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ROUNDTABLE ARTICLE

Chemical/Biological Terrorism: Coping with a New Threat

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Abstract. **In March 1995, Japanese terrorists released nerve gas on the Tokyo subway, causing eleven deaths and more than 5,000 injuries. Although terrorists have sought to acquire chemical/biological (C/B) agents in the past, and a few have employed them on a small scale, the Tokyo attack was the first large-scale terrorist use of a lethal chemical agent against unarmed civilians, weakening a long-standing psychological taboo. This tragic incident has therefore drawn worldwide attention to the emerging threat of chemical/biological terrorism. Despite significant technical hurdles associated with the production and delivery of C/B agents, such weapons are within the reach of terrorist groups that possess the necessary scientific know-how and financial resources. This article proposes a C/B counterterrorism strategy based on preemption and civil defense, and recommends several short-term and longer-term policy options for mitigating this emerging threat.**

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AT 8:05 A.M. ON MARCH 20, 1995, at the height of the morning rush hour in the Tokyo subway, members of a fanatical Buddhist sect called Aum Shinrikyo (Supreme Truth) staged a bizarre but deadly terrorist attack. Five two-person commando teams dressed in business suits placed plastic pouches concealed in morning newspapers on crowded subway cars, which were traveling on three major lines converging on Kasumigaseki Station between 8:09 and 8:13 a.m., just before the 8:30 start of the workday (Strasser, 1995). As the trains approached the targeted station, one terrorist in each team punctured the plastic pouch with a sharpened umbrella tip, releasing a puddle of clear liquid—the highly toxic chemical nerve agent sarin—while the other team-member kept lookout (Purver, 1995).

The liquid sarin evaporated slowly, giving most of the perpetrators time to escape, although one terrorist was overcome by the fumes. As the noxious vapors spread through the packed subway cars and into station platforms, pandemonium broke out as hundreds of commuters experienced troubled breathing, headache, chest pain, uncontrollable coughing, choking, vomiting, impairment of hand-eye coordination, and loss of voluntary control over body functions. Overcome passengers staggered off the trains at sixteen different stations along the three subway lines. Many of the victims lost consciousness, collapsed, and had to be revived in hospital. The final toll was eleven dead and more than 5,000 injured, with some seven hundred requiring hospitalization (Suzuki et al., 1995). Since Kasumigaseki Station is in the heart of Tokyo's government district, within walking distance to the major ministry buildings, the poison-gas attack was clearly intended to kill large numbers of government bureaucrats on their way to work. Had it not been for the poor quality of the sarin employed and the crude method of dissemination, the incident could have caused tens of thousands of casualties on the crowded Tokyo subway, which carries more than five million passengers per day.

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The ability of a little-known religious cult to acquire the equipment, materials, and technical expertise needed to manufacture and deliver a deadly chemical warfare agent was a wake-up call for government policymakers. Aum Shinrikyo was a shadowy organization with about 50,000 members (including membership in Russia three times as large as the roughly 10,000 in Japan), assets worth more than $1 billion, and offices in Bonn, Sri Lanka, New York, and Moscow. An intensive police investigation later revealed that the cult had acquired more than 100 tons of chemical ingredients and had employed chemists working in a sophisticated clandestine production plant to manufacture sarin and other lethal nerve agents. Even more disturbing, the Aum cult was experimenting with the production of biological-warfare (BW) agents such as anthrax and botulinum toxin (Holley, 1995). Cult officials had also acquired a Russian military helicopter and two drone aircraft, which they planned to equip with sprayers to disseminate chemical and biological agents over major Japanese cities (U.S. Senate, 1995).

The Tokyo subway incident revealed the vulnerability of contemporary urban areas to terror attacks with chemical or biological weapons. As the first large-scale terrorist incident involving a lethal chemical agent, it weakened a long-standing psychological taboo and raised the spectre of more such incidents in the future. Lt. Gen. James Clapper, a former director of the Defense Intelligence Agency, has called the potential for terrorism involving mass-casualty weapons one of the "most nightmarish concerns" facing the United States and its allies (Starr, 1994). The Aum Shinrikyo incident has also raised a number of important policy issues about the emerging threat of chemical and biological (C/B) terrorism. How likely is another incident similar to that in the Tokyo subway, and how prepared are governments to deal with this contingency from the intelligence, law-enforcement, and public-health perspectives? What are the most immediate and least costly policy options for countering the emerging C/B terrorist threat? And what longer-term but potentially more effective steps should also be considered?

A New Type of Terrorist

Terrorist groups have generally sought to achieve their objectives with small arms and conventional explosives. This tendency may be changing, however, with the emergence of more deadly forms of terrorism. Most incidents in the 1960s and 1970s involved the highjacking of aircraft, the taking of hostages, and occasional shootings that resulted in relatively few casualties. Since the late 1980s, the number of international terrorist incidents has gradually declined—the total in 1994 was 321, down from 666 in 1987 (Nelan, 1995). At the same time, however, the average level of violence per incident has increased as terrorists have resorted to the indiscriminate use of high explosives to kill and injure large numbers of innocent civilians, in an apparent bid to win the attention of an increasingly desensitized public and news media. Examples of this trend include the bombing of a Pan Am jetliner over Lockerbie, Scotland, in December 1988, killing 259 passengers and 11 people on the ground; the bombing of the World Trade Center in New York in February 1993, killing 6 and injuring hundreds; and the bombing of the Federal Building in Oklahoma City in April 1995, killing 168 and injuring more than 500. The Tokyo subway incident was similarly indiscriminate, although the choice of weapon was particularly shocking.

Another troubling aspect of the Tokyo incident was the motive behind the crime. Shoko Asahara, the charismatic leader of the Aum Shinrikyo sect, preached that the contemporary social structure was beyond reform and had to be swept away by a vast cataclysm that Aum would help to bring about, allowing the cult to become the supreme power in Japan (U.S. Senate, 1995). To further this apocalyptic agenda, Aum members employed aggressive recruitment efforts (often involving the use of psychotropic drugs), acts of violence against opponents, and the systematic acquisition of materials and equipment for the production of C/B weapons through a network of front companies and agents overseas (Smith, 1995a). Aum Shinrikyo was thus a new type of terrorist organization, combining elements of a doomsday cult and a large-scale criminal enterprise.

Terrorists motivated by religious or racist fanaticism are particularly dangerous because, unlike politically motivated groups, they are not subject to rational constraints on the scope of their violent acts, nor are they easily deterrable by credible threats. Politically motivated groups such as the Irish Republican Army and the Basque, Kurdish, Tamil, Sikh, and Palestinian national liberation movements have used terrorist incidents as a form of "political theater" to draw public and media attention to their cause, to disrupt ongoing negotiations, or to obtain bargaining leverage with an adversary government by threatening similar attacks in the future if their demands are not met.

Despite the trend toward the indiscriminate use of explosives, politically motivated terrorists have not resorted to C/B weapons for a number of reasons. First, an attack that produced thousands of fatalities would be perceived as disproportionate to the political objective and would undermine the legitimacy of the terrorists' cause, alienating core supporters and potential sympathizers alike. This is particularly true with regard to chemical and biological weapons, which are widely viewed as abhorrent. A large-scale C/B attack would also provoke extreme countermeasures on the part of the state, possibly leading to the total annihilation of the group (Hurwitz, 1982; Rose, 1989).

Second, politically motivated terrorists may have been deterred from C/B agent use by the fact that the handling and dissemination of highly toxic or infectious agents involve hazards, technical problems, and uncertainties much greater than those associated with plastic explosives. In the case of open-air dispersal of C/B agents, the efficiency of dissemi-

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nation depends on the prevailing meteorological conditions, making the effects of an attack fairly unpredictable and difficult to control. In an enclosed space like a subway car, the use of nerve agent would be no more devastating than a traditional pipe bomb—although the shock value would be arguably greater. Finally, unlike chemical weapons, biological weapons produce illness and death only after an incubation period lasting a few days, multiplying the uncertainties associated with their use. And because a BW agent exposure would have no immediate effects, it would not create the horrific images needed to attract media attention. For all of these reasons, politically motivated terrorists have generally been deterred from using C/B agents.

Despite these drawbacks, terrorist groups motivated by religious fanaticism or supremacist ideology might be drawn to C/B weapons if they

- possess the necessary technical know-how;
- are intent on inflicting mass casualties rather than attracting attention to a political cause;
- have no clearly defined base of popular support; and
- are willing to accept substantial physical risks.

All these conditions applied to Aum Shinrikyo, which did not use terror for political pressure or blackmail but rather in pursuit of a perceived moral imperative to destroy the existing social structure in Japan. Aum sought to discredit the Japanese government by demonstrating its lack of preparation and inability to respond. The sarin employed in the Tokyo subway was impure and ineffectively disseminated and thus caused relatively few deaths, but what mattered was the widespread public panic that the attack elicited. As arms control analyst Spurgeon Keeney, Jr. has pointed out,

> Political terrorists see themselves as fighters for a cause, seeking revenge, intimidation, or recognition. But because they serve a larger cause, their actions must be to some extent circumscribed, lest they invite retaliation that would endanger their goal or alienate political supporters. Now, we have the unconstrained terrorist, whose objective of unlimited destruction is a necessary first step to achieving his goal. (1995:2)

For such groups, C/B agents might be attractive because they are relatively cheap to produce and are deadly in small quantities, simplifying the problems of production and concealment. Indeed, the cultivation, transport, and delivery of BW agents could probably be carried out by a small number of people (Chevrier, 1993).

Other than the activities of Aum Shinrikyo in Japan, there have been relatively few cases of C/B terrorism over the past quarter-century, although the number has risen ominously in the past few years. Some major incidents reported by the news media are summarized below:

- In 1972, members of a U.S. fascist group called Order of the Rising Sun were found in possession of 30-40 kilograms of typhoid bacteria cultures, with which they planned to contaminate water supplies in Chicago, St. Louis, and other large Midwestern cities (U.S. Congress OTA, 1992).
- In 1984, two members of an Oregon cult headed by Bhagwan Shree Rajneesh cultivated *Salmonella* (food poisoning) bacteria and used them to contaminate restaurant salad bars in an attempt to affect the outcome of a local election. Although some 750 people became ill, and 45 were hospitalized, there were no fatalities (U.S. Congress OTA, 1992).
- In 1993, the Muslim terrorists who bombed the World Trade Center in New York allegedly packed their bomb with cyanide in order to spread the poison throughout the building. According to the judge who sentenced the defendants, the plot failed only because the cyanide burned in the explosion (Post, 1995).
- In March 1995, two members of the Minnesota Patriots Council—a right-wing militia organization advocating violent overthrow of the U.S. government—were convicted of conspiracy charges for planning to use ricin, a lethal biological toxin. The two men, Douglas Baker and Leroy Wheeler, allegedly conspired to assassinate Internal Revenue Service agents and a deputy U.S. marshall who had served papers on one of them for tax violations (Herbert, 1995).
- In April 1995, a month after the Tokyo subway incident, the *Baltimore Sun* reported that two Japanese citizens associated with Aum Shinrikyo had planned to launch a lethal sarin attack at Disneyland in California over the Easter weekend. According to the newspaper, FBI agents had been tipped off by the Tokyo police and had foiled the plot by arresting the two cult members at Los Angeles International Airport (Lait and Malnic, 1995). The U.S. Department of Justice later denied the story.
- In May 1995, Larry Wayne Harris, a member of the white supremicist organization Aryan Nation, was arrested on charges of forgery and receiving stolen property after allegedly misrepresenting himself when ordering three vials of freeze-dried bubonic plague bacteria from American Type Culture Collection, a Maryland biological supply house (Robinson, 1995).
- In December 1995, Thomas Lewis Lavy, an Arkansas man with survivalist group connections, was charged with having attempted to smuggle 130 grams of ricin

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across the border from Alaska into Canada in 1993 and with intent to use the toxin as a weapon (Kifner, 1995). The next day, Lavy hanged himself in his jail cell (Associated Press, 1995).

The number of religious cults with a propensity to violence has also increased in recent years. Well-known examples are Jim Jones and members of the Peoples Temple, more than 900 of whom committed mass suicide in Guyana in November 1978; David Koresh and the Branch Davidians, more than 70 of whom died in a violent confrontation with U.S. federal agents near Waco, Texas, in April 1993; and Luc Jouret and the Order of the Solar Temple, more than 40 of whom committed mass suicide in October 1994 at sites in Switzerland and Quebec (Riding, 1994).

A wide variety of religious cults are now active, ranging from Christian white supremacists to messianic Jews, Islamic fundamentalists, Buddhists, and radical Sikhs. Some of these groups espouse a dangerous mixture of political paranoia, messianic fervor, and obsession with apocalyptic prophecy. As the year 2000 approaches, there may also be a growing number of "millennial" cults whose members believe that death in a cataclysmic battle against the forces of evil—that is, the federal government or anyone else who opposes their agenda—will guarantee them a place in paradise. According to Hal Mansfield, an expert on alternative religions, "We're in for a helluva ride with these millennial groups. Whatever technology is out there, they're going to use it" (Post, 1995:40).

A second potential danger is the emergence of a more virulent form of state-sponsored terrorism. The suspected pursuit of chemical and biological warfare capabilities by countries such as Iraq, Iran, Libya, Syria, and North Korea—all of which have supported terrorism in the past—raises the possibility that "rogue" governments might supply terrorist groups with C/B agents. Indeed, during the Persian Gulf War, U.S. intelligence services reportedly foiled a number of Iraqi-sponsored terrorist attacks against American targets, some of which may have involved C/B weapons. According to a partially declassified 1991 intelligence report, the East German State Security Service trained Iraqi agents in the use of chemical and biological agents against civilian targets at a special school near East Berlin and at training camps in the Middle East (GulfLINK, 1995). One possible scenario for state-sponsored terrorism is that a rogue government could ship small containers of C/B agents to its overseas embassies in diplomatic pouches—which are exempt from customs inspection—and distribute them to terrorists already in-country.

Technical Aspects of CB Terrorism

While both chemical and biological agents are capable of producing mass casualties, they differ significantly in their effects and production technology.

Chemical Warfare Agents

Chemical warfare (CW) agents are poisonous man-made gases, liquids or powders that have toxic effects on people and animals. "Blood" agents such as hydrogen cyanide interfere with cellular respiration, causing death by anoxia; "choking" agents such as phosgene cause severe lung damage; "blister" agents such as sulfur mustard and lewisite cause painful chemical burns of the skin, eyes, and lungs; and "nerve" agents such as tabun, sarin, soman, and VX disrupt the functioning of the nervous system. The various types of chemical agents differ in the rapidity of their effects: whereas hydrogen cyanide and some nerve agents produce incapacitating symptoms almost immediately, sulfur mustard does not give rise to pain and blistering until between three and eight hours after exposure.

The nerve agent sarin was discovered in 1939 by Gerhard Schrader of the German company IG Farben, during research on new organophosphorus pesticides. Throughout the Cold War, the United States and the Soviet Union produced and stockpiled chemical arsenals containing many thousands of tons of sarin and other nerve agents. These compounds exert their lethal effects by inactivating an enzyme called cholinesterase, which is essential for the normal transmission of nerve impulses. Absorption of a lethal dose of nerve agent disrupts the activity of the peripheral and central nervous systems, causing the victim to develop pinpoint pupils, a runny nose, and tremors, followed by loss of consciousness and convulsions. Death by respiratory arrest takes place in about five minutes. Although common pesticides such as malathion are also members of the organophosphate class, nerve agents are between 100 and 1,000 times more potent at inhibiting cholinesterase. The various nerve agents differ in volatility and persistence: whereas sarin is a volatile liquid that evaporates quickly and acts primarily through inhalation of vapors, VX is an oily liquid that persists in the environment for days or weeks, depending on ambient temperature, and can be absorbed both by inhalation and through the skin.

Terrorists intent on acquiring chemical weapons would have two options: buying or stealing them from existing national stockpiles, or manufacturing them independently. With respect to the first option, Russia has divulged that it possesses 40,000 metric tons of chemical-warfare agents, which are stored at seven declared storage sites. Recent visitors have found lax physical security at four of these sites, including unguarded doors, simple locks, and no alarms (Crossette, 1995; Smithson et al., 1995). The planned destruction of Russia's huge CW stockpile will eventually eliminate the risk of theft or purchase, but that task will take more than a decade once it begins. To date, the start of the Russian CW destruction program has been delayed by environmental, economic, and political concerns. On the other hand, the fear that international criminal organizations such as the Russian *Mafiya* or the Colombian drug cartels might seek to steal or otherwise acquire C/B weapons and sell them

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to rogue governments appears to be unfounded. Organized-crime groups would tend to avoid such activities because they would almost certainly provoke a harsh crackdown on the part of government officials and the police, on whose tacit or active collusion the mafias rely to stay in business.

Although the news media have exaggerated the ease with which terrorists could produce chemical and biological weapons in basement laboratories, the relevant technology is within the reach of groups that possess sufficient financial resources and technical expertise, such as members with postgraduate education in organic chemistry or microbiology. Leaders of the Aum Shinrikyo cult aggressively recruited university-trained scientists and engineers in Japan and Russia to work on the development of C/B weapons. Many Aum members were young intellectuals in their twenties and thirties who had become disenchanted with mainstream Japanese society (Reid, 1995; Hatsumi, 1995). The cult's chief scientist, for example, was thirty years old and had a master's degree in organic chemistry from a Japanese university (Guest, 1995).

Chemical Ingredients. Aum Shinrikyo reportedly decided to manufacture sarin because of its relative ease of production compared with other nerve agents, its volatility (making it relatively easy to disseminate in an enclosed space—Croddy, 1995), and the fact that the necessary ingredients could be obtained commercially. Chemicals that serve as starting materials in the synthesis of CW agents are known as "precursors." The globalization of the chemical industry has led to large international flows of dual-use precursor chemicals that have legitimate commercial applications but could also be diverted to the production of CW agents. For example, some of the ingredients involved in the production of sarin, such as isopropanol and hydrogen fluoride, are commodity chemicals consumed by commercial industry in millions of tons per year, and hence are difficult to control. (Isopropanol, or rubbing alcohol, is a common industrial chemical, whereas hydrogen fluoride is used in large quantities by oil refineries and can also be derived from phosphate deposits, which usually contain fluorides.) More specialized sarin precursors, such as phosphorus trichloride and trimethyl phosphite, have legitimate industrial applications in the production of pesticides and fire retardants. Although these precursors are manufactured in much smaller volumes, making it somewhat easier to monitor trade flows, phosphorus trichloride has about forty producers worldwide and trimethyl phosphite about twenty (U.S. Department of Commerce, 1991).

Developing countries seeking a CW capability generally lack the ability to manufacture chemical agents from the most basic starting materials, and hence must purchase immediate precursors from foreign sources. Because of this dependency, twenty-nine countries with large chemical industries, including the United States, have sought to slow the proliferation of chemical weapons by establishing a committee—known as the Australia Group—that coordinates national export-control regulations in order to restrict the sale of C/B-relevant materials and production equipment to suspected proliferators (Robinson, 1992). The Australia Group restricts exports to target countries but not to substate actors. Aum Shinrikyo was therefore able to purchase all of the chemical precursors and processing equipment it needed to manufacture sarin by importing them through front companies controlled by the cult, legitimate chemical manufacturers owned by cult members, and overseas shipping agents. Because such illicit transactions often yield extremely high profits, many suppliers and middlemen have been willing to take the risk of violating national export laws. Thus, while export controls are a modest impediment to chemical terrorism, they are far from a definitive solution.

Production of Sarin. Synthetic pathways for the production of sarin involve four basic reaction steps (oxidation, alkylation, chlorination/fluorination, and esterification), which can be carried out in different sequences (Zapf, 1993). Several production pathways have been published in the open literature, all of which begin with the same precursor chemical, phosphorus trichloride (PCl_3). Three steps in the synthesis of sarin are particularly difficult or hazardous and would pose significant technical hurdles to terrorist groups. First, the alkylation reaction requires high temperatures or extremely reactive chemicals and hence is rarely used in the production of commercial pesticides. Second, the fluorination reaction necessitates the use of hydrogen fluoride (HF), a highly corrosive chemical that is difficult to handle and erodes the walls of steel reactor vessels and pipes. Third, if pure sarin with a long shelf-life is desired, the final product must be distilled to remove excess hydrochloric acid, an extremely hazardous operation. Distillation is not necessary if the agent is produced for use within a few weeks (U.S. Congress OTA, 1993). In general, the final stages of sarin production are particularly dangerous because they entail the handling of live agent.

Although it is possible to manufacture sarin without using corrosion-resistant equipment, doing so significantly increases the risk of dangerous leaks. For this reason, a terrorist group intent on producing significant quantities of sarin would probably purchase reaction vessels and pipes lined with glass or teflon, or made of a corrosion-resistant steel alloy containing 40% nickel such as the commercial products Monel and Hastalloy. Other items of specialized equipment that might be used to produce nerve agents include double-walled piping, double-seal or magnetic-drive pumps, diaphragm valves, heat exchangers and condensers, activated-carbon filters and scrubbers capable of purifying large volumes of contaminated air from ventilation systems, and systems for treating and incinerating hazardous chemical wastes (Zapf, 1993). The ease with which Aum was able to purchase such equipment from international suppliers is disturbing, and raises questions about the effectiveness of export controls on dual-use technologies.

Devising and testing an effective CW agent delivery system, such as a bomb or spray device, poses another major technical hurdle—one that caused Aum Shinrikyo particular difficulties. Because of the extreme hazards associated with handling and disseminating chemical agents, terrorists might be attracted to "binary" chemical weapons, which are safer to produce, store, and transport. In a binary system, two relatively nontoxic precursor chemicals are stored in separate containers and mixed immediately before use to produce the lethal agent. Sarin, for example, can be produced in a binary system by reacting isopropanol (rubbing alcohol) with methylphosphonic difluoride (DF).

In advanced binary munitions such as those developed by the U.S. Army in the early 1980s, the two precursors are stored in separate cannisters separated by a metal diaphragm. This barrier ruptures while the shell is in flight to the target, allowing the chemicals to react and form the lethal agent, which is released on impact. Since terrorists would be unlikely to have access to such sophisticated technology, they would probably have to mix the two precursor chemicals manually before use—an exceedingly hazardous operation—or attempt to develop an automatic or remote-controlled device to carry out the mixing and dispersal steps, a task requiring considerable technical expertise.

Sarin Production by Aum Shinrikyo. Aum Shinrikyo's three-story chemical factory near Mount Fuji, known as Satian No. 7, was reportedly "extremely sophisticated" and equipped with computerized process controls. This facility produced thirty kilograms of sarin over a two-year period before an accident in early 1994 caused it to halt operation. Aum members then tested the sarin on sheep at a ranch that the sect had purchased in 1993 in a remote part of Western Australia (U.S. Senate, 1995).

On June 27, 1994, nine months before the Tokyo subway incident, Aum staged a trial poison-gas attack in a quiet residential area of Matsumoto, a town in central Japan about 125 miles northwest of Tokyo. Cult members sprayed a cloud of vaporized sarin from a nozzle device attached to a truck that had been specially modified for that purpose. The motive for the crime was the attempted murder of three judges who were about to reach a guilty verdict in a case involving fraud charges brought against Aum by various landowners in Matsumoto. All three judges were sleeping in a dormitory residence downwind of the sarin release and fell ill as a result of the exposure, delaying the guilty verdict as the cult leaders had planned. The sarin cloud also killed seven people and injured more than 260 others (U.S. Senate, 1995; Morita et al., 1995).

The subsequent March 20 terror attack on the Tokyo subway was prefaced by a curious mixture of careful and haphazard preparation. Aum officials planned the attack to take place simultaneously on three subway trains, which were scheduled to arrive at the central Kasumigaseki Station within four minutes of each other. The sarin used in the attack was of poor quality, however, having been manufactured quickly in a small-scale laboratory inside the Aum compound the day before. Aum chemists also diluted the low-grade sarin with an organic solvent to make it less hazardous to handle by personnel not wearing gas masks (Hadfield, 1995). The sarin solution was then filled into plastic pouches made of three-ply nylon polyethylene, which were sealed with a special laminating machine. The fact that the sarin was low-grade, diluted with solvent, and disseminated as a liquid made it much less hazardous to the terrorists and their victims, so that only those passengers in the immediate vicinity of the releases were killed. As the puddles of dilute agent evaporated, they gave off sarin vapor at relatively low concentrations. Had the Aum terrorists disseminated the sarin as an aerosol of microscopic droplets suspended in the air, delivering much higher concentrations of agent to the lungs, the attack would have caused many more fatalities.

Had the Aum terrorists disseminated the sarin as an aerosol of microscopic droplets suspended in air, delivering much higher concentrations of agent to the lungs than a liquid could, the attack would have caused many more fatalities

For a second chemical attack in the Tokyo subway, Aum Shinrikyo developed a crude binary weapon that fortunately malfunctioned. On May 5, 1995, cult members placed the device in a men's room at Shinjuku subway station, the busiest in Tokyo. The weapon consisted of two plastic pouches, one containing two kilograms of sodium cyanide crystals and the other filled with 1.5 liters of dilute sulfuric acid. A primitive chemical ignition system caused the sodium cyanide pouch to catch fire after a time delay. The two pouches were arranged so that as the flames from the first spread to the second, the cyanide crystals would react with the sulfuric acid to form deadly hydrogen cyanide gas. Fortunately, the jury-rigged device failed to operate as planned. Although four subway workers who doused the flames were overcome by toxic fumes and briefly hospitalized, the station was evacuated before anyone else was hurt (U.S. Senate, 1995).

Aum also sought to develop chemical agents even more lethal than sarin. According to U.S. Senate investigators, Aum chemists synthesized small quantities of VX, a supertoxic nerve agent that can kill both through inhalation and by penetrating the skin. Cult members used syringes filled with a small quantity of VX to assassinate two Aum critics, one in December 1994 and the other in January 1995. The first victim died ten days after the attack, while the second was hospitalized for several weeks after the incident but

apparently survived (U.S. Senate, 1995). If future terrorist groups were to use more potent and persistent nerve agents such as VX, or to develop more effective means of delivery—such as remote-controlled binary devices—the risk of mass casualties would increase significantly.

Biological Warfare Agents

Whereas CW agents are man-made poisons, biological warfare (BW) agents are microorganisms and naturally occurring toxins that cause illness or death in people, livestock, and crops. Microbial pathogens considered suitable for military use include the bacteria that cause anthrax, tularemia, and brucellosis; the rickettsia that induce Q-fever; and the viruses responsible for Venezuelan equine encephalitis (VEE) and certain hemorrhagic fevers. During the offensive BW program of the 1950s and 1960s, the United States deliberately pursued animal pathogens such as anthrax, tularemia, brucellosis, and VEE that can cause serious infection in humans when inhaled as a concentrated biological aerosol but are not transmitted naturally from one individual to another. Since such agents are not contagious in man, the localized epidemic produced by a BW attack would be self-limiting and unlikely to boomerang against the attacker's own troops or population. Nevertheless, it is conceivable that terrorist groups bent on producing mass casualties might deliberately produce and disseminate disease agents that are contagious in humans, such as pneumonic plague bacteria or various types of hemorrhagic fever viruses, with the aim of triggering widespread epidemics that would undermine social structures.

Anthrax bacteria are not contagious but are considered particularly effective BW agents because of the high lethality of virulent strains, the relative ease of production, and the fact that the bacteria can be induced to form spores—a dormant state in which the microbes form a tough protective coat and thus become considerably more resistant to environmental stresses such as heat, drying, and sunlight. Since even spores are susceptible to ultraviolet radiation, a BW attack would probably be carried out at night, dawn or dusk, or on an overcast day. Inhalation of only about 8,000 anthrax spores—a dose invisible to the naked eye—is sufficient to cause a systemic infection in 50% of the target population that can be fatal within 96 hours (Erlick, 1989). After entering the lungs, the spores travel to the lymph nodes where they germinate, multiply, and give rise to systemic infection; the severity of the illness depends on the dose inhaled and retained by the body. Whereas infections with plague and tularemia respond to intravenous antibiotics if treatment is begun within 24 hours, before the appearance of symptoms, anthrax is unique in that antibiotic therapy can only delay the disease process. When the antibiotics are halted, the clinical disease may appear. Cure of an anthrax infection is only possible if active immunization begins during the antibiotic therapy, and the patient is able to mount a protective immune response (Franz, 1994: 62-63).

Natural toxins are potent poisons synthesized by a wide variety of living organisms, including bacteria (e.g., botulinum toxin, tetanus toxin), fungi (mycotoxins), animals (cobra venom, saxitoxin), and plants (ricin). More than 500 such compounds have been characterized to date. Toxins are nonliving chemicals that range in size from small molecules to large proteins, and they exert their effects with a latency period ranging from a few minutes to several hours. Some natural toxins are lethal in extremely low doses because they act at specific biochemical target sites in the body. A few toxins have been considered in the past for military use, including botulinum toxin, ricin, saxitoxin, and *Staphylococcus* enterotoxin B. Before the 1991 Persian Gulf War, Iraq produced and weaponized large quantities of two toxin agents, botulinum toxin and aflatoxin, and also experimented with ricin and two potent fungal toxins known as trichothecenes (United Nations, 1995).

Weight-for-weight, biological and toxin agents are potentially thousands of times more potent than even the most toxic man-made chemical agents (U.S. Congress OTA, 1993). Because of the ability of pathogenic microorganisms to multiply rapidly within the host, small quantities of a biological agent—if widely disseminated through the air as a respirable aerosol—can inflict casualties over a large area. Under optimal meteorological conditions, producing 50% fatalities over a square-mile area would require about a metric ton of chemical nerve agent but only about 10 grams of anthrax spores (Chester and Zimmerman, 1984). Depending on the type and concentration of agent and the atmospheric conditions, an aerosol cloud of BW agent released from a "point" source would form an elongated plume extending from a few to several tens of kilometers downwind from the site of release. Continous release of agent from a moving "line" source would generate a broader plume covering a much larger surface area.

Production of Biological and Toxin Agents. The cultivation of BW agents does not differ substantially from the production of legitimate biological products. Indeed, nearly all of the materials and items of equipment used to cultivate BW agents have commercial applications in the production of beer, wine, food products, animal feed supplements, biopesticides, vaccines, and pharmaceuticals. Seed cultures of pathogenic bacteria such as anthrax can be purchased from commercial vendors by sending a request letter on the letterhead of a university or research institute. Iraq, for example, purchased bacterial seed stocks that it used to grow anthrax spores and botulinum toxin from biological supply houses in the United States and France (U.S. Senate, 1994). Microbial seed stocks could also be obtained though a third party, stolen from a university or industry laboratory, or extracted from natural sources such as soil or diseased animals. In 1992, the Aum Shinrikyo cult sent a medical mission to Zaire, purportedly to assist in treating the victims of an Ebola virus outbreak. The real objective, however, may

have been to obtain a sample of the deadly virus to take back to Japan for BW purposes (U.S. Senate, 1995).

Basic fermentation techniques are widely described in the scientific literature, although the efficient cultivation of pathogenic microorganisms requires practical knowledge and experience in microbiology and fermentation process control. Items of dual-capable equipment that can be used to make BW agents include computer-controlled fermenters, centrifugal separators, freeze- and spray-dryers, high-efficiency particulate air filters and other specialized biocontainment systems, and equipment for microencapsulating microorganisms and toxins to shield them from environmental stresses. According to a report by the Central Intelligence Agency, scores of commercial firms manufacture such equipment (Starr, 1995). A terrorist group might also choose to do without sophisticated equipment by growing small-scale batches of biological or toxin agents in a pilot-scale fermenter or in laboratory glassware. Even using such a low-tech approach, the entire cultivation process—starting with a vial of seed culture and ending with several kilograms of agent (e.g., a concentrated slurry of anthrax spores)—could take as little as 96 hours. As a result, terrorists would not need to stockpile agent for long periods but could produce it to order shortly before a planned attack.

High-containment measures are not required for the production of BW agents, since there is a relatively low risk of generating hazardous aerosols. Adequate protection for personnel during the production phase could be achieved by vaccination against the infectious agent (if a vaccine is available) and through the use of protective masks. The danger of contamination from leaking valves would depend on the infectious agent and its concentration, and might be minimized by applying disinfectant to small leaks. Downstream processing steps—such as concentrating the agent in a continuous-flow centrifuge, drying it in a spray- or freeze-dryer, and milling the dried cake to a fine powder—would have to be effectively contained to reduce the risk of infection. Nevertheless, inspections of dual-capable biological facilities in Iraq by the United Nations Special Commission indicate that the Baghdad government viewed BW production workers as expendable and was prepared to cut corners on safety and biocontainment.

One concern that has often been raised is that technically sophisticated terrorists might employ recombinant-DNA techniques to produce genetically modified pathogens that are more lethal, persistent in the environment, or resistant to existing vaccines and antibiotics. In fact, this scenario appears unlikely. Although recombinant-DNA methods are now widely utilized in science and industry, the techniques are complex and require specialized know-how that would exceed the resources of most terrorist groups. In addition, infectivity or virulence are complex traits controlled by multiple genes, so that simple genetic manipulations would have little effect (Tucker, 1992). It is much more likely that terrorists would grow well-characterized agents such as anthrax or botulinum toxin, although they might seek to develop antibiotic-resistant strains by means of classical selection techniques.

Weaponization and Delivery

Effective delivery of BW agents is considerably more difficult than production. Use of BW agents to contaminate municipal water supplies would probably not be effective because most water-treatment systems employ filtration and chlorination to kill ordinary pathogenic microoganisms present in the water, and would destroy microbial BW agents in the process. The enormous dilution factor would also necessitate using impractically large quantities of agent. To serve as mass-casualty weapons, BW agents would have to be delivered against target populations in the form of a respirable aerosol—a relatively stable cloud of suspended microscopic droplets or particles containing from one to a few thousand bacterial or virus particles. Whereas chemical agents can be disseminated as a vapor or spray, BW agents are nonvolatile solids that, with rare exceptions, do not penetrate the skin. Moreover, only particles between 1 and 5 microns (thousandths of a millimeter) in diameter can remain suspended in the atmosphere for long periods without settling and can also be retained deep in the lungs.

Dry powders of microbial agent or toxin produced by freeze- or spray-drying have the best dissemination characteristics and would be easier to store and handle than liquid slurries, which tend to lose viability and potency over time. Nevertheless, since it would be technically difficult to produce a dry BW agent with the microscopic particle size needed for respiratory infection, a terrorist group would probably prepare the agent in liquid form and store it under refrigeration until use.

It is conceivable, however, that terrorists intent on acquiring sophisticated BW weaponization capabilities, such as the drying and microencapsulation of microbial and toxin agents, might seek technical assistance from a state with an advanced BW program. Indeed, some analysts have expressed concern that Russian President Boris Yeltsin's April 1992 decree to eliminate the massive biological weapons program inherited from the former Soviet Union could lead to a "brain drain" of BW experts. According to congressional testimony by former CIA director Robert Gates, "a

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few thousand [former Soviet scientists] have the knowledge and marketable skills to develop and produce biological weapons." Gates went on to identify the most serious problem as individuals whose skills have no civilian counterpart, such as engineers specializing in the weaponization of BW agents (Gates, 1992). Given this situation, there is the danger that terrorists might attempt to recruit such individuals for their deadly expertise.

Biological agent in dry or wet form might be dispersed with a commercially available agricultural sprayer or fogger (e.g., for the application of biopesticides) mounted on a small airplane, a helicopter, or a sealed vehicle, or carried by an individual protected from infection by vaccination and/or a surgical mask. The area that can be covered effectively with a given amount of agent depends strongly on the meteorological conditions prevailing at the time of release. Sunny, warm conditions give rise to vertical air currents, causing the agent particles to rise into the atmosphere and dissipate, and living biological agents die fairly quickly in air when exposed to sunlight. For these reasons, an outdoor attack with BW agents would probably occur at dusk, night, dawn, or under overcast skies. Optimal atmospheric conditions for dispersal would occur on a clear, cold night with a gentle breeze, since a stable inversion layer of air would form over the ground and keep the microbes at a low altitude where they can be inhaled. Even under optimal conditions, however, outdoor dissemination of BW agents poses significant uncertainties. Aum Shinrikyo reportedly released anthrax bacteria from a building in central Tokyo at least twice without causing any apparent casualties (U.S. Senate, 1995).

Since biological agents are invisible, odorless, and tasteless, a BW attack would be undetectable by human senses, and no reliable real-time biological detection and warning systems are currently available (Beal, 1995). Moreover, the incubation period that follows upon infection with microbial pathogens means that the effects of exposure would be delayed for several hours or days depending on the type of agent used. Instead of a gradual rise in the number of sick individuals from a small number of precursor cases over several weeks—characteristic of a natural epidemic—there would be an "explosive" outbreak of infectious disease in many hundreds or thousands of people within the span of a few days (Woodall, 1991).

The fact that there is a significant delay before the symptoms of a BW attack manifest themselves represents a major difference between the effects of chemical and biological weapons, and makes the possible terrorist use of BW agents particularly chilling. If the terrorists chose not to provide any advance warning, the appearance of symptoms would be the first indicator of a biological attack. Moreover, if an endemic disease agent were disseminated covertly, it might take several days for public-health officials to determine that the epidemic was the result of a deliberate BW attack and not a natural outbreak of disease. By the time the real cause of the outbreak was determined, the perpetrators could have long since left the country.

Counterterrorism Strategy

The Tokyo subway incident has demonstrated the devastating potential of C/B terrorism. Aum Shinrikyo broke the monopoly that the nation-state has previously held over the most powerful means of organized violence, creating a threat to Japanese and international society disproportionate to its numbers (Gardels, 1995). Indeed, the diffusion of mass destructive power to subnational groups undermines the ability of the nation-state to protect the security of its citizens—the fundamental source of its political legitimacy. Although states are well organized to defend themselves against external enemies, they are much less capable of protecting their populations against terrorist groups operating in their midst.

Chemical/biological terrorism poses a particularly grave threat to the viability of democratic societies. Whereas authoritarian states can crush terrorist groups on their territory through the massive use of surveillance and repression, democratic societies deliberately limit the power of the state and hence are most threatened by the rise of mass-casualty weapons in the hands of extremists. Even so, the potential for C/B terrorism should not cause democratic states to abandon their respect for civil liberties, since such a response would be self-defeating. Democratic societies must instead find the right balance between liberty and regulation. Without banning fringe groups or depriving them of their constitutional rights, government authorities should be prepared to assess and respond promptly to any C/B-related activities that would threaten public health and security.

It is a sobering fact that no simple technical fix can completely eliminate the vulnerability of urban populations to the terrorist use of C/B weapons. Yet this realization does not mean that policymakers should throw up their hands in despair or complacency. An effective C/B counterterrorism strategy would combine two approaches: preemption and civil defense.

Preemption

Preemption, or the ability to prevent terrorist attacks before they occur, presupposes a number of elements. First, it requires good intelligence about terrorist groups and their activities. Before the Tokyo subway attack, intelligence on Aum Shinrikyo was appallingly lacking despite the cult's worldwide efforts to procure C/B agent precursors and production equipment. During U.S. Senate hearings in November 1995 on the threat of C/B terrorism, senior counterterrorism officials from the Federal Bureau of Investigation (FBI), the Central Intelligence Agency (CIA), and the Department of Defense (DOD) admitted that they had focused their intelligence-collection efforts on state-sponsored terrorist groups with a political agenda and thus had been entirely unaware of the existence of the Aum Shinrikyo cult before the Tokyo subway incident (Smith, 1995b).

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Since nearly all of the equipment needed to manufacture C/B agents is dual-capable and the agents themselves are fairly easy to conceal and to deliver covertly, there are few distinctive "signatures" associated with such activities. In the case of biological weapons, the delayed appearance of symptoms would also make it difficult to detect an attack in a timely manner. Because of these constraints, national technical means of intelligence collection, such as reconnaissance satellites, are of little help in this area. Instead, good intelligence on terrorism relies heavily on human sources—particularly defectors and infiltrators—supported by communications intercepts and other forms of surveillance.

A second prerequisite for a strategy of preemption is the existence of domestic laws making the development, production, possession, and use of chemical and biological weapons a serious crime. Such domestic legislation provides the legal basis for aggressive law-enforcement activity, including preemptive police raids and arrests when groups are known to have acquired C/B-related materials and equipment for illicit purposes. In particular, the 1972 Biological Weapons Convention (BWC) states in Article IV that each state party shall take "any necessary measures" to make the treaty prohibitions binding on all citizens and businesses on the territories under its jurisdiction or control and on its nationals residing overseas, and to impose punitive sanctions for violations. After a delay of several years, the U.S. Congress finally passed the Biological Weapons Anti-Terrorism Act of 1989, the law under which the federal government successfully prosecuted the defendants in the Minnesota ricin poisoning conspiracy. Several other countries have also passed legislation criminalizing acts prohibited to states under the BWC (including Australia, the Czech Republic, Finland, Germany, The Netherlands, Norway, Russia, Sweden, and Switzerland), but less than 40 of the 135 states parties have done so.

The 1993 Chemical Weapons Convention (CWC), which is still being ratified by the required 65 states and is expected to enter into force in 1997, differs from the BWC in that it includes an explicit requirement for implementing legislation. Article VII of the CWC requires all states parties to enact domestic legislation making it a crime for any persons under their jurisdiction (individuals or businesses) to develop, produce, stockpile, or use chemical warfare agents. According to the proposed legislation submitted to Congress by President Clinton, terrorists convicted of these acts would face up to life imprisonment, fines, and forfeiture of their property, whereas companies that knowingly sold equipment or precursor chemicals to terrorist groups or states that sponsor them would face punitive sanctions. Until such legislation is passed, however, it is not technically illegal for anyone to develop, produce, and stockpile sarin or other chemical weapons—provided there is no conspiracy to use them for criminal purposes.

The CWC further requires states parties to impose export controls on the sale of key precursor chemicals that could be diverted to the production of chemical weapons, either by proliferator-states or subnational groups. After the entry into force of the convention, a new international agency, the Organization for the Prohibition of Chemical Weapons (OPCW), will be established in The Hague (The Netherlands) to monitor the movement of CWC-controlled chemicals around the globe and to conduct on-site inspections of treaty-relevant facilities. Under this regime, any company that manufactures more than a threshold quantity of a chemical that could be diverted to the production of chemical-warfare agents will have to account for it.

A third prerequisite for a strategy of preemption is to control the availability of "cookbook" type information that a layman could use to produce C/B weapons. Over the past several years, detailed instructions on how to produce C/B weapons for terrorist purposes have been disseminated by groups on the extreme left and right of the political spectrum (Stern, 1993). One infamous tract, *The Anarchist's Cookbook*, was published in 1971 as a handbook for left-wing terrorists (Powell, 1971). Two other mail-order primers have been found in the possession of right-wing groups: *The Poisoner's Handbook* describes how to produce poisons (including ricin) in a home laboratory, whereas *Silent Death* informs readers how to deliver such poisons most effectively (Kifner, 1995).

Deadly cookbooks are also available on the Internet. In addition to *The Anarchist's Cookbook*, users of the World Wide Web can access *The Terrorist Handbook*, *The Big Book of Mischief*, and *The Jolly Roger Cookbook*. One web site, titled "Scott's Anarchy Page," includes the following disclaimer: "Through the use of this page you agree to hold me not responsible for any occurrence(s) legal or otherwise that may occur from the misuse of the information contained herin [sic]." Another web site, known as "Candyman's Bomb Page," includes a recipe for the home production of botulinum toxin.

A recent incident demonstrated that such information has more than entertainment value. In February 1996, three thirteen-year-old boys from a town near Syracuse, New York, were arrested and charged with plotting to set off a homemade bomb in their junior high school after obtaining plans for the device on the Internet (Stout, 1996).

Civil Defense

Whereas countries such as Sweden, Switzerland, and Israel have long incorporated civil defense into their overall defense concept, the United States has tended to view the development of effective civil defenses against C/B weapons as belonging in the "too hard" or "unthinkable" category. In the past, the U.S. Department of Defense has tended to focus narrowly on detecting and defending against acute-level exposures to chemical or biological agents on the battlefield, and has developed individual protective gear for use by soldiers but not civilians. Moreover, although the FBI, the Federal Emergency Management Agency (FEMA),

and the U.S. Public Health Service have developed an integrated crisis-management plan in the event of a threatened act of C/B terrorism, there has been relatively little emphasis on devising practical measures for protecting public health in the event of such an attack.

There are two possible types of emergency response to threats of C/B terrorism:

- before an incident occurs, assuming that advance warning has been provided; or
- after a toxic agent has been released.

In the former case, federal, state, or local government officials might receive a blackmail threat that a C/B attack will occur in a particular urban area unless some action is carried out, such as the paying of a ransom, the release of a prisoner, or the publication of a political manifesto. Law-enforcement authorities would then have a limited amount of time to track down the perpetrators and/or the toxic material before it is released. Alternatively, as in the case of the Tokyo subway incident, a C/B attack might come without warning. Indeed, this contingency is more likely if the perpetrator is an Aum-like cult that does not wish to promote a political agenda or to extort money or concessions, but merely seeks to inflict large-scale casualties.

According to FEMA, terrorists typically target high-profile locations such as international airports, large buildings, major sporting events, resorts, and famous landmarks because these sites offer relatively easy access, intense media coverage, and large crowds that can enable the perpetrators to avoid detection before and after an attack (FEMA, 1995). If a chemical terrorist incident were to occur at such a location, local emergency officials would have to respond promptly, instructing people to evacuate the area, providing shelter in sealed rooms, and treating immediate casualties.

The public-health consequences of a chemical attack would depend on the location and type of agent employed. Although only 11 people died in the Tokyo sarin attack, more than 5,000 were injured and many hundreds required immediate treatment in hospital emergency rooms with antidotes and medical support. Such a large influx of casualties has the potential to overwhelm emergency medical facilities even in a large city. Another unique characteristic of a CW attack that differentiates it from a conventional terrorist bombing is the potential for post-attack transmission to additional victims from direct contact with liquid contamination, creating a potential multiplier effect. Thus, if persistent chemical agents were used, casualties and buildings would have to be closely monitored and decontaminated to prevent the further exposure of victims and emergency personnel, greatly increasing the number of people needed to manage the disaster (Baker, 1993).

Lessons from Bhopal. Useful lessons about how to respond to a chemical disaster were learned from the tragic leak of the toxic gas methylisocyanate (MIC) from a Union Carbide plant in Bhopal, India. Just after midnight on December 3, 1984, some 50,000 pounds of MIC in vapor and liquid form escaped from a holding tank at the Bhopal plant and formed a cloud that was carried by a light wind over nearby shanty towns. A temperature inversion kept the toxic cloud close to the ground and prevented it from dispersing, allowing the concentrated gas to blanket an area of more than ten square miles. The most vulnerable individuals were small children, the elderly, people with chronic pulmonary disorders, and those who tried to escape by running through the gas cloud. As soon as the severity of the accident was recognized, patients flooded into area hospitals. About 100,000 patients were given some kind of medical care in the first 24 hours. Some 500 died before getting any treatment, almost 2,000 more died within the first week, and roughly 10,000 people in all were seriously injured (Lorin and Kulling, 1986).

Useful lessons about how to respond to a chemical disaster were learned from the tragic leak of the toxic gas methylisocyanate (MIC) from a Union Carbide plant in Bhopal, India

Although the quantity of chemical agent involved in the Bhopal disaster greatly exceeds even the largest plausible terrorist attack, it should be remembered that nerve agents are between 100 and 1,000 times more toxic than MIC. Thus, the Bhopal incident offers some useful insights into managing large-scale toxic exposures. Swedish doctors who visited the city after the disaster drew three main lessons. First, in order to suppress widespread panic and chaos, the government must be ready to provide public information immediately and continuously after a chemical disaster has occurred, both in the immediate area by means of officials equipped with loudspeakers and over a larger area through emergency radio and television broadcasts. Local emergency authorities should be prepared to explain clearly the cause of the disaster, what the victims should do, how long the crisis will last, where to obtain help, and how people can protect themselves from exposure.

Second, the Bhopal incident revealed that organizations taking part in life-saving actions, such as fire-brigade, police, and civil-defense units, do not always know how to treat toxic chemical exposures. Regular training for rescue teams should therefore include first aid for chemical casualties. In disasters involving releases of toxic substances, the injuries are similar for all victims—albeit differing in severity—so that the treatment can be standardized. Indeed, it may be sufficient to have only a few medical specialists on call who can give instructions to other members of the health-care team.

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Finally, in large chemical disasters such as Bhopal, all of the injured cannot be brought to hospitals. To avoid chaos and overcrowding, it is important to plan for satellite treatment areas in sports centers, schools, and other buildings that are equipped with central heating, hot and cold running water, and telephones. At these field sites, medical personnel and equipment can be brought in and a large number of patients treated (Lorin and Kulling, 1986).

Lessons from Israel. In developing public-health strategies for coping with the threat of C/B terrorism, U.S. government planners should also consider the case of Israel, which has acquired extensive experience in civil defense against C/B agents. During the three-month period preceding the outbreak of the 1991 Persian Gulf War, Israeli authorities distributed approximately five million gas masks and antidote kits to the general civilian population, at government expense. Households were also instructed through public-service announcements to establish a "sealed room" within the home in which family members could take shelter from Iraqi Scud missiles carrying C/B warheads (Lapidot, 1994).

A sobering lesson of the Israeli experience during the Gulf War is that even when ordinary citizens were equipped with gas masks and other protective equipment, they often failed to use them properly. None of the Iraqi missiles that hit Tel Aviv turned out to have chemical or biological payloads, and only two Israelis were killed directly by Scuds with conventional warheads. Because intense anxiety mimics the signs and symptoms of nerve-agent poisoning, however, many Israeli citizens believed they were being gassed during the missile attacks and were overwhelmed by panic. As a result, ten people died from the indirect effects of protection against chemical weapons—either by suffocating after failing to remove the plug from the gas-mask filter or by injecting themselves with atropine, a nerve-agent antidote that, if not counteracted, can itself cause serious harm.

The United States, of course, does not face the same level of military threat as a country like Israel, which lacks strategic depth and has hostile neighbors armed with C/B weapons and long-range missiles. Moreover, the Israeli population is small enough so that the government could afford to equip all civilians with gas masks free of charge, but that is not a realistic option for a country the size of the United States. In sum, given the problems that Israel experienced with the civilian use of gas masks and the fact that a terrorist C/B attack might occur without warning, it would not be cost-effective to stockpile gas masks for such a contingency. Instead, civil-defense preparations for responding to a C/B terrorist attack should focus on emergency medical responses.

To meet the medical demands associated with a chemical agent attack, initial triage and holding sites would have to be established where patients would be decontaminated and given initial treatment. Within these areas, medical staff would work in full protective clothing. According to Israeli civil-defense specialists, care of chemical casualties should be based on the following principles:

- provision of medical care simultaneously to a large number of victims;
- rapid and logical triage of victims according to severity of injury, followed by matching of seriously ill patients to appropriate tertiary care facilities;
- standardization of delivery of care, including medical equipment and drugs; and
- training of paramedical teams to assist in treatment of victims (Shemer and Danon, 1994).

A covert biological attack would be much harder to manage medically because of its delayed effects. Since it would not be feasible to vaccinate civilian populations to putative BW agents prior to an attack, the medical response would have to focus on post-exposure treatment with antibiotics and antisera. Yet the exposed population would not experience the onset of symptoms until after an incubation period of a few days, by which time the affected individuals could have dispersed widely. Effective disease-surveillance mechanisms would therefore need to be in place to detect the onset of the epidemic and differentiate it from a natural disease outbreak. Moreover, given the speed with which pathogens such as anthrax can induce a life-threatening illness, rapid identification of the infectious agent would be essential to save lives with antimicrobial therapy. Finally, if terrorists used a highly contagious pathogen such as pneumonic plague, the victims would have to be quarantined. General hospitals might even refuse to admit BW casualties for fear of infecting the vulnerable patient population.

It should also be noted that BW defense has different detection and masking requirements than CW defense. With only a few rare exceptions, biological agents cannot penetrate intact skin, so that the sole route of exposure is through the lungs. Moreover, since the particles making up a biological aerosol cloud are relatively large, once they settle out they tend to adhere to surfaces and are difficult to reaerosolize. Thus, there is little risk that the downwind settling of biological agent particles would result in a persistent contamination hazard. For these reasons, emergency medical personnel facing a BW threat would not need to wear cumbersome gas masks and full-body protective suits. All that is needed for effective individual protection against biological agents is a relatively low-cost surgical-type mask that forms a tight seal over the mouth and nose and filters out airborne particles in the respirable range (Danzig, 1996). In contrast, persistent chemical agents such as VX can enter the body either as an inhaled vapor or as liquid droplets that penetrate the skin, and may remain toxic in the environment for days or even weeks. Effective protection against chemical agents therefore requires the use of a gas mask with an activated-charcoal filter and a full-body protective suit.

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U.S. Policy Options

Since it is very likely that local and state medical resources in the United States would be rapidly overwhelmed in the aftermath of a major C/B terrorist attack, the federal government would have to intervene quickly to manage the disaster. Today the centerpiece of the federal response to both man-made and natural disasters is the National Disaster Medical System (NDMS), which coordinates the emergency medical response activities of FEMA and the Departments of Defense, Health and Human Services, and Veterans Affairs (Brandt et al., 1985; Mahoney and Reutershan, 1987). The NDMS has three major components: pre-hospital treatment, patient evacuation, and in-hospital care. Pre-hospital treatment is provided by Disaster Medical Assistance Teams (DMATs), which are responsible for first aid, casualty clearing, medical staging, and field surgical intervention (Mahoney et al., 1987). There are about 60 DMATs in existence, of which 21 are "level 1" teams that can mobilize within six hours. These teams are self-sufficient with tents, food, and water purification equipment, and have enough medical supplies for 72 continuous hours of operation (Young, 1995).

Nevertheless, while the level-1 DMATs are suitable for natural disasters such as earthquakes and hurricanes, the six hours required to mobilize them would be too long to handle the unique medical emergency that would result from a C/B attack, including—in the case of a chemical but not a biological incident—the need for immediate field treatment of large numbers of stricken victims. Other special requirements associated with an effective medical response to C/B terrorism include:

- rapid identification of the toxic or infectious agent;
- prompt administration of antidotes or antibiotics;
- decontamination of victims, buildings, and equipment; and
- equipping emergency and medical personnel with protective masks and suits so that they can avoid becoming casualties themselves.

Immediately after the Tokyo subway attack, the U.S. National Security Council tasked the Public Health Service (PHS) to develop a plan of operation for the health and medical consequences of a C/B terrorist incident. An interagency task force, chaired by the Office of Emergency Preparedness at PHS, was established to draft an interim plan that integrates the immediate health and medical responses of the federal agencies in support of states and local governments. This plan calls for the creation, under NDMS auspices, of special "metropolitan strike teams" in high-risk urban areas—integrated groups of emergency health professionals who would provide pre-hospital patient care, including first aid, triage, decontamination, treatment, and evacuation. These strike teams would receive training in the treatment of C/B agent exposures and would be capable of responding within 30 to 90 minutes of an attack. The interim plan also calls for improved communications systems for use in a terrorist disaster (Young, 1995).

In addition to the interim plan, other policies for dealing with the emerging threat of C/B terrorism should be developed. Such policy options can be divided into two groups: low-cost steps that could be implemented immediately, and longer-term, more resource-intensive options that warrant further consideration. To avoid arousing public anxiety and perhaps even provoking unstable individuals to contemplate acts of C/B terrorism, any steps that the federal government undertakes in this area should remain low-profile.

Short-Term Steps

Short-term steps that might be considered to address the emerging threat of C/B terrorism include the following:

1. *The federal government should better coordinate its C/B counterterrorist planning with state and local authorities.* Although the federal government has established an interagency working group on nuclear, biological, and chemical (NBC) terrorism, and major cities such as New York have developed their own contingency plans (Altman, 1995), there has been relatively little communication between them. One problem is that current law authorizes FEMA to advise states and localities on how to do their planning but gives the agency no authority to dictate either planning activities or their content. This lack of coordination at the various levels of government would be a major barrier to effective response in a crisis. To set a national agenda for action, Congress should authorize the FBI, FEMA, and other participating federal agencies to develop a comprehensive national civil-defense plan specifying how emergency-response and public-health resources at the federal, state, and local levels would be mobilized to deal with C/B terrorist incidents. After this plan has been fleshed out, civil-defense officials should conduct annual or semiannual exercises in which they simulate a C/B terrorist attack and test emergency responses under realistic field conditions.

2. *All signatories of the Chemical Weapons Convention (CWC) should work for the prompt entry-into-force of the treaty, urge hold-out states to sign and/or ratify, and pass the domestic implementing legislation required under Article VII.* Although the CWC cannot prevent chemical terrorism, it will reinforce the international norm against the use of chemical weapons and create new obstacles for terrorists by requiring parties to criminalize the acquisition and stockpiling of chemical weapons, allowing law-enforcement agencies to intervene against terrorist groups seeking to acquire chemical weapons before an attack actually occurs. The convention will also require member states to report to the international CWC organization on the activities of companies that produce, process, consume, import, or export certain chemical precursors. Such annual reporting will

oblige both governments and private companies to be more vigilant about suspicious transactions. Similarly, all parties to the Biological Weapons Convention that have not yet passed domestic legislation making the treaty prohibitions binding on their citizens and businesses should be strongly pressured to do so.

3. *The U.S. Department of Commerce (and its counterparts in other countries) should educate domestic chemical companies and biological suppliers about the threat of C/B terrorism and urge them to police themselves more effectively.* A privately based control system in which industry assumes responsibility for preventing the misuse of its own products is much more desirable than adding yet another layer of external government regulation. For example, chemical suppliers would be advised to scrutinize their overseas and domestic customer lists to make sure that dual-purpose precursors and production equipment sold to firms, groups, or individuals for ostensibly legitimate purposes are not diverted to the production of chemical weapons. One way to enforce this system would be to hold chemical and biological suppliers civilly liable for the misuse of their products by terrorists. Companies that undertook reasonable steps to limit the chance of diversion would face a reduced liability in the event of misuse—a provision known in legal circles as a "limited safe-harbor." For example, in the event injuries resulted from the terrorist use of its products, a firm that had made a good-faith effort to screen its customers might be held liable for compensatory damages but not punitive damages.

4. *Commercial laboratories such as American Type Culture Collection (ATCC), which supply seed cultures of pathogenic microorganisms for biomedical and public-health research, should require customers to prove that they have a legitimate need for such materials before being allowed to purchase them.* Demanding that legitimate researchers prove their *bona fides* before being allowed to order dangerous pathogens would make it more difficult for terrorists to obtain them by impersonating biomedical scientists or by submitting orders on stolen or fictitious university letterhead. One approach would be for national or international scientific bodies (such as the American Society for Microbiology, the American Public Health Association, or the International Union of Microbiological Societies) to establish a certification or licensing procedure that would authorize scientific researchers with a legitimate need to purchase seed cultures of dangerous pathogens from biological supply houses. Criteria for such certification might include academic affiliation and publication record, so as to weed out terrorists seeking to impersonate scientists. The list of approved recipients could be stored on diskette and made available to all relevant suppliers.

5. *The U.S. Congress should consider legislation imposing civil liability on any U.S. resident or company that aids and abets terrorists by publishing detailed recipes for the production of C/B weapons, either in book form or on the Internet.* Without infringing on constitutional protections, one can make a compelling case that the publication of cookbooks for the production of C/B agents represents a clear and present danger to the health and security of the nation and thus does not constitute protected speech under the First Amendment. (The constitutional questions surrounding this issue are likely to be clarified by a pending legal case against a book that provides detailed instructions on how to commit assassinations—with a disclaimer that it is strictly for educational purposes—and was allegedly used to commit an actual murder.) Although censoring such materials outright would set a dangerous precedent, publication could be deterred through the threat of legal liability. To this end, Congress might pass legislation imposing treble damages on the author and publisher for any injuries arising from the terrorist use of a C/B primer, and enabling the federal government to recover costs associated with law enforcement. Since the Internet transcends national borders, the United States would have to urge other governments to enact legislation covering content providers operating under other national jurisdictions.

6. *The intelligence community should devote greater resources to tracking attempts to acquire C/B weapons by both domestic and international terrorist groups.* In particular, the CIA and the U.S. Customs Service should improve their ability to detect and interdict foreign trafficking in C/B precursor materials, equipment, and know-how. U.S. intelligence agencies should also expand the sharing of information with friendly countries (including Russia) on international terrorist groups that might be contemplating C/B attacks. Such exchanges could take place through Interpol, the Australia Group, and bilateral intelligence channels. Where there is probable cause to suspect that a domestic group is engaged in the purchase of C/B-related materials, the FBI should obtain a warrant to engage in intensive surveillance, including wiretaps and infiltration by undercover agents. Nevertheless, counterterrorism must not be used as an excuse to curtail the civil liberties of unpopular groups that do not resort to violence.

7. *FEMA and the Public Health Service should develop public-service announcements for emergency radio and television broadcast in the event of a C/B terrorist attack.* These spots would be designed to provide detailed information and instructions to the public, helping to suppress widespread panic.

Longer-Term Steps

At the same time that the immediate measures listed above are being implemented, the following longer-term policies for addressing the threat of C/B terrorism should also be considered.

1. *The U.S. Congress should appropriate funds to expand the epidemiological surveillance programs run by the U.S. Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) to monitor background levels of infectious disease around the world.* Beyond the obvious benefits of this surveillance program for international health, it would help differentiate covert BW attacks from unusual outbreaks of disease attributable to natural causes (Wheelis, 1992; Lederberg, Shope, and Oaks, 1992).

2. *FEMA should purchase and stockpile C/B defensive materials at major medical centers in the nation's twenty largest cities.* These stockpiles might include

- chemical and biological agent monitoring devices for identifying contaminated areas and individuals;
- antidotes against chemical nerve agents, such as atropine and PAM; and
- broad-spectrum antibiotics and antisera for treating exposures to known bacterial, viral, and toxin agents.

Enough antidotes and medications should be stockpiled in each city to treat the estimated casualties from a realistic C/B attack scenario, based on population density and other variables.

3. *The U.S. Public Health Service should create a national training program for "first responders" to a C/B terrorist incident, including paramedics, police, firefighters, and other emergency workers.* The curriculum would cover the rapid triage and care of C/B casualties and the use of chemical protective equipment, with the goal of creating a ready reserve of emergency response teams who could be activated promptly in the event of a large-scale C/B terrorist attack.

4. *The FBI should instruct major urban police departments in specialized surveillance and law-enforcement techniques related to the emerging threat of C/B terrorism.* Such a program would require training detectives and officers to recognize criminal behavior on the part of religious cults (along the lines of Aum Shinrikyo), as well as subtle indicators of C/B agent acquisition, development, and production.

5. *The Department of Defense, in cooperation with other federal agencies, should establish specialized detection teams to investigate threats of C/B terrorism prior to an attack, much like the existing Nuclear Emergency Search Teams (NEST) for nuclear terrorist threats* (Waller, 1996). Whereas nuclear weapons are radioactive and emit subatomic particles that can be picked up at a distance by a Geiger counter, a bomb containing a chemical or biological agent would not be detectable unless the agent leaked or was deliberately released. It would therefore be next to impossible to find a device containing a chemical or biological agent hidden somewhere in a large city. Nevertheless, C/B weapon search teams equipped with portable sampling and analysis equipment would be able to identify the agent involved in an attack shortly after it occurred, facilitating the appropriate medical response.

6. *The U.S. Congress should increase government funding for research and development on improved C/B agent detection and identification systems, and encourage joint efforts with other like-minded countries.* Prompt identification of chemical and biological agents is critical to ensure accurate medical diagnosis and effective treatment. Ideally, field detection systems should be capable of identifying C/B agents in close to "real time" with a very low probability of false-negatives or false-positives, yet this goal remains elusive (Starr, 1995). During the 1991 Persian Gulf War, the automatic CW agent detector/alarms deployed with U.S. troops in Saudi Arabia were notoriously unreliable. BW agents could only be detected by taking concentrated air samples at regular intervals and performing an immunoassay, yet because this test takes at least 30 minutes to yield a result, it could only determine in retrospect if troops had been exposed. In the aftermath of the Tokyo sarin attack, the Japanese police were reduced to using caged canaries as crude poison-gas detectors (Van Biema, 1995).

7. *The U.S. Congress should provide incentives for the pharmaceutical industry to develop improved broad-spectrum antibiotic and antiviral drugs capable of treating exposures to a variety of putative BW agents.* New and improved antibiotics are also needed to protect the public health as common disease-causing microorganisms become resistant to existing drugs through natural processes of mutation and selection.

Although another large-scale chemical biological terrorist attack remains unlikely, the Tokyo subway incident has lowered the threshold for future disasters of this type. Given the potential cost in human lives and psychological trauma, the emerging threat warrants a significant U.S. national investment in the preparation of contingency plans, the training of medical personnel, and the stockpiling of relevant medications. Most of the policy recommendations listed above also apply, with appropriate adaptations, to other countries.

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EDITOR'S NOTE

(with thanks to Graham Pearson)

As we go to print, it has become clear that our roundtable on chemical/biological terrorism is indeed timely, as the threat of use of such materials for terrorist purposes was included in the communiqué issued by the Heads of Government of the G7/8, who met in Lyon, France on June 27, 1996. They condemned the attack on Dhahran as a "barbarous and unjustifiable act" and also condemned other recent terrorist acts. They said that these tragedies strengthened them in their conviction that terrorism is "a major challenge to all our societies and states today," and they reaffirmed their "absolute condemnation of terrorism in all its forms and manifestations, regardless of its perpetrators or motives." They also proclaimed their common resolve to unite their efforts and their "determination to fight terrorism by all legal means."

They went on to say that "special attention should be paid to the threat of utilization of nuclear, biological and chemical materials, as well as toxic substances, for terrorist purposes."

The Heads of Government further indicated that they considered the fight against terrorism to be their "absolute priority," and reiterated "the necessity for all states to adhere to the relevant international conventions." They decided that a ministerial meeting should be held in Paris, as early as the month of July, to consider all measures liable to strengthen the capacity of the international community to defeat terrorism and recommend further actions.

This Ministerial Conference on Terrorism, held in Paris on July 30, 1996, issued a Final Declaration which noted that there is a "growing commitment within the international community to condemn terrorism in whatever shape or form, regardless of its motives; to make no concessions to terrorists; and to implement means, consistent with fundamental freedoms and the rule of law, to effectively fight terrorism." The participants affirmed their determination "to work with all states, in full observance of the principles and standards of international law and human rights, in order to achieve the goal of eliminating terrorism, as affirmed in the Declaration adopted by the United Nations General Assembly in December 1994."

The declaration set out a framework of 25 practical measures to be implemented by the G7 countries, and which all states were invited to adopt. Three of these practical measures were concerned with use of chemical and biological materials. First, the parties called on all states to "expand training of personnel connected with counter-terrorism to prevent all forms of terrorist action, including those utilizing radioactive, chemical, biological, or toxic substances." Second, the parties recommended to States "Parties to the Biological Weapons Convention to confirm at the forthcoming Review Conference their commitment to ensure, through the adoption of national measures, the effective fulfillment of their obligations under the convention to take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition or retention of such weapons within their territory, under their jurisdiction or under their control anywhere, in order, *inter alia*, to exclude use of those weapons for terrorist purposes."

Third, the conference called on all states to "intensify the exchange of operational information, especially as regards," among other things, "the threat of new types of terrorist activities, including those using chemical, biological or nuclear materials and toxic substances."

As the Final Declaration ends by calling on each country's experts on terrorism to meet before the end of 1996 to assess the progress of the work undertaken to implement these measures, *Politics and Life Sciences* is pleased to contribute to one aspect of this initiative through this roundtable on chemical and biological terrorism.

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