2. ASSESSING THE THREAT TO PUBLIC HEALTH

Among the many emergencies or disasters to which public health authorities may be called upon to respond is the deliberate use of biological or chemical agents to cause harm. For public health authorities, the problem this raises is one of priorities. What priority should be given to preparedness for such releases as compared with other emergencies or disasters and the regular needs of public health? This chapter provides an historical introduction to this problem and to the more detailed discussion of threat assessment in Chapter 3.

2.1 Background

Poisons and pathogenic microorganisms are among the natural health hazards with which human beings are obliged to coexist. Difficult to perceive and therefore to avoid, they present a threat that is both insidious and damaging or deadly. Humans have survived by adaptation, partly physiological, as in the development of the immune system far back in vertebrate evolution, and partly social, as in the development of both individual and public health practices that serve to limit exposure to the dangers or to alleviate the illness they cause.

Historically, the codes of professional behaviour adopted by the military that forbid the use of poison and therefore also of disease may be regarded as a part of that same social adaptation. From the Manu Laws of India to, for example, the Saracen code of warfare based on the Koran, the Lieber Code of 1863 in the United States and the 1925 Geneva Protocol *(1)*, this taboo seems so widespread, ancient and specific as to require some such explanation *(2)*.

International law relating to biological and chemical warfare is considered in Chapter 5, which describes how the multilateral treaties of 1972 and 1993 on the total prohibition of biological and chemical weapons have extended that law. Underlying this extension was a widespread concern that powerful new weapons were on the verge of proliferating and spreading within a global security system poorly capable of containing the destabilization that they could cause. The United Nations, almost from its inception, has distinguished between *conventional weapons* and *weapons of mass destruction*. It defined the latter in terms of their operating principles and destructiveness,[4] but the main concern was with their consequences, namely their potential for bringing devastation, death and disease to human societies on a scale incompatible with their survival. New weapons technology might, in other words, be generating threats to humanity that called for improved forms of protection: a strengthening of social adaptation to present dangers. At its summit session in January 1992, the Security Council determined that the "proliferation of all weapons of mass destruction constitutes a threat to international peace and security". Moreover, the 15 Member States of the Council also committed themselves "to working to prevent the spread of technology related to the research for or production of such weapons and to take appropriate action to that end" *(4)*.

Throughout most of the world, the public health infrastructure is stretched to its limits coping with natural health hazards. In 1998, a quarter of the world's 53.9 million deaths were due to infectious disease, and in developing countries such disease caused one in two deaths *(5)*. It poses a major threat to economic development and the alleviation of poverty. Against such a background, the additional threat to public health of disease caused in a country by biological or chemical warfare might be no more than a slight addition to the existing burden. Conceivably, however, it might also be on such a scale or of such a nature as to be beyond the capability of the health-care system to cope. For deliberate use (or threats of use) of biological or chemical agents, a spectrum of threat can therefore be envisaged that ranges between those two extremes: relative insignificance at one end, mass destruction of life or mass casualties at the other. Where along this spectrum a particular biological or chemical menace is situated will be determined by the

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4 In September 1947, weapons of mass destruction were defined in a Security Council document as "atomic explosive weapons, radioactive material weapons, lethal chemical and biological weapons, and any weapons developed in the future which have characteristics comparable in destructive effect to those of the atomic bomb or other weapons mentioned above" *(3)*. It was this wording, proposed by the United States, that the United Nations subsequently used to differentiate the two broad categories of weapon in order to guide its work on the "system for the regulation of armaments" required under Article 26 of the Charter of the United Nations. Note, however, that, as is described in Chapter 5, the BWC and the CWC are not limited to weapons of mass destruction.

characteristics of the agent and the way it is used, and by the vulnerability of the threatened population, reflecting such factors as the health status and degree of preparedness of that population. Particularly threatening would be the possibility of a pandemic resulting from the intentional or inadvertent release of infective agents that cause contagious disease, such as smallpox, for which effective hygienic measures, prophylaxis or therapy may be unavailable. Towards the mass-destruction end of the spectrum, remedies or countermeasures may be beyond the resources of many countries and therefore available, if at all, only through international cooperation.

There is some historical guidance on the likelihood of such a catastrophe. Biological or chemical weapons have only rarely been used by military forces. Unsubstantiated accusations of use have been more common, but this may reflect the difficulty of proving that they have or have not been used because of the lack of reliable information on such unverified episodes, or the readiness with which the emotions aroused by anything to do with poison gas or germ warfare lend themselves to calumny and disinformation. Biological or chemical warfare may have recurred sporadically for at least as long as its proscription. Poison is no novelty as a weapon of murder, and the deliberate pollution, for example, of water supplies is an expedient that retreating forces must often have found attractive. Only in recent times, however, owing to advances in technology, has the position of chemical and biological weapons moved from the insignificant towards the mass-destruction end of the spectrum.

2.2 Technological developments

The event that most clearly marked the emergence of this form of warfare from its prehistory took place near Ypres in Belgium on 22 April 1915, eight months into what was becoming the First World War. Alone among the belligerents, Germany possessed the industrial capacity needed for the large-scale liquefaction of chlorine gas and, as the war progressed, it turned to this comparative advantage as a possible way out both from the trench warfare that was immobilizing its armies in the field and from the shortage of explosives brought about by enemy naval blockade. These military necessities were given precedence, in keeping with the primacy (since disavowed) given to the German legal doctrine of *Kriegsraison* over the ancient prohibition of the use of poisons in warfare that had been reaffirmed at The Hague less than a decade previously. On the late afternoon of that day, 180 tonnes of liquid chlorine contained in 5730 pressure cylinders were released into the breeze that would carry the resultant cloud of asphyxiating vapour towards enemy lines. The available records are sparse but it is said that as many as 15 000 French, Algerian and Canadian soldiers became casualties in this onslaught, one-third of them dead. The actual numbers may have been different but, whatever they were, this was the world's first experience of a weapon of mass destruction.

This new weapon polluted the air that its target population was obliged to breathe, so protection, in the form of air filters, was not impossible to arrange. The first filters contained chemicals that reacted with the poison gas, and were therefore easily circumvented as the weaponeers turned to toxicants of different chemical composition, notably phosgene, or to ways of establishing airborne dosages more than large enough to consume the reactant contained in the filter. Improved filters were then introduced in which the pollutant was physically adsorbed, as in the activated charcoal and particle-retaining paper filters of the respirators, or "gas masks", that today remain the principal and most dependable countermeasure against vapours or aerosols. By 1917, the growing efficacy of gas masks had stimulated the development of chemicals that could attack on or through the skin, the paramount example being an oily liquid known as "mustard gas". The skin is harder to protect effectively than the lungs if those protected are to remain mobile and active, but effective skin attack commonly requires much larger quantities of agent than does inhalation attack, so that the weapons are effective over a substantially smaller area. Mustard gas used in hot weather is an exception to this general rule, as even its vapour attacks the skin. This is one of several reasons why this particular chemical agent remains so menacing even now.

Another way forward for the weaponeers was to use special methods of disseminating the chosen agent, capable of surprising target populations before they could put on their masks. Such a result could be achieved with sudden heavy airborne concentrations of agent delivered by massed artillery or, later, by aerial bombardment. Alternatively, it could be achieved with the imperceptible airborne casualty-producing dosages that could, with the right agent, be established by upwind spray-systems or aerosol-generators. Yet here, too, protective countermeasures were available, some more effective than others, but, taken together, capable today of negating the mass destructiveness of the weapons, at least when used against military forces. Comparable protection of larger and less disciplined civilian populations would be much harder, but not necessarily impossible, to achieve. Countermeasures may be of the following types: (i) medical (therapy and, for some agents, prophylaxis); (ii) technical (respirators that can be worn for many hours, and automatic agent-detection equipment able to give early warning of the need to mask or to enter air-conditioned protective shelter and when to leave); and (iii) organizational (specially developed intelligence systems, standard operating procedures, and training). More recently, new instruments of international law have been included in this range of measures, notably the BWC, the CWC, and the Statute of the International Criminal Court.

Vulnerabilities remain of course, especially in countries where the economic or technological base is not capable of providing even rudimentary protection. This is why, when chemical warfare has recurred since the First World War, it has invariably taken place within the less industrialized regions of the world, e.g. Morocco (1923–1926), Tripolitania (1930), Sinkiang (1934), Abyssinia (1935–1940), Manchuria (1937–1942), Viet Nam (1961–1975), Yemen (1963–1967) and Iraq/Islamic Republic of Iran (1982–1988) *(6)*. In other conflicts, notably the Second World War, the widespread deployment of antichemical protection served to reduce the relative attraction of chemical weapons as compared with those against which protection is less effective. There was no significant strategic or battlefield use of chemical warfare in that conflict.

Vulnerabilities are not absent even in situations where the best protective measures are available. The struggle for supremacy between offence and defence that characterized the development of chemical warfare during the First World War continued after it, and the search for novel agents was one of the forms taken by that struggle. Thus, agents were sought capable of inducing new types of physiological effect from which military advantage might be gained, e.g. casualty-producing agents of low lethality, which promised to reduce the political costs of resort to armed force, or agents causing percutaneous casualty effects more quickly so that chemical weapons could be used like landmines to deny terrain to unprotected personnel. Above all, there was a search for agents of increased potency that would enable weapon-delivery systems to be used more economically and more efficiently. Toxic chemicals having effective doses measurable in tens of milligrams per person, e.g. phosgene and hydrogen cyanide, were replaced in the 1940s and 1950s by organophosphate acetylcholinesterase inhibitors ("nerve gases") that were active in milligram or submilligram quantities, so that substantially fewer munitions might be needed to attack a given target, thereby conferring logistic advantage. The most important of these nerve gases and other new chemical-warfare agents are identified in Chapter 3 and described in Annex 1.

Beyond the nerve gases on the scale of increasing toxicity are certain toxins, such as those described in Annex 2, and beyond them, in the nanogram and smaller effective-dose range, are pathogenic bacteria and viruses. As understanding of the microbiology and airborne spread of infectious diseases rapidly increased during the 1920s and 1930s, so too did the idea of weaponizing microbial pathogens as a more powerful form of poison gas. By the time of the Second World War, biological weapons of this type were being studied as a natural development of chemical weapons, exploiting the same delivery technology and the same understanding of cloud physics, meteorology and airborne dispersion. Before the end of that war, the feasibility of such aero-biological warfare had been demonstrated on weapon-proving grounds in, at least, Europe and North America. There were reports, too, of field experiments in which invading forces had disseminated bacterial pathogens from aircraft over populated areas of China *(7–8)*.

Other concepts of biological warfare were being considered. The vulnerability of draught animals to deliberate infection with diseases such as anthrax or glanders was exploited by saboteurs during the First World War in covert attacks on war-related transportation systems. In the interwar years, as the vulnerability of municipal infrastructures to air raids became increasingly apparent, the idea of spreading contagious disease by the bombardment of public health facilities (such as water-treatment and sewage-disposal plants) attracted attention. This, in turn, gave rise to investigations of other possible ways of deliberately initiating the spread of infectious disease. One thought was to establish foci of a contagious disease that would then spread of its own accord to parts of the target population not initially exposed to the biological agent concerned. Because of the uncertainties associated with the epidemic spread of disease, such an approach could not be accommodated at all readily within military doctrine except in the context of certain types of strategic or clandestine operation. In their selection of biological agents to weaponize or to take precautions against, military staffs therefore tended to place greater emphasis on non-contagious than on contagious diseases. In the context of terrorism, however, the objective and the consequent choice of agent may be different.

During the first half of the Cold War era, arsenals of biological weapons exploiting some of these, and other, approaches were accumulated, together with nerve gases and other chemical weapons, on both sides of the superpower confrontation. After 1970, preparations to produce biological weapons appear to have continued on one side only. The principal biological agents known with reasonable certainty to have entered the process of weaponization during the Cold War are identified in Chapter 3 and described in Annex 3**.** The biological weapons developed ranged from devices for clandestine use by special forces to those designed for large guided missiles or heavy bomber aircraft capable of generating large clouds of aerosol inhabited by live causative agents of contagious disease intended for far-distant rear targets, or of non-contagious disease for closer targets. Here were biological weapons that could, in principle, produce mass-casualty effects greatly exceeding those of the chemical weapons that their progenitors had emulated.

Weapons capable of producing effects comparable even with the life-destroying potential of nuclear weapons seemed to be emerging. The field testing, in large-scale open-air trials at sea during 1964–1968, of aerial weapons each capable of laying down a cross-wind line source of pathogenic aerosol tens of kilometres long demonstrated the capability of infecting experimental animals at ground level up to several tens of kilometres downwind. It thus appeared that people living within areas of the order of thousands, even tens of thousands, of square kilometres in size could now be threatened with disease by a single aircraft. At the same time, some defence science advisers were anticipating a new generation of chemical weapons having a comparable area-effectiveness *(9)*.

Despite the variety of these different weapon concepts, the chief lesson here from history is that biological warfare and, to a somewhat lesser extent, chemical warfare remained a perverse enterprise of extremely rare occurrence, notwithstanding the elaborate preparations made during the Cold War.

Large-area weapons for exploiting the damage potential of chemical or biological agents made new categories of target, such as food crops and livestock, open to attack. At the time of the Second World War, chemicals had been discovered that were as toxic to plants as the new nerve gases were to people. These herbicides, notably derivatives of 2,4-dichloro- and 2,4,5-trichlorophenoxyacetic acid in formulations such as Trioxone and Agent Orange, were used as weapons in several conflict areas of Africa and South-East Asia during the period 1950–1975, sometimes targeted against food crops and sometimes against the forest vegetation that could offer concealment. Certain plant and animal pathogens were also weaponized. Indeed, some of the first wide-area biological and toxin antipersonnel weapons were based on agent delivery systems originally conceived for anti-agriculture purposes.

Since the possible impacts on public health of anti-animal and anti-plant biological agents are indirect, such agents and their chemical counterparts are not described in detail, but the ability of biological agents, in particular, to endanger food security should not be disregarded.

2.3 Advancing science

Technological change in biological and chemical warfare has been driven, not only by factors such as the competition between the weapon and the protection against it, but also by new user requirements stemming from changes in military doctrine. More profoundly, technological change has also been driven by advances in the basic sciences within which the technology is rooted. New knowledge in the life sciences is now accumulating so rapidly that major changes in the nature, accessibility or efficacy of biological and chemical weapons may already be possible. Increasing the resulting concern are certain non-military technologies that are emerging from the new science and diffusing around the world, for some of these, and notably biotechnology, are also potentially dual use, i.e. applicable also to biological and chemical warfare. In fact, as the old armament imperatives of the Cold War recede, the threat may not be decreasing, but it is unfortunately true that the duality of the new science is making the threat seem larger.

The advent of genetic engineering offers opportunities for the improvement of human health and nutrition, yet in principle it could also be used to produce novel and perhaps more aggressive biological agents and toxins as compared with those used in earlier weapons programmes. Ability to modify more or less at will the genetic properties of living organisms could allow the insertion of new heritable characteristics into microorganisms that will make them more resistant to the available defences, more virulent or pathogenic *(10)*, better able to withstand the stresses of an unnatural environment, or more difficult to detect by routine assays. In so doing, experience shows that other necessary characteristics of the microorganism are likely to be lost; but perhaps not invariably so.

Genetic engineering also offers the possibility of making accessible toxic substances that have hitherto been available in quantities far too small for hostile use. For example, the fact that recombinant technology has been used to insert genes for a number of non-microbial toxins into microorganisms, leading to toxin expression, could enable those toxins to be produced on a large scale.

Still other aggressive possibilities may exist, e.g. weapons may be developed that could be used to harm human populations by disrupting cell-signalling pathways, or by modifying the action of specific genes.

Given the great range and variety of pathogens already present in nature, it is not immediately obvious why a weapons programme might be based on a modified organism. Nor is it always true that the new biotechnologies necessarily favour offence over defence. Vulnerability to biological agents exists chiefly because of the current inability to detect their presence in time for prompt masking or sheltering. Rapid detection methods based on modern molecular techniques are now being brought into service, although the extent to which they have the necessary sensitivity and generality, and whether they can produce results quickly enough and exclude false positives, is not clear. Moreover, the need to detect certain agents at exceedingly low concentrations continues to impose an enormous air-sampling requirement, even when polymerase chain reaction (PCR) or other amplifying methods are used. Other new biotechnologies are transforming the development of vaccines and therapeutics, while still others are thought to promise nonspecific alternatives to vaccines. An example to be mentioned here is the recent emphasis on blocking pathways of pathogenesis that are common to many infective agents, such as overproduction of cytokines. Such measures may become more important against both natural and deliberately caused infections because they are generic rather than specific to a particular pathogen, and because pathogens are less likely to be able to evade such measures by natural or artificial mutation.

Yet, overall, there can be little doubt that the spread of advanced biotechnology and the new accessibility of information about it offer new tools to any country or hostile group intending to develop a biological weapon *(11–19)*.

2.4 Preliminary threat assessment

Appraisals and priorities will certainly differ from country to country, but it seems clear from what has just been related that prudent Member States will have at least some organization and some plan in place to deal with deliberate releases of biological or chemical agents. It is true that the existence of vulnerability does not necessarily mean the existence of threat. Yet in that spectrum of menace to the public postulated earlier in this chapter, the far mass-destruction end has already been approached by some of the bacterial or viral aerosol weapons of the Cold War. Nor is catastrophe on the scale implicit in such weapons the principal threat with which public health authorities must concern themselves. One lesson from the still-unresolved "anthrax letters" episode in the United States (see pages 98–108 below), is the havoc that can be caused by very much smaller-scale and less technically elaborate releases of biological agents. There is a somewhat similar lesson in the fact that the chemical agent that has thus far figured most commonly in deliberate releases in the United States has been not some deadly nerve gas, but butyric acid, which is a malodorant. So public health authorities may not be at fault if they consider that the threat of less than full-scale attack using only simple means of agent delivery may be the most worrisome possibility of all.

A salient factor here is the demonstrable existence of increasingly severe technological constraint as that far mass-destruction end of the spectrum has been approached: the greater and more assured the area-effectiveness sought for the weapon, the greater the practical difficulties of achieving it. There are, in short, inherent technical limitations that the threat assessment should take into account.

Consider, for example, some of the problems of conveying an agent to its intended target. Toxic or infective materials can be spread through drinking-water or foodstuffs but, as explained in Annex 5, their effects would then be expected to remain localized unless the contaminated items were themselves widely distributed or unless any biological agent that had been used succeeded in initiating contagious disease. Otherwise, large-scale effects are possible if the materials can be dispersed in the form either of vapour or of an aerosol cloud of liquid droplets or solid particles that can then be inhaled. This mode of attack is subject to uncertainty. The movement of the vapourized or aerosolized agent towards and across its target would be by atmospheric transport, the agent then being moved both laterally and vertically, causing a possibly large fraction of it to miss the target. The rate of this dispersion will vary greatly depending on the stability of the atmosphere at the time, and the direction of travel will depend both on local meteorological conditions and on the local topography. If aerosol or vapour is released inside enclosed spaces rather than in the open, the outcome may be less uncertain or difficult to predict, meaning that such smaller-scale attacks are that much less subject to technological constraint. A further major consideration is that many agents may be unstable in the atmosphere and decay over time following their dissemination in airborne form, which process may itself also stress the agent to the point of substantial degradation or complete inactivation. Furthermore, for the agent to be retained after inhalation and to exert its intended pathological effects, other technical requirements must be satisfied. In the case of particulate material, for example, larger particles may not be able to penetrate far enough into the respiratory tract. The optimal size range is, moreover, a narrow one, and the production and maintenance of the optimal size distribution within an aerosol cloud is subject to a variety of difficulties, not least the processes of evaporation or condensation that will be taking place as the cloud travels and even within the respiratory tract. These considerations apply to the aerosol dissemination of agents of both contagious disease and non-contagious disease, though an attacker might hope to rely on epidemic spread to compensate for poor aerosol presentation. However, that spread, too, is subject to unpredictabilities of its own, and therefore to uncontrollabilities. In addition, such spread, if detected early, can be limited by hygienic and prophylactic measures.

These technical factors operate to render such large-scale forms of attack more demanding in terms of materials and skills than is commonly supposed. Particularly for non-transmissible agents or chemicals, large amounts of agent will need to be disseminated to be sure that a sufficient proportion will reach the target population for a period of time sufficient to cause the desired effect. Several uncertainties will affect the outcome. Micrometeorological variation in the atmosphere could result either in the agent becoming diluted to harmlessness or in the cloud missing the target due to some veering of the wind. Such attacks are bound, therefore, to be indiscriminate, the more so if agents of contagious disease are used.

Nor are these difficulties of delivery the only or even the most demanding technical problems. In the case of biological agents, there are, for example, the difficulties of selecting the appropriate strain in the first place, including testing it, and then of maintaining its virulence throughout culturing, harvesting, processing, storing, weapon-filling, release and aerosol travel.

The conclusion to be drawn is that, although the probability of a large-scale high-technology biological/chemical attack may be low, if it nevertheless happened with, improbably, all the many imponderables and uncertainties favouring the attacker, the consequences of the event could be great. In considering strategies for national preparedness against such attacks, therefore, the possibility of a low-probability catastrophic outcome must be weighed against that of public health hazards of higher probability but smaller magnitude. It would certainly be irresponsible to disregard the possible effects of deliberately released biological or chemical agents, but it would be prudent not to over-estimate them *(20–21)*. Given the emotional shock of even an alleged threat of a biological or chemical release, it will therefore be wise for Member States at least to consider how to address such dangers, should they occur, as an integral part of the national response to other threats to public health and well-being.

Technical factors are not the only consideration. Throughout much of the world, the social constraints on resort to biological or chemical weapons, including the provisions of national and international law, will increase the practical problems of acquiring and gaining advantage from such weapons. These constraints will impede access to the necessary materials, and will also obstruct those less tangible forms of assistance otherwise available from international service providers, consultants or even academics, whose corporate image, reputation or trading status would stand to suffer once their involvement became apparent. Furthermore, there would be additional justification for concerted international action against any weapons programmes. The long and continuing period during which no substantial biological attack has occurred suggests that the number of competent groups or states actually intending to use biological weapons must be small. Indeed, the element of intent is central to the probability of use, and itself is susceptible to inhibitions including those of morality and the threat of apprehension and punishment.

Yet the "anthrax letters" episode in the USA provides serious warning against complacency on this score, especially if one asks what the consequences might have been had the anthrax mailer sent a thousand letters instead of just a few. History is not always a reliable guide to the future. Therefore, preparation for the eventuality of some form of deliberate agent release, with a response strategy and plan held at the ready, will surely be thought necessary.

Whether in relation to natural disasters such as earthquakes, or to large-scale accidents in industrial production, storage or transportation facilities, many countries will already have formulated a general response strategy and plan, which they will maintain and modify in the light of changing circumstances and experience. The principles of risk management for dealing with chemical or biological attacks will overlap with those for dealing with natural or man-made disasters or emergencies. Where deliberate biological or chemical releases pose additional risk-management problems, biological and chemical addenda to an existing disaster/emergency strategy and plan will suffice, in most circumstances, for civil preparedness.

Beyond that, Member States should also consider preparing themselves to treat any deliberate use, even the most local use, of biological or chemical agents to cause harm as a *global public health threat*, and to respond to such a threat in other countries by sharing expertise, supplies and resources in order rapidly to contain the event and mitigate its consequences. The fact that there is vulnerability, however, does not always mean that there is threat.

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