualties. Inclusion of the effects of chemical weapons and treatment of the resulting casualties both in standard medical curricula and in the training of first responders and the staff of local hospital accident and emergency departments, is an essential component of medical preparedness for responding to chemical incidents.

## **Conclusions**

The release of sarin by a terrorist group in Japan resulted in a highly publicized incident with mass casualties. In scale, however, it did not approach the human and environmental toll that has resulted from a number of recent terrorist attacks using conventional explosives, and it falls far short of what happened in the United States on 11 September 2001. Despite many difficulties, Japanese emergency units and local hospitals were able to achieve a remarkably rapid response, without which the casualty figures might have been considerably higher. While analysis of the event reveals a number of important lessons for authorities to consider when preparing for such incidents, it also reveals many of the technical difficulties associated with toxic chemicals and their limitations as weapons for use by terrorist groups.

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## APPENDIX 4.3: THE DELIBERATE RELEASE OF ANTHRAX SPORES THROUGH THE UNITED STATES POSTAL SYSTEM

During the autumn of 2001, several letters containing spores of *Bacillus anthracis* were sent through the United States postal system, causing 11 cases of inhalational anthrax, five of them fatal, and 11 confirmed or suspected cases of non-fatal cutaneous anthrax. The first onset, of cutaneous anthrax, occurred in late September and the last, of inhalational anthrax, in mid-November. Of the four letters that were recovered, one was addressed to a television newscaster, another to the editor of a newspaper, both in the city of New York, and two were addressed to United States senators in Washington, DC.

Twenty of the 22 patients were exposed to work sites that were found to be contaminated with anthrax spores. Nine of these had worked in United States Postal Service (USPS) mail-processing facilities through which the anthrax letters had passed. Two patients, both with fatal inhalational anthrax, had no known exposure to contaminated mail or contaminated premises.

Polymerase chain reaction (PCR) tests and DNA sequencing indicated that all attacks involved the same strain of *B. anthracis*. A year after the attacks, two United States mail-processing facilities remained shut down pending decontamination, and accountability for the letters remains a mystery.

This appendix outlines some of the relevant background and summarizes information about the letters, the patients, the public health response, and the clean-up operations. Sources include reports and publications by the United States Centers for Disease Control and Prevention (CDC), the United States Federal Bureau of Investigation (FBI), and the USPS, as well as United States Congressional hearings, official statements to the press, the medical literature, and accounts of USPS officials and postal workers.

## Background

In 1990, immediately before the Gulf War, the United States' concern about potential anthrax attacks led to the vaccination of more than 100 000 military personnel. In 1995, this concern was again aroused when the United Nations Special Commission (UNSCOM) learned that Iraq had been developing and testing anthrax weapons during the Kuwait War. In 1998, a programme was initiated to vaccinate all United States military personnel and a Presidential Decision Directive further defined the authority and responsibilities of United States government agencies for responding to possible biological or chemical terrorist attacks on United States civilian centres. This reaffirmed and refined a 1995 Directive designating the FBI, as assigned by the Department of Justice, as the lead agency in charge of investigation and overall response management, with authority to designate other government agencies as lead agencies for specific operational tasks. By 2001, with federal assistance, most American state and large-city governments had begun to develop plans to deal with bioterrorism and many had staged mock attacks to test local emergency response capacity.

Starting in 1997, the United States experienced an increasing number of anthrax threats and hoaxes that, by the end of 1998, were almost a daily occurrence. Prominent among these were envelopes containing various powders and materials sent through the postal service to abortion and reproductive health clinics, government offices, and other locations. Until the events of autumn 2001, none of these materials tested positive for pathogenic *B. anthracis* nor had there been a case of inhalational anthrax in the United States since 1976.

In Canada, after several anthrax hoax letters there, the Defence Research Establishment, Suffield conducted experiments during February–April 2001 to estimate the hazards arising from opening a letter containing spores of *B. anthracis*. The Canadian researchers used as a simulant spores of non-pathogenic *B. globigii*, donated by the United States Department of Defense, Dugway Proving Ground, Utah. It was found, contrary to the expectation of those conducting the tests, that large numbers of spores were released into the air upon opening an envelope containing even as little as a tenth of a gram of spores, and that large doses would be inhaled by an unprotected individual in the

room in which the letter was opened. The ensuing report, released in September 2001, also warned that envelopes not thoroughly sealed could pose a threat to individuals in the mail-handling system. Following the United States anthrax-letter attacks, however, it was realized that anthrax spores might escape even from fully sealed envelopes, depending on the type and grade of paper.

Dose–response measurements over a range of doses of anthrax spores to cynomolgus monkeys conducted in the pre-1969 United States offensive biological weapons programme had shown that under the experimental conditions employed, the inhalational median lethal dose ( $LD_{50}$ ) was about 4000 spores. Although other measurements carried out with monkeys under various experimental conditions gave a wide range of  $LD_{50}$  values and although there are no reliable dose–response data for inhalational anthrax in any human population, it was subsequently assumed for military planning purposes that the human  $LD_{50}$  was approximately 8000–10 000 spores. While it is self-evident that doses below the  $LD_{50}$  will infect less than 50% of an exposed population, it is not known whether inhalation of even a single spore can initiate infection, albeit with very low probability. Uncertainty regarding dose–response relationships for human populations continues to make hazard prediction for inhalational anthrax problematic.

In contrast to inadequate or insufficiently appreciated knowledge regarding the dispersibility of dry spore powders, the permeability of sealed envelopes and dose–response relationships, effective medical measures for prophylaxis and therapy of cutaneous and inhalational anthrax were established and published in the medical literature well before the anthrax-letter attacks. Long experience with human cutaneous anthrax had shown it to be readily curable with several antimicrobials. Although penicillins were recommended for treatment of cutaneous anthrax, recent studies of experimental inhalation anthrax in monkeys led to the designation of doxycycline and ciprofloxacin as the antimicrobials of choice, both for prophylaxis in cases of known or suspected exposure and, if given soon after the onset of clinical disease, as therapy. Because of the possible retention of infective spores in the lungs for many days before an infection starts, suggested by United States monkey studies and human data from the

1979 Sverdlovsk (former Soviet Union) epidemic, it was recommended that antimicrobial therapy be continued for as long as 60 days following inhalatory exposure.

### **The anthrax letters**

All four of the recovered spore-containing envelopes were sealed with tape and postmarked from Trenton, New Jersey. Envelopes, postmarked 18 September 2001, were addressed to a National Broadcasting Company (NBC) television newscaster and to the editor of the *New York Post* at their New York City offices. Two other envelopes, postmarked 9 October 2001, were addressed to Senator Tom Daschle and Senator Patrick Leahy at their Washington offices. All four recovered envelopes were postmarked and sorted at a mail-processing facility in Hamilton Township, near Trenton, before being sent to other processing and distribution centres. Those addressed to the two senators were processed at the Brentwood facility in Washington. Both facilities were found to be heavily contaminated with anthrax spores.

There are indications that at least three additional anthrax letters were sent but were lost or discarded. There were confirmed cases of cutaneous anthrax at the offices of American Broadcasting Company (ABC) and of Columbia Broadcasting System (CBS) Television News in New York and of inhalational anthrax at American Media Incorporated (AMI) in Boca Raton, Florida. Positive nasal swabs were obtained and environmental contamination was found at all three sites, and contamination was found at several mail-processing facilities through which their mail passed. Individuals at all three locations fell ill before 9 October, making it possible that three unrecovered letters were posted together with the two recovered letters of 18 September.

Both of the letters postmarked 18 September contained identical hand-printed messages in block letters that included the words "TAKE PENACILIN NOW" [sic], and both letters postmarked 9 October contained identical messages with the words "WE HAVE THIS ANTHRAX". Given that penicillin has historically been a recommended antimicrobial therapy against anthrax, that the strain used was subsequently found to be sensitive to penicillin, and that identification of the pathogen would facilitate appropriate therapy, it appears that

the perpetrator sought to convey information that would enable the recipients to take protective action.

All four recovered letters included the words “ALLAH IS GREAT” and the date “09–11–01”, the day of the aircraft attacks on the World Trade Center in New York and the Pentagon in Virginia, apparently with the intention to portray the sender as an Islamic terrorist.

The two letters dated 18 September and the letter addressed to Senator Daschle were recovered from the offices of their addressees, but the letter to Senator Leahy, which had been misdirected by a mechanical error to the State Department, was discovered in November only after a search of unopened government mail collected from the United States Capitol. This was collected in 635 rubbish bags that were then sealed and individually sampled for anthrax spores. Sixty-two bags were found to be contaminated, one far more than the others. Individual examination of the letters it contained then led to the discovery of the Leahy letter.

The anthrax strain was identified as the variant called Ames, originally isolated from a diseased cow in Texas in 1981 and sent to the United States Army Research Institute for Infectious Diseases (USAMRIID) at that time. From there, it was distributed to laboratories in the United States, the United Kingdom, Canada, and elsewhere. The 9 October letters contained a highly pure preparation of anthrax spores, almost entirely free of debris, while the 18 September material was decidedly less pure, containing an appreciable proportion of vegetative *B. anthracis* cells. No additives have been confirmed to have been present. Carbon isotope ratio analysis of the material in the Leahy envelope indicated that it had been produced within the two years preceding its mailing.

### **The patients**

On or about 25 September, an assistant in the office where the NBC anthrax letter had been received and taken into custody by the FBI developed a lesion diagnosed by her physician as possibly being cutaneous anthrax, but this was not confirmed by laboratory testing until 12 October. The first case to reach public notice was that of an AMI photo editor in Florida. After an illness of several days, he died of inhalational anthrax on 5 October, one day after laboratory confirmation of the

diagnosis by the Florida Department of Health and CDC. Although the federal authorities at first considered naturally occurring anthrax infection to be a possibility, the discovery of environmental contamination at AMI caused the FBI on 7 October to declare the site a crime scene. On 1 October, a second AMI employee, a mailroom worker, was hospitalized with a misdiagnosis of community-acquired pneumonia, later diagnosed as anthrax by laboratory testing on 15 October. He recovered and was discharged on 23 October.

Of the 22 confirmed or suspect cases, 12 (eight inhalational and four cutaneous) were mail handlers. These included nine USPS workers, two media company mailroom workers, and an employee in the State Department mailroom through which the Leahy letter had mistakenly passed. An additional case of cutaneous anthrax was a Texas laboratory worker engaged in testing samples from the outbreak.

Recorded onsets of symptoms fall into two clusters, 22 September–1 October and 14 October–14 November, with a 12-day gap between with no recorded onsets (Table 4.4). The two clusters may reflect the two dates on which the recovered letters were posted. Most of the inhalational cases (9 of the 11) were in the second cluster, six of them being USPS workers. This concentration of inhalational cases in the second cluster and among postal workers may reflect differences in the spore preparations; greater inhalatory exposure in mail-processing facilities, where sorting and cleaning operations generate aerosols, and/or differences between work sites in the time elapsed between exposure and the start of antimicrobial prophylaxis.

In the first cluster, 22 September–1 October, seven patients developed confirmed or suspected cutaneous anthrax. None of these cases was diagnosed by laboratory testing until 12 October or later. Overall, the time between onset and laboratory diagnosis ranged from 2 to 26 days for cutaneous anthrax and from 3 to 16 days for inhalational anthrax, with laboratory diagnosis becoming more prompt as the outbreak progressed. Although cutaneous anthrax was diagnosed by laboratory testing in two workers at the Hamilton mail-processing facility on 18 and 19 October (after which the facility was closed), the risk from leaking envelopes was not understood by officials in time to prevent inhalational

anthrax in two Hamilton employees and in four employees at Brentwood (which closed on 21 October), two of whom died.

The last two cases, both inhalational and both fatal, had recorded onsets of 25 October and 14 November. Unlike any of the earlier infections, there was no known link to the anthrax letters and no evidence of environmental contamination. In the first of these perplexing cases, an employee at a New York hospital died on 31 October. Although her workplace had housed a temporary mailroom, no contamination was found there. In the second case, a 94-year-old woman residing in Connecticut died on 21 November. Whatever the source of the pathogen, these two cases emphasize the possibility that, with very low probability, perhaps depending on the health status and age of the individual, even small numbers of inhaled spores may initiate infection.

No onset of any form of anthrax was recorded among personnel at any site after they were instructed to start antimicrobial prophylaxis. Six patients diagnosed with inhalational anthrax who were admitted to hospital with only prodromal symptoms and were given antimicrobials active against *B. anthracis* survived. These observations are consistent with pre-existing experimental and clinical evidence and indicate that antimicrobial prophylaxis prevented clinical disease in exposed people, limiting the extent and duration of the outbreak, and that antimicrobial therapy, when begun soon after onset, prevented death.

### **Public health response**

Most cases were detected through self-reporting and from unsolicited reports from clinical laboratories and clinicians, with the assistance of active surveillance established by local public health authorities.

After laboratory confirmation of cutaneous anthrax in an NBC employee on 12 October, an Emergency Operations Center was established at CDC to organize teams of epidemiologists and laboratory and logistics staff to support local, state and federal health investigations. Investigators responded to reports of possible cases from clinicians, law enforcement officials, and the general public.

Local and federal agencies, including the Office of the Attending Physician, United States Congress, implemented the rapid distribution of antimicrobials (ciprofloxacin and doxycycline) to individuals after an inhalational anthrax risk was officially estimated at specific sites. The United States National Pharmaceutical Stockpile, mandated by the United States Congress in 1999, facilitated the emergency availability of drugs to some 32 000 people who were potentially exposed. Altogether, National Pharmaceutical Stockpile teams distributed some 3.75 million antimicrobial tablets. Those presumed to be at higher risk were advised to remain on a prolonged course of 60 days and were encouraged to participate in a follow-up study conducted by CDC through a private contractor. At that time, they were also given the option of anthrax vaccination. Public health officials were candid about the limited data supporting the efficacy of post-exposure vaccination. Fewer than 100 people, many of them Senate staff, took advantage of the offer.

During the crisis, collection and testing of environmental and clinical samples, as well as materials from suspicious incidents and hoaxes, placed an immense burden on the FBI, Defense Department, CDC, and public health laboratories throughout the United States. The magnitude of the clinical and environmental testing undertaken would have quickly overwhelmed the United States national capacity had a significant investment not already been made in expanding laboratory training and capacity through a system called the Laboratory Response Network. This links state and local public health laboratories with advanced capacity clinical, military, veterinary, agricultural, and water- and food-testing laboratories. Established in 1999, it operates as a network of laboratories with progressively more stringent levels of technical proficiency, safety, and containment necessary to perform the essential rule-out, rule-in, and referral functions required for agent identification. The network consists of 100 core and advanced capacity public health laboratories and two higher-level laboratories, at USAMRIID and at the CDC National Center for Infectious Diseases.

During the acute phase of the outbreak, Laboratory Response Network laboratories processed and tested more than 120 000 environmental and clinical specimens for *B. anthracis*. This was accomplished chiefly by state and local public health laboratories, USAMRIID, the Naval

Medical Research Center and CDC. Forensic tests and analyses of the recovered anthrax-contaminated envelopes and their contents and of control materials were conducted by the FBI, Northern Arizona University, USAMRIID, Lawrence Livermore National Laboratory, Sandia National Laboratories and several other facilities. Epidemiological investigations were performed or coordinated by CDC.

### **Environmental contamination and decontamination**

FBI, CDC, and USPS personnel and contractors collected surface samples from diverse locations, including offices, postal facilities and private homes. Samples collected from adjacent surfaces by swipes with wet cotton or rayon gauze and by vacuum collection through high-efficiency particulate arresting (HEPA) filters gave reasonably concordant results, but dry swipes consistently gave far less agreement and were judged unacceptable. At some sites, air sampling was also conducted. Contamination was found in at least 23 postal facilities and post offices, nearly all in New Jersey, New York, Washington, and south Florida but also as distant as Kansas City. The risk of disease associated with any level of air or surface contamination remained undefined, though more valid sampling and risk estimates quickly became a high priority for United States public health officials.

USPS mail-processing facilities were the most extensively affected environments. Mechanical agitation and air turbulence produced by high-speed sorting equipment and the use (now discontinued) of compressed air to clean machines undoubtedly contributed to the creation of dangerous aerosols and high levels of surface contamination. The Hart Senate Office Building was decontaminated with gaseous chlorine dioxide and is again in operation. After a year, the Brentwood and Hamilton mail-processing facilities remained closed, pending decontamination. In order to reduce potentially contaminated dust and aerosols from the atmosphere in its facilities, the USPS has introduced some 16 000 HEPA vacuum machines and, as a precaution, routinely sterilizes mail going to federal agencies by electron-beam irradiation. For the two fiscal years 2003–2004, it has budgeted US\$ 1.7 billion for additional modifications and improvements in its ability to protect the health of its workers and to prevent pathogens and other hazardous substances from being distributed through the mail.

Table 4.4. Postal anthrax attacks 2001: demographic, clinical and exposure characteristics of the 22 cases

Case number	Date of onset of symptoms	Date of anthrax diagnosis by laboratory testing	State <sup>a</sup> (attack sites)	Age (years)	Sex <sup>a</sup>	Race <sup>a</sup>	Occupation <sup>a</sup>	Case status	Anthrax presentation	Outcome
1	22 September	19 October	NY	31	F	W	New York Post employee	Suspect	Cutaneous	Alive
2	25 September	12 October	NY	38	F	W	NBC anchor assistant	Confirmed	Cutaneous	Alive
3	26 September	18 October	NJ	39	M	W	USPS machine mechanic	Suspect	Cutaneous	Alive
4	28 September	15 October	FL	73	M	W/H	AMI mailroom worker	Confirmed	Inhalational	Alive
5	28 September	18 October	NJ	45	F	W	USPS mail carrier	Confirmed	Cutaneous	Alive
6	28 September	12 October	NY	23	F	W	NBC television news intern	Suspect	Cutaneous	Alive
7	29 September	15 October	NY	0.6	M	W	Child of ABC employee	Confirmed	Cutaneous	Alive
8	30 September	04 October	FL	63	M	W	AMI photo editor	Confirmed	Inhalational	Dead (5 October)
9	01 October	18 October	NY	27	F	W	CBS anchor assistant	Confirmed	Cutaneous	Alive
10	14 October	19 October	NJ	35	M	W	USPS mail processor	Confirmed	Cutaneous	Alive
11	14 October	28 October	NJ	56	F	B	USPS mail processor	Confirmed	Inhalational	Alive

Table 4.4. (continued) Postal anthrax attacks 2001: demographic, clinical and exposure characteristics of the 22 cases

12	15 October	29 October	NJ	43	F	A	USPS mail processor	Confirmed	Inhalational	Alive
13	16 October	21 October	DC	56	M	B	USPS mail worker	Confirmed	Inhalational	Alive
14	16 October	23 October	DC	55	M	B	USPS mail worker	Confirmed	Inhalational	Dead (21 October)
15	16 October	26 October	DC	47	M	B	USPS mail worker	Confirmed	Inhalational	Dead (22 October)
16	16 October	22 October	DC	56	M	B	USPS mail worker	Confirmed	Inhalational	Alive
17	17 October	29 October	NJ	51	F	W	Bookkeeper	Confirmed	Cutaneous	Alive
18	19 October	22 October	NY	34	M	W/H	New York Post mail handler	Suspect	Cutaneous	Alive
19	22 October	25 October	DC	59	M	W	Government mail processor	Confirmed	Inhalational	Alive
20	23 October	28 October	NY	38	M	W	New York Post employee	Confirmed	Cutaneous	Alive
21	25 October	30 October	NY	61	F	A	Hospital supply worker	Confirmed	Inhalational	Dead (31 October)
22	14 November	21 November	CT	94	F	W	Retired at home	Confirmed	Inhalational	Dead (21 November)

<sup>a</sup> NY, New York; NJ, New Jersey; FL, Florida; DC, District of Columbia; CT, Connecticut; F, female; M, male; W, white; W/H, white with Hispanic ethnicity; B, black; A, Asian; NBC, National Broadcasting Company; USPS, United States Postal Service; AMI, American Media Inc.; CBS, Columbia Broadcasting System.

Adapted from Jernigan DB et al. Investigation of bioterrorism-related anthrax, United States, 2001: epidemiologic findings. Emerging Infectious Diseases, 2002, 8(10): 1019–1028 (available at <http://www.cdc.gov/ncidod/EID/vol8no10/02-0353.htm>).