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I was asked to speak on how health care providers perceive the threat of biological and chemical weapons against our population, and its impact on public hospitals. The potential health impact of biological weapons used against a population was first evaluated in a 1970 study supported by the World Health Organization. The study, entitled "Health Aspects of Biological and Chemical Weapons,"[1] attempted to predict which toxic agents perpetrators determined to achieve a maximum effect might choose. It included a hypothetical assessment of the capacity of individual biological agents to cause mass illness and death.[2] For an American population that had, for the most part, only experienced war while safely tucked between two vast oceans and bordered by friendly neighbors, the relevant descriptor was "hypothetical." Additionally, most Americans believed the promises of the 1972 Biological Weapons Convention.[3] I remember as a young physician grappling with the ethical implications brought on by the failure of the United States to destroy the world's "last" vials of smallpox, which were instead safeguarded by our country at Fort Dietrich. Even the 1979 outbreak of anthrax in Sverdlovsk, Russia, an event that indicated to the world that Russia was developing biological weapons in violation of the 1972 treaty, did not intrude on our sense of personal safety within our communities.[4] For health care workers and officials at local levels, as for every citizen, the events of September 11 demonstrated a commitment and capacity to harming civilians that most had not seriously envisioned. Our sense of vulnerability deepened as, soon after September 11, weapons-grade anthrax easily and effectively spread through our postal system. For health care providers, especially

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1. World Health Organization, *Health Aspects of Biological and Chemical Weapons* (2d ed. 1970), *available at* http://www.who.int/emc/pdfs/BIOWEAPONS_FULL_TEXT2.pdf(last visited May 26, 2002).

2. *Id.*

3. The Biological and Toxin Weapons Convention, Apr. 10, 1972, U.S.-U.K.-U.S.S.R., *available at* http://www.projects.sipri.se/cbw/docs/bw-btwc-mainpage.html (last visited June 22, 2002).

4. PBS Online, *The 1979 Anthrax Leak in Sverdlovsk*, FRONTLINE, *available at* http://www.pbs.org/wgbh/pages/frontline/shows/plague/sverdlovsk (last visited June 22, 2002) [hereinafter Sverdlovsk].

those in large, urban public hospital emergency departments where the staff work on the front line of any disaster, these events have prompted serious examination of our capacity to respond to threats, which, although acknowledged for decades, seem more of a possibility now.

I. Emergency Response

Disasters challenge hospitals all over the United States. Urban public hospitals, such as Parkland Hospital in Dallas, Texas ("Parkland"), work with county and state systems, leading the vanguard in planning for, and dealing with, disasters. Hospitals like Parkland have developed excellent systems for managing multiple casualties that result from severe weather, industrial or mass transit disasters, or unusually large numbers of holiday motor vehicle crashes. In Dallas County, we have redundant systems staffed by the Environmental Protection Agency and the Dallas County Fire Department to manage the decontamination of persons with chemical exposures, such as where a large industrial accident or hazardous material highway spill occurs. The North Central Texas Trauma Regional Advisory Council coordinates access to care for trauma victims in nineteen counties and has an extensive communication system that identifies available hospital beds for trauma victims. The emergency department at Parkland houses the Dallas County BioTel system, an emergency medical service communications center that directs the transport of sick and injured patients in the Dallas community. The system can also communicate with the incident command on the scene of a major traumatic event, thereby facilitating the efficient dispersal of trauma victims to all designated trauma center hospitals, so no individual hospital is overwhelmed. In the event of overwhelming mass casualties, the Dallas County Emergency Operations Center can request and receive assistance from the Federal Emergency Management Agency and the National Disaster Management System, a process that has been in place since the Korean War. Initially a military system, the National Disaster Management System, run by the National Public Health Service, has maintained a system for distributing victims of both war and civilian trauma to burn and trauma centers throughout the United States. There has yet to be an occasion to use the National Disaster Management System. As a long time participant in the system, Parkland prepared to accept fifty traumas and burn patients from the New York City area on September 11. Our assistance was not needed. Despite the huge loss of life on that day, only 10 percent of the survivors required critical care, a number that did not overwhelm the local medical resources.

The specter of mass illness forces us to confront new scenarios and acknowledge the limitations of disaster management plans that focus on traumatic injuries. If the terrorist agenda is to kill as many people as possible, then large cities with dense populations make very attractive targets. If economic and social disruption is an equally important part of their agenda, any population center could be a target.

II. Terrorism by Infection

Biological weapons give terrorists the potential to cause huge loss of life and instill terror in an entire population. They can be released from a great distance, allowing the perpetrators to escape detection. Although their production requires significant technical expertise, biological weapons are relatively inexpensive compared to conventional or nuclear weapons.

A. Anthrax

Anthrax, for example, is readily found in the soil of many Texas farming communities. Although anyone with a college education in microbiology can grow anthrax bacilli, the production of "weapons-grade" spores capable of causing widespread harm is not a home-brew operation. First, some strains are not as virulent as others, so pathogenic strains must be selected. Second, the size of the spore is very important, so a sophisticated milling procedure is required to produce an effective weapon. Spores that are two to three microns in diameter can go straight into the lungs and start infection. Smaller particles don't "stick" and are exhaled, while larger particles become lodged in the upper airway and do not cause infection. Also, the number of persons that become infected decreases as the density of the dispersed spores or organisms decreases. To be effective, the spores have to be aerosolized and kept aloft; they can't be too sticky and they can't be too heavy. The perpetrator also needs an effective and undetectable dispersal mechanism. In the aftermath of September 11, it is unlikely that a crop dusting plane over a metropolitan area would get very far.

The most effective biological weapon would be safe and easy to produce, stable in storage, highly infectious and highly lethal, communicable, and without available treatments or effective vaccine.[5] Fortunately, no single agent meets all these criteria. As part of their biological weapons program the Soviets looked at smallpox, plague, anthrax, botulism, and various viral agents that cause encephalitis.[6] The Centers for Disease Control (CDC) has also evaluated the potential destructiveness of common infectious agents.[7] Q Fever, plague, brucellosis and tularemia are diseases endemic in the United States. Q Fever and brucellosis have relatively low mortality and therefore do not meet terrorists' objectives. Plague, brucellosis, and tularemia are very difficult to produce in culture. The agents of viral encephalitis present impractical production difficulties, according to the CDC, while the highly infectious and fatal viral hemorrhagic fevers, such as Ebola, are hard to get, dangerous to grow, and destroyed by sunlight. Fortunately, the production of botulinum toxin appears to present insurmountable production difficulties. Judging from the strain on intensive care resources with only five cases presented at Parkland, apocalyptic consequences would result if terrorists were to successfully surmount these production difficulties.

The 1970 World Health Organization study evaluated the hypothetical effects of distributing fifty kilograms of various aerosolized biological agents along a two-kilometer line upwind of a 500,000-person population.[8] The amount of illness produced was directly related to both the ability to disseminate the agents and their intrinsic infectivity, while mortality was related to their virulence. The most effective biological weapon identified by this study was anthrax, which resulted in 95,000 hypothetical deaths. By contrast, Rift Valley Fever caused only 400 hypothetical deaths, 500 by brucellosis. Looking at the ease of production, infection rates, and deadliness, both anthrax and smallpox seem the most likely weapons choice for a serious assailant.[9] Each of these agents would offer very different management challenges to a medical community. Smallpox, though highly contagious, is

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5. Mark A. Kortepeter & Gerald W. Parker, *Potential Biological Weapons Threats*, CDC, July-Aug. 1999, *available at* http://www.cdc.gov/ncidod/EID/vol5no4/kortepeter.htm(last visited May 26, 2002).

6. *Id.*

7. *See generally* the Centers for Disease Control and Prevention (CDC) Web site, *available at* http://www.cdc.gov (last visited June 22, 2002).

8. *Health Aspects of Biological and Chemical Weapons*, *supra* note 1.

9. Kortepeter & Parker, *supra* note 5.

easily identifiable in its infectious stage, and preventable by vaccine. Anthrax is not contagious, can be prevented by antibiotics, is clinically obscure in the treatable phase but can be easily diagnosed in the late stage.

Anthrax is endemic throughout the world, especially in farming communities. The skin lesions characteristic of the infection have been called "Siberian Ulcer" in recognition of the common occurrence of anthrax infection in that part of the world. Animals contract anthrax by inhaling spores while grazing. The animal dies as the bacteria multiply in pulmonary lymph nodes and disseminate throughout its body. Spores, which are a dormant seed-like form of the bacillus, form as the carcass decomposes and dries. This leaves areas of dense anthrax infectivity that may be viable for years.

Cutaneous anthrax, the most common naturally acquired form of the infection, is seen in persons who handle the carcasses and skins of dead animals. Cutaneous anthrax has an ulcerated, necrotic appearance that initially resembles the more familiar bite of the brown recluse spider. Its appearance prompts the initiation of antibiotics that are generally effective even if the presence of anthrax is not recognized until the wound cultures grow. Untreated, the mortality rate of cutaneous anthrax is estimated at 20 percent.

Intestinal anthrax is a severe illness that occurs as a consequence of eating contaminated meat. This form of anthrax would be highly impractical and inefficient as a means of intentional dissemination of the disease to humans.

Inhalational anthrax, in which inhaled spores cause infection in the lymph nodes of the chest, is the form that is most likely to result from a biological attack. As we all learned from the daily news reports this fall, the early manifestations are similar to, and difficult to distinguish from, those of influenza.[10] To a very experienced eye, a mild abnormality on the chest radiograph (mediastinal widening) may give a clue to the diagnosis; however, it is not proof of infection. The challenge anthrax presents is that while it is curable with antibiotics in this very early stage, it becomes highly fatal as it progresses. The reluctance of health care providers to administer antibiotics to persons with a suspected viral illness has a basis in common sense. Antibiotics themselves have a significant risk of side effects, some of which can be fatal. In addition, the widespread use of antibiotics creates bacterial resistance, which makes them useless when they are truly needed.

A bedside test that demonstrated the presence of anthrax infection at an early stage would be highly desirable but does not exist. Nasal swab cultures will be positive in some members of an exposed population and therefore have value as an epidemiologic tool. However, they are of little value for the diagnosis of any individual, although media coverage implied the opposite. The advanced form of anthrax is easily diagnosed by the demonstration of the bacillus growing in blood and spinal fluid samples. The first unexplained case of advanced anthrax in a community would assuredly prompt a different approach than to the patient with unexplained fever.

The 1979 release of anthrax spores in Sverdlovsk, Russia, demonstrated how cases appear following a release of spores.[11] Humans became infected as far as ten kilometers from the site of release, while animals as far away as forty kilometers were infected. Approximately sixty-four out of an estimated seventy-five to ninety-five infected persons died, and new

10. Luciana Borio & Thomas Inglesby, *Hemorrhagic Fever Viruses as Biological Weapons*, 287 J. AM. MED. ASS'N 1300 (2002), *available at* http://www.jama.ama-assn.org/issues/v287n18/abs/jst20006.html (last visited May 26, 2002).

11. Sverdlovsk, *supra* note 4.

cases continued to be observed for forty-four days after the release. This latter figure prompted the prolonged courses of antibiotic prophylaxis that were administered to persons suspected to be at risk during the postal assault.

B. Smallpox

Smallpox has been a scourge of human populations since antiquity. It is highly contagious by respiratory transmission. Its incubation period lasts seven to seventeen days, followed by several days of a "prodromal" fever, then the onset of the rash. The rash looks superficially like chicken pox; however, most experienced parents would recognize the difference. Smallpox lesions are all in the same stage, rather than in the different stages (red spot, blister, pustule, scab) that are familiar in chicken pox. The rash begins in the throat where it is difficult to detect and then spreads to the face and limbs, whereas chicken pox is most prominent on the trunk. Smallpox is only contagious when the rash is present, which at least offers a means of identifying infectious persons.

Smallpox infection can be prevented by a vaccination, which is effective if given within one week of exposure. Concerns about a smallpox epidemic could be eradicated by a return to the practice of mass vaccination against smallpox. Unfortunately this approach carries a significant risk to some individuals in the population. The vaccine is a live virus (vaccinia) with potentially serious complications for persons with compromised immune systems. The spin to the press has been that mass vaccination would be too risky because there are many HIV-positive patients in our population. In truth, a vaccination plan would exclude any identified HIV-positive persons, thus eliminating the increased risk of a disseminated vaccinia infection. These persons would still be protected from smallpox by the concept of "herd immunity," which means simply that if no one around them were susceptible to infection, there would be no one from whom to catch it. Persons at risk other than patients with HIV may not be identified; thus, mass vaccination would bring a risk of serious illness or death to a finite number of persons in the community. During the decades when smallpox cases were still being identified, the benefit of vaccination of our population clearly outweighed this risk. The important question now, when not a single case of smallpox has been observed since 1977, is whether alleviating the fear of a biological attack is worth the lives that would certainly be lost due to vaccination. Another important consideration is the limited available vaccine – currently only enough to protect forty million people, although work is progressing in this area. Recent studies have demonstrated that a diluted form of the virus retains efficacy, which offers an immediate ability to increase the current number of effective doses.[12] There is growing support in the medical community for the vaccination of health care workers who would be the front line of defense against an epidemic of smallpox, and for voluntary vaccination of members of the public at large.[13]

C. Mass Exposure

By now all of you are familiar with the impact of random individual anthrax exposures. A simple scenario illustrates the complex level of the planning that must occur on a national

12. Sharon E. Frey et al., *Clinical Responses to Undiluted and Diluted Smallpox Vaccine*, 346 New Eng. J. Med. 1265-74 (2002).

13. William J. Bicknell, *The Case for Voluntary Smallpox Vaccination*, 346 New Eng. J. Med. 1323-25 (2002).

basis to respond to an outbreak of smallpox. Imagine the surreptitious dissemination of aerosolized smallpox virus among passengers on an airplane traveling from Washington, D.C. to Dallas. In Dallas, two or three hundred persons would deplane; some would stay in Dallas, others would transfer to flights bound for Seattle, Honolulu, Los Angeles, Denver, etc. One or two weeks later, individual cases of smallpox would begin to appear in cities all over the west, necessitating a demand for investigation and vaccination that would likely strain current local and national capabilities to respond. Dissemination of anthrax by this scenario would cause much less illness and fewer deaths because there is no risk of spread of the disease by infected persons, nevertheless, the terror effect would be substantial.

In order to be effective as weapons of mass destruction, chemical agents must either be highly toxic or applied in a very high concentration. Only one episode of mass poisoning appears in our recent history – Bhopal, India in 1984.[14] In that incident, forty tons of Methyl Isocyanate, a chemical that is toxic to the lungs, was dispersed over a city of nine hundred thousand people. Four thousand died of lung injury, and four hundred thousand suffered chronic lung injury. Similarly vast amounts would be needed to cause mass population injury using agents such as mustard gas or phosgene, the "trench warfare" compounds. These heavier-than-air compounds were effective against troops in World War I and civilians in the Iraq-Iran war, but are not truly efficient agents for mass murder. Even cyanide, a powerful toxin that is highly effective for isolated murders, would likely be required in impractical amounts to cause serious poisoning of a large population. The toxicity of nerve gases is much, much greater than any of those agents. Their potential effects were demonstrated in the 1995 dissemination of sarin nerve gas in the Tokyo subway system by the Aum Shinrikyo terrorist group. Small, easily concealed containers of liquid sarin were spilled at a few places throughout the subway system, resulting in the poisoning of five thousand people.[15] Fortunately, only eleven died.

III. Managing Mass Contamination

The challenges of managing mass casualties related to nerve gas toxicity are substantial. A huge field decontamination capability and a much greater availability of antidotes than are currently stocked is needed. In addition, individual hospitals need to anticipate events similar to what occurred in Tokyo, where the arrival of many poisoned persons by public transportation and private vehicle contaminated the emergency departments and exposed health care workers, 20 percent of whom became ill. Hospital personnel need personal protective equipment, and training in its use. Hospitals need to develop a substantial capacity to contain and decontaminate exposed persons before they enter the hospital.

In dealing with biological weapons, the priorities are: (1) Early identification of the infecting agent, especially those that have treatable prodromal stages (anthrax) or are prevented by timely vaccination (smallpox); (2) Identification of specific groups at immediate risk; (3) Creation of systems to distribute mass vaccination or antibiotic prophylaxis; (4) Designation of alternative public spaces in which to care for or isolate huge numbers of sick and/or contagious persons; and (5) Development of communication systems to keep

14. AcuSafe, *Bhopal, India (1984)*, *available at* http://www.acusafe.com/Incidents/Bhopal1984/incident-bhopal1984.html (last visited May 26, 2002).

15. Sadayoshi Ohbu et al., *Sarin Poisoning on Tokyo Subway*, *available at* http://www.sma.org/smj/97june3.htm (last visited May 26, 2002).

the public informed and to facilitate cooperation and communication among hospital providers, and city, county, and state agencies.

Since no warning lights or sirens would alert to the onset of a biological attack, a great deal of attention has been focused on the task of recognizing the presence of an epidemic and identifying its cause. The timely recognition of the first case of smallpox requires a highly educated health care community. The presence of mass illness in a community due to other agents would be rapidly suspected by the rise in unusual visits to emergency departments. Although sick patients will begin to show up at doctors' and school nurses' offices, emergency departments are best positioned to detect changes in illness and injury patterns in the community. These departments are well attuned to both seasonal (influenza, meningitis, New Year's Eve celebrations) and situational (a World Series game) fluctuations in visits, so an unexpected increase in otherwise healthy persons with fever, rash, or unusual pneumonia would prompt rapid investigation. In case it is not glaringly obvious that something is amiss, Parkland and many other urban emergency departments are keeping daily tabs on fever patterns as an early indicator of unusual illness. Only a finite number of non-viral pathogens cause human illness, and most hospital laboratories are sufficiently sophisticated to identify even unfamiliar infectious agents, usually within twenty-four hours. For example, in the 1980s at New York City's Bellevue Hospital, the staff became acutely aware of a large number of previously healthy young men with very unusual and severe pulmonary infections. Although most of the staff had never seen Pneumocystis pneumonia, using standard medical diagnostic tools we were quickly able to identify the infectious agent and procure appropriate treatment, long before the cause of the AIDS epidemic was uncovered. During the recent anthrax assault, the media focused on a Florida infectious disease specialist's recognition of possible anthrax in the index case, leaving the impression that were it not for this almost fortuitous circumstance, this unusual illness might have gone undetected. In reality, the hospital laboratory made the microbiological diagnosis concurrently from examination of the patient's spinal fluid, and had full confirmation of the diagnosis and knew the antibiotic susceptibility of the bacillus within a day of the patient's arrival. In the present day, the significance of identifying a single case of pneumonic plague, anthrax or smallpox would not be overlooked. Unless new technologies become available that allow health care providers to detect the cause of an unusual illness at the patient's bedside, or unheard of "bugs" are sent to plague us, diagnosing the presence and cause of mass illness is likely to be the least of our problems.

For both chemical and biological exposures, the biggest challenge for communities, for the nation, and for individual hospitals, is being prepared to care for large numbers of exposed or sick persons. Currently most hospitals, and especially public hospitals, are overflowing with patients suffering from ordinary illnesses and injuries. Facilities for isolation are very limited. At Parkland, for example, of seventy isolation beds, almost all of them are regularly filled with tuberculosis patients. Since patients with communicable diseases could not be shipped off to other area hospitals for care, local communities must devise other methods of isolation such as home quarantine, designation of a single contaminated hospital, or designation of large public spaces pre-supplied with caches of equipment. Community hospitals in Israel have formed creative liaisons with local hotels to expand bed availability, and have expanded available personnel by training local high school students to perform hospital tasks related to transport and the provision of non-technical care. Being able to respond to the challenges of biological terrorism requires that we find creative ways to use familiar systems and facilities. Health care providers need to increase the flexibility and redundancy of our communication systems, creating the ability to divert trauma communication systems currently in place to effect communication about bioterror incidents. We can broaden the training of paramedics and use the emergency medical service (EMS) system to dispense antibiotics or vaccine. Identifying exposed, at-risk persons needing preventative vaccination or antibiotic prophylaxis will be a major public health challenge, as will be identifying persons who need isolation. Public Health Departments accustomed to a manageable level of tuberculosis and sexually transmitted diseases, and investigating causes of focal outbreaks of intestinal infections, are grossly understaffed and under-funded for the epidemiologic tasks that would fall to them in the event of mass biological exposure.

In addition to educating health care providers, educating the public is crucial. The public needs to understand, in advance of any attack, what procedures they would need to follow in case of a threatening epidemic. Health care providers need to work closely with the media to develop effective ways to communicate information to the public so their cooperation can be enlisted. Hospitals normally poised to compete with each other need to develop supportive relationships, with communication capabilities that allow cross-credentialing of health care providers, sharing of pharmaceutical resources, ready identification and transfer of patients to available beds, and rapid dissemination of information regarding identified infectious or chemical exposures.

IV. Conclusion

In conclusion, the prospect of widespread terrorism creates huge challenges for local and national governments: Planning ahead for the necessity of mass quarantine or isolation, identifying and protecting exposed persons, and providing supportive care to huge numbers of sick persons. Public hospitals must upgrade facilities, especially in the development of isolation and decontamination capabilities. More importantly, they must participate in community planning for care of victims when emergency facilities are overwhelmed. Hospitals must create effective avenues of communication with local government and public health officials, and plan for cross credentialing that allows sharing of personnel and supplies in case a hospital is disabled. The public must be educated and informed, and systems put in place for ongoing sharing of information and plans during any threat.