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Modeling for Bioterrorism Incidents

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1. INTRODUCTION

A training gap exists in the preparation necessary for first responders, hospital, health department, and law enforcement personnel from local, state, and federal agencies should a bioterrorism event occur. Because of the unique nature of a bioterrorism event, the definition of a "first responder" has evolved to include hospital and public health personnel *(1)*, who may lack an understanding of the overall incident command structure, in general, and the hospital emergency incident command structure, specifically. Additionally, agencies that traditionally rely on their own infrastructure (e.g., public health, law enforcement) to perform their normal functions must rely on new partners to respond to a bioterrorism event. Intensive coordinated planning and training efforts that bring all participant agencies together to understand each other's roles and responsibilities in a disaster can remedy these disparities.

Irrespective of the current level of preparedness of municipal, state, or federal agencies, the same methods that are used to assist coordinated planning and training for other catastrophic events can be used to plan for bioterrorism. These techniques include the composition of an agency- or government-specific disaster response plans, conducting tabletop exercises, and holding a live drill exercise. Realistic disaster scenarios should be incorporated into each of these training techniques to familiarize participants with each others' roles and responsibilities and to plan for the unique nature of a bioterrorism event. The primary emphasis herein is on the tabletop exercise, which can be conducted by a municipality, state, or federal entity even in the absence of a formalized response plan and without the resources and expenses required for a live drill exercise. A bioterrorism scenario used in statewide training will be examined, along with the participant's response to that scenario. Actual bioterrorism incidents will be considered, as will the various essential components of the public health response to bioterrorism.

2. PREDICTING FUTURE BIOTERRORISM EVENTS

The ability to predict a future terrorist attack with a biological weapon against a civilian population presents an enormous, if not impossible, challenge. When designing bioterrorism scenarios, planners must think "out of the box" in addition to using knowledge of prior biological attacks and natural disease outbreaks. The anthrax cases caused by contaminated letters that occurred in late 2001 clearly demonstrated

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the ability of small amounts of a finely milled biological agent to cause disease. Those mailings, directed at political and media targets, also demonstrated the potential extensive repercussions that can result even with a small-scale attack. Importantly, extensive media coverage can amplify terrorist objectives. Large-scale anxiety, fear of contamination, economic loss, exhaustion of antibiotic supplies for prophylaxis (necessary and unnecessary), and extensive (and expensive) decontamination efforts were just some of the ripple effects from the anthrax mailings.

The release of a biological agent by aerosol is among the most effective methods a terrorist could employ to expose large numbers of individuals *(2)*. The simultaneous infection of those exposed to an infective agent dose would be the primary result, with potential reaerosolization of a persistent biological agent possibly leading to more exposures and infections. A recent example of the potential for a biological agent to become a persistent health threat occurred when anthrax spore-laden envelopes passed through postal service mail sorter machinery in Washington, DC. The pressure on the envelopes from the mail handling processors forced anthrax spores through unsealed portions of the envelope and resulted in numerous of infections in postal workers at the facility *(3)*.

A highly concentrated aerosolized cloud of a biological agent could more readily be achieved in an enclosed space, such as a building, rather than in open-air dispersal outdoors. By way of example, when the Aum Shinrikyo released chemical agents that became entrained in an office building in Matsumoto in 1994, they caused about 200 persons to be hospitalized and 7 deaths *(4)*. The Aum Shinrikyo also attempted several releases of botulinum toxin in an outdoor environment in Yokosuka and Yokohama in 1990 and in Tokyo in 1993. These attempts failed to cause any recognized cases of illness, perhaps as a result of several factors, including the dilution effect by the environment on a small amount of agent *(5)*.

Another potential vehicle for the future use of a pathogen for bioterrorism is through the contamination of the food supply. In American society, the farm-to-table continuum, which includes growing, processing, distribution, and preparation, has a myriad of potential vulnerabilities for contamination *(6)*. One wake-up call to purposeful food contamination with an infectious disease pathogen occurred in 1984 in The Dalles, Oregon. The perpetrators of this crime sprayed *Salmonella typhimurium* in salad bars *(7)*. The desired outcome was to influence an election by causing illness among voters, thereby causing them not to vote. This clearly meets the definition of a bioterrorist's objectives *(5)*. A second example occurred in Texas in 1996, when another food-borne pathogen, *Shigella dysenterae*, was used in the contamination of pastries given to coworkers at a laboratory *(8)*. This incident is considered a biocrime, because the motivation behind this activity lacked political, ideological, or religious underpinnings *(5)*.

One can also study the many nonpurposeful food-borne pathogen contaminations to determine avenues for potential purposeful outbreak scenarios. An outbreak in Minnesota in 1985 affecting more than 16,000 persons with antimicrobial-resistant salmonellosis was eventually hypothesized to have been caused by cross-contamination of raw milk into a pasteurized milk product sold to the public *(9)*. Although this outbreak had occurred unintentionally, a significant criminal investigation occurred simultaneously with the epidemiological investigation because of the size of the outbreak and the associated deaths of 14 individuals who consumed the milk product *(9)*. This outbreak and many others *(10–12)* demonstrate that food-borne bioterrorism has perhaps greater chances of success the closer to the table that contamination occurs, thus circumventing issues of dilution of the pathogen and destruction by cooking/pasteurization.

Water-borne contamination is perhaps more difficult for a terrorist to achieve, because the large volumes and the extensive water purification process in use in industrialized countries should tend to negate a biological contaminant. However, a determined enemy could overcome the purification process. Deleterious effects could also result from purposeful biological contamination of the water supply distribution system after the purification process. A private well-water supply system may be more vulnerable to attack because a private well may have a smaller volume of water and may not have as an extensive water purification process as a public water supply. One example of an extensive water-borne disease outbreak resulting from contaminated well-water is the *Escherichia coli* O157:H7 and *Campylobacter sp.* outbreak that occurred in 1999 at a New York State county fair *(13)*. More than 900 illnesses and 2 deaths resulted from this bacterial contamination of well water. Although this event was not a planned terrorist event, the potential for a terrorist to purposefully contaminate a well is apparent. The possibility of a purposeful contamination of a public water fountain should also be considered. A recent natural outbreak of gastroenteritis was associated with an interactive water fountain at a Florida beachside park *(14)*. One can imagine the effect of, for example, a large amount of botulinum toxin surreptitiously added to a public water fountain in a similar manner.

Infected vectors, such as plague-infected fleas or encephalitis-infected mosquitoes, can also be used to transmit disease. During the Japanese occupation of China during World War II, fleas were used in some of the horrific biological weapons experiments conducted by Japanese Military Unit 731 *(15)*. According to Alibek *(2)*, the release of infected vectors is not particularly effective for military or terrorist purposes because of the high probability of affecting those producing the weapons or in proximity to the site of release.

2.1. Probable Scenarios for a Bioterrorism Attack

The terrorist use of a pathogen that is normally endemic or periodically epidemic in a certain population would be more difficult to detect as an unusual event than an exotic pathogen. Therefore, a bioterrorism attack could be masked as a naturally occurring outbreak. This kind of covert attack might be detected initially in numerous ways, such as by an astute clinician or by laboratory identification. However, epidemiological surveillance and investigation will ultimately determine whether an attack is intentionally induced. Certain indicators, or red flags, could point toward an intentional event, for example, changes in the normally occurring season of illness (e.g., influenza in the summer), host illness patterns (i.e., ill animals in conjunction with ill persons, both infected with a similar zoonotic illness), or unusual geographical patterns of illness (e.g., many outbreaks of the same bacterial illness occurring simultaneously).

A terrorist attack might have special features associated with it that would not be expected in the course of a natural outbreak. These could include the use of a combination of agents, either different pathogens mixed together or a biological pathogen in combination with a chemical or radiological one. Attacks may occur in multiple locations (yielding multiple point-source outbreaks), such as the anthrax mail outbreak during fall 2001 or the *Salmonella typhimurium* outbreak caused by contamination of multiple salad bars throughout The Dalles, Oregon, in 1984 *(7)*. Additionally, the presentation of the disease may be unusual (e.g., multiple cases of pneumonic tularemia rather than the more common ulceroglandular presentation).

A potential terrorist might choose to use a pathogen not usually considered to be a biological threat, and perhaps not even monitored by public health agencies, such as the West Nile virus, which was responsible for a natural outbreak in New York in 1999 *(16)*. The introduction and establishment of West Nile virus in the United States was considered by some to have been a purposeful event *(17)*. Finally, the use of novel or genetically engineered strains of agents by terrorists could be particularly insidious. The development of antibiotic-resistant and novel chimeras has been claimed of the former Soviet biological weapons program by one of its past directors, Dr. Ken Alibek *(18)*.

Large-scale bioterrorism attack scenarios with agents such as smallpox and anthrax have been published in civilian theoretical exercises *(19,20)*. It has been suggested that a large-scale biological attack against a civilian population is much less likely than a small-scale attack *(21)*. According to Leitenberg *(21)*, a small-scale biological attack through crude dispersal of a biological agent in an enclosed area is the most likely mode of attack. One benchmark of a successful exercise is to have the participants respond to an unanticipated event followed by participation in a lessons learned summary that will enable them to learn from their mistakes. Exercises that involve as many of the various local, state, and federal emergency response partners as possible will greatly foster the development of a team response approach *(22)*. This type of exercise will also enable each participant group to discover their weaknesses and strengths (and each others') in response to a disaster.

Finally, it should also be noted that synergistic effects have been demonstrated in animal models for combined radiation and biological pathogen exposure *(23,24)*. As horrible as the consequences may be to consider, it will behoove the biological disaster planner to consider similar worst-case scenarios when designing exercises.

2.2. Modeling of Probable Scenarios: Response Plan, Tabletop Exercise, and Live Drill

An important component of training for a bioterrorism event is to involve participants in a progression of planning steps from a theoretical response to prepare for an actual event. The sequence usually used by hazardous materials trainers for modeling an incident response among participants is to develop a response plan, conduct tabletop exercises, and then to engage participants in a live drill.

2.2.1. Response Plan

A comprehensive plan of incident response is created with each participating agency contributing a description of their resources, capabilities, and roles in an emergency incident. The final plan describes the interactive roles of each agency, their responsibilities, and how they work together and communicate with each other as a cohesive whole in response to an incident. This plan is then reviewed and accepted by each agency and is revised annually with any changes in personnel, resources, and responsibilities.

2.2.2. Tabletop Exercise

The response plan is vetted through an exercise involving all of the primary incident response players. The exercise is designed to task the response plan and study a coordinated response using the incident command system (ICS) and hospital emergency incident command system (HEICS), communications, and lines of control between the players, which are vital components required in response to a bioterrorism event *(25,26)*. At the conclusion of the tabletop exercise, a thorough lessons learned review is conducted to examine how the players responded to the incident. A tabletop exercise can vary in length from an hour or two to several days, depending on the resources to be tested by the drill. Finally, a report should be written to summarize the exercise, response, and observations and should be distributed to all participants.

Several bioterrorism tabletop scenarios have used a combination of weapons of mass destruction (WMD) events: either a fire or a hazardous materials (hazmat) scenario along with the surreptitious release of a biological agent. Examples include two tabletop exercises that were used at the Connecticut Fire Academy during 2001 and the tabletop exercise used in the November 2001 US Army Medical Research Institute of Infectious Diseases (USAMRIID)/VA *(27)* satellite broadcast. The use of a combined WMD scenario in a tabletop exercise permits the involvement of the various first responders (fire, police, EMS) and hospital personnel in the exercise and also presents the most challenging model for a bioterrorism event. The events of late 2001 presented an unexpected and unmodeled scenario: the use of the postal system to deliver anthrax spore-containing envelopes to media and political targets. The demands of this unexpected bioterrorism event on the public health resources would have been overwhelming in the absence of a coordinated preparation. The tabletop exercise serves as a good starting point for training to achieve a better-coordinated response.

2.2.3. Live Drill

Perhaps the most thorough way to test an emergency response plan is to conduct a live drill incorporating all of the players in their real-life roles using their actual equipment and resources. This is the most resource-intensive way to test an emergency response plan *(28)*, and would best be undertaken in the presence of an existing plan in which the players are already familiar with their response roles. A live drill is normally conducted when most of the players are unaware of the timing of the event *(28)*. This type of exercise is best followed by an extensive evaluation incorporating comments from participants and a final written report that incorporates the participant's comments as well as those of the official observers. Any necessary changes discovered through this exercise should be made to the appropriate emergency response plans.

3. THE IMPORTANCE OF THE TABLETOP EXERCISE AS A BIOTERRORISM TRAINING TOOL

At the time of this writing, few state public health agencies had developed a comprehensive bioterrorism or WMD response plan. Prior federal funding specifically targeted for statewide bioterrorism plan development has funded few states to develop these plans. In the absence of a written response plan, a bioterrorism tabletop exercise can be successfully conducted with the participants following their standard protocol for emergency disaster events. An exercise conducted in this manner can be viewed as an important source of information for the development of a bioterrorism response plan, because unprepared-for deficiencies will quickly become evident during the tabletop exercise.

Two bioterrorism tabletop exercises were conducted in Connecticut in 2001 at the State Fire Academy located in Windsor Locks. For training, this Fire Academy has available a ping-pong table-sized model of a hypothetical city, "Peterboro," with HO-scale (1:87) model buildings, vehicles, and paraphernalia. Peterboro's hypothetical population of 14,593 is spread over 43 square miles, with two fire stations (three fire engines, and ladder, command, utility, rescue, and ambulance vehicles; all staffed by fire and EMS personnel); a police department (three cars available per shift, with off-duty officers subject to recall); and a small community hospital with a 10-bed emergency department. Altogether, 40 buildings are present on the tabletop, located on six main highways, and a railroad spur is present in the northern section of the town. Any city or town could inexpensively duplicate this ingenious model to train first responders and hospital personnel to learn to work together in an emergency situation.

Participants in these tabletop exercises have included federal (e.g., USPHS, Federal Bureau of Investigation [FBI], FEMA, CT and MA ARNG WMD-CST teams, and the US Army Soldier and Biological Chemical Command [SBCCOM]), state (e.g., state police bomb squad, Department of Environmental Protection Haz-Mat team, and Office of Emergency Management) and local (e.g., police, fire, EMS, and physicians) responders. Although this is a good representation of first responders, a thorough exercise would also include other potential participants (e.g., morticians, medical examiners, media representatives) and key elected officials.

When players participated in a tabletop exercise at the fire academy, they were identified by reflective vests clearly marked with their role, i.e., Fire Department, Police Department, EMS, Public Safety, and so on. Some of the past tabletop exercise drills at the fire academy have also been "facilitated" by providing the participants' with walkie talkies all set to the same frequency. This scenario tests the ability of the participants to create and adhere to an ICS disaster response model.

Our tabletop exercise began with the participants introducing themselves to each other and observers, followed by a general situational briefing to set the groundwork for the scenario. The briefing explained the layout and logistics of the community of Peterboro and the resources in the town available for fire, police, EMS, and hospital personnel. Participants were then sequentially handed a preprinted timed situation card. The participant read the card aloud, and then decided on an appropriate response to the situation and whether to include other participants in the decision as required. The exercise lasted about 60–90 min, followed by at least 60 min for a public debriefing, discussion, and analysis of the response by participants.

3.1. Bioterrorism Model Scenario

For these drills, the scenario consisted of a fire in Peterboro, with concurrent inhalational smoke injuries, the need for building evacuation, victim rescue, and some minor injuries among the emergency responders. Twenty minutes into the incident, participants heard a loud bang. The noise hypothetically originated about a block away from the fire. Five minutes later, a pesticide truck was found near the incident site, which was then turned away from the site by law enforcement personnel directing traffic.

After the first responders and hospital personnel described their actions to participants and observers, the scenario was fastforwarded for two follow-up scenarios, where victims present with plague (24 h) and tularemia (48 h). The tularemia scenario that was used is described here:

- On days 2 and 3, both domestic and wild dead animals were noted around Peterboro. Hordes of deerflies were also noted in certain areas of the town. Early on day 3, six patients (three of whom were pediatric) presented to the hospital emergency room (ER): all had fever, headache, malaise, and three had a nonproductive cough. By that afternoon, four additional patients presented at the hospital ER with similar symptoms.
- Early on day 4, 10 additional patients (6 pediatric) presented to the ER with similar symptoms, although a few of the patients also presented with substernal chest discomfort and loss of appetite. Later that morning, 25 patients (10 pediatric) presented with similar symptoms, and an additional nine arrived who had nonspecific findings such as fever and complaints of malaise. By midday, about 100 patients presented at the ER; roughly half were ill with the same symptoms seen in earlier patients. Two of the patients had painful purulent conjunctivitis with cervical lymphadenopathy. Chest X-rays revealed pleural effusions in some of the ill patients. By the early evening of day 4, 30 additional patients presented to the ER; 10 of these had no obvious disease manifestations but were worried. Three of the patients seen at the ER the previous day suffered respiratory arrest. The supplies of antibiotics at the hospital had been exhausted. Laboratory results on the patients have proved inconclusive to date. None of the patients who had evidence of pneumonia with sepsis responded to streptomycin therapy.
- By day 5, 35 more ill patients with similar symptoms presented to the ER, as well as 15 who had no obvious physical findings but were concerned. Also on day 5, an anonymous phone call to a local radio station claimed that "all unbelievers will soon perish in an apocalypse." One patient's chest X-ray revealed mediastinal lymphadenopathy. A lab technician who has handled some clinical samples developed pneumonia. During this day, a Gram-negative coccobacilli was identified from blood cultures and an immunofluoresence assay of a patient sputum sample revealed the presence of *Francisella tularensis*.
- On day 6, 10 of the patients seen in the past 3 d suffered respiratory arrest. Before the end of the day, more than 200 additional patients presented to the hospital ER, the majority of whom had a pneumonic process.
- On day 8, a serum sample rushed to Centers for Disease Control and Prevention (CDC) was determined to have an elevated titer for *Francisella tularensis*. There were 23 fatalities on this day, all from patients who had been ill since day 3 and had either self-medicated at home or had delayed antibiotic treatment.

3.2. Exercise Review and Lessons Learned

Immediately after the exercise was conducted, all participants and observers participated in an open forum to evaluate the response to the scenario. Among the lessons learned through evaluations from this tabletop exercise were:

- The initial presentation of nonspecific flu-like symptoms that were caused by a bioterrorism agent was not likely to alarm hospital emergency physicians in the initial stages of the outbreak. In this type of event, concern that a bioterrorism event had occurred would only come after a certain critical mass of patients presented for care. Astute emergency department staff may observe an additional patient influx and report this directly to state health authorities. Daily reporting to the state health authorities from a hospital-based syndromic surveillance system should have detected an increase in cases of a nondescript illness. This type of reporting is important to public health bioterrorism disease detection. The system should be sensitive enough to detect cases spread throughout a state's hospital system when sick individuals present to at different healthcare facilities.

Although syndromic surveillance models have been developed *(29)*, public health agencies have been left to construct their own unique models for syndromic surveillance of biological terrorism (BT)-associated diseases to meet their own needs.

- Hospital antibiotic stores can be exhausted rapidly. A system designed to alert state health authorities when unusually large amounts of antibiotics are used by hospitals should be put in place.
- All aspects of the hospital emergency response plan must be activated immediately once it is recognized that resources have become overwhelmed. Rapid establishment of hospital crowd control measures and of a public information office need to be in the plan.
- Chaos can evolve quickly and is best controlled by participant adherence to the ICS *(30)* and the HEICS *(31)*. These systems provide the framework for an organized response to a disaster by first responders and medical personnel. Both the public health and emergency management participants in a BT response have much to learn from these emergency response models.
- Should a large bioterrorism incident occur, the hospital personnel and materiel resources could be rapidly overwhelmed. Both the hospital and state contingency plans should plan for this.
- All first responders and medical personnel need to be attuned to unusual events, potential exposures, and patient symptoms. For example, inadvertent exposure to droplets and respiratory secretions from individuals with pneumonic plague may result in cases among healthcare providers and hospital personnel.
- Healthcare personnel must immediately notify the FBI when exposure to or use of a bioterrorism agent is suspected. This is of vital importance for the criminal and epidemiological investigations that must occur when there is a the purposeful use of a deadly pathogen. Coordinated criminal and epidemiological investigations are of vital importance and should occur simultaneously to identify ill and exposed individuals as well as to assist in the identification of those responsible for a BT event *(32)*.
- Local logistic expertise is vital to incident response. When logistics support fails, all aspects of the response fail, including the EMS system *(33)*.
- The state emergency operations center should be able to be activated at short notice. This is essential for the statewide coordination of emergency, medical, logistic, and other resources as needed by response personnel.

4. LESSONS LEARNED FROM A RECENT INTENTIONALLY SPREAD EPIDEMIC

A surreptitious small-scale biological attack occurred in the United States from September through November 2001, when spore-laden envelopes of *Bacillus anthracis* were sent to persons in the media and to the offices of two US Senators *(34)*. As a consequence, at least 23 individuals became ill from the handling of anthrax-tainted letters. Of those exposed, seven were confirmed (four others were suspected, but not confirmed) as having cutaneous anthrax, and 11 were confirmed as having developed inhalational anthrax. Five deaths occurred among those with inhalational anthrax *(35–37)*.

This act of bioterrorism created huge media interest *(34)*, perhaps in part because of the difficulties in responding to a bioterrorism scenario that was not previously anticipated. Among the misunderstandings about the bioterrorism use of anthrax were *(38)*:

- The historical death rate of virtually 100% among those having inhalational anthrax may be overestimated should extraordinary modern medical care be available.
- The lower limit of spores necessary to cause illness was (and is) not well-understood and may depend on other factors such as age, immunity status, and/or the presence of comorbid conditions.

- Public health authorities and government officials attempted to allay the fears of the public but messages were inconsistent, did not occur in real-time, and were sometimes contradictory.
- Medical and criminal investigations were not well-coordinated.
- Laboratories were rapidly overwhelmed with samples to rule out anthrax.

Many of these deficiencies have been identified previously through bioterrorism exercises *(20,39)* or predicted by modeling *(40)*. A study of anthrax dissemination from envelopes containing *Bacillus globigii* determined that significant amounts of respirable aerosol particles are released when an envelope is opened that contains as little as 0.1–1.0 g of bacterial spores *(41)*. Deficiencies in the governmental response to an unanticipated bioterrorism event may be addressed through the development of comprehensive response plans and an increase in public health response capacities.

Although no one (except perhaps a future perpetrator) can predict what biological pathogen(s) will be used against an unsuspecting target and how it will be used, the public has been sensitized to the intentional use of infectious disease agents as weapons following the events of late 2001.

5. COMPONENTS OF AN EFFECTIVE BIOTERRORISM RESPONSE: DEVELOPMENT OF BIOTERRORISM RESPONSE PLANS

The most comprehensive response plans developed to date to prepare for the use of biological weapons against a civilian population has been the Biological Weapons Improved Response Project (BW-IRP) as developed by the SBCCOM *(42)*. This program was developed to provide enhanced support to improve the capabilities of state and local emergency response agencies to prevent and respond to terrorist incidents involving WMDs at both the national and local levels *(42)*. BW-IRP publications include assessments of hospital resources and preparedness *(43)*, government preparedness for a smallpox outbreak *(44)*, the integration of public health and law enforcement in a bioterrorism investigation *(45)*, and an integrated approach to emergency medical response *(46)*.

Although this work has been transitioned to the US Department of Homeland Security, the templates that have been developed are invaluable for state and local biological weapons preparedness planning *(47)*. These outstanding templates should be more widely distributed to federal, state, and local government personnel to prepare for a BT event. For example, the BW-IRP's Criminal and Epidemiological Investigation Report *(45)* demonstrates how to improve coordination of an investigation between public health and law enforcement personnel, which is one of the key problems mentioned by Altman and Kolata in their article describing miscalculations that occurred with the anthrax letter investigations *(38)*.

An uneasy association exists at times between public health and law enforcement. Law enforcement (especially the FBI) has the lead role in bioterrorism crisis management and criminal investigation. Public health and law enforcement personnel must learn to work together and to appreciate each other as vital components of the investigative team for a bioterrorism event. Law enforcement personnel can gather much case-specific information for an epidemiological investigation and public health personnel can obtain information of use to the criminal investigation. Information of mutual interest to public health and law enforcement includes obtaining personal historical activities data from those who are ill and uncovering the nature of the incident or exposure that caused the illness *(45)*. Both the epidemiological and criminal investigation represent unique opportunities to obtain information that may be relevant to discovering the cause and source of a bioterrorism event and could also lead to early identification of those potentially exposed to a biological agent.

5.1. Pharmaceutical Supplies for Bioterrorism

Pretreatment (e.g., vaccination, chemoprophylaxis) is of limited use for many of the primary threat agents when used in a bioterrorism event *(2)*. Medications and medical supplies to be used in the response to biological attack need to be available for rapid deployment to any part of the United States. Therefore, the prepositioned Strategic National (pharmaceutical) Stockpile (SNS) is of primary importance in the medical response to a bioterrorist attack *(48)*. Delivery and distribution of the SNS should be part of the scenario response evaluation for a bioterrorism tabletop exercise. State medical authorities and civil defense, emergency preparedness, and pharmaceutical authorities need to work together for the SNS acceptance at the point of delivery. These agencies also need to designate responsibility for the pharmaceutical and patient monitoring process, as well as the delivery of medication where it is most needed. The SNS initially was deployed in response to the events of September 11, 2001, in New York City subsequent to activation of the Federal Response Plan *(49)*.

Mass prophylaxis must be preplanned, and needs to include *(48)*:

- Identification of responsibility for receipt of SNS.
- Designation of licensed health professionals to receive the controlled substance portion of the SNS.
- Identification of an appropriate airfield for incoming pharmaceutical and medical supplies.
- Acquisition of cargo handling equipment.
- Acquisition of secure storage facilities for breakdown and repackaging supplies.
- A tracking system that will enable SNS asset deployment.
- Logistics determinations including who will supply trucks and provide personnel to move supplies to distribution sites.
- Establishment of communication links between all key personnel/facilities dealing with SNS distribution and identifying contact personnel.
- Acquisition of baseline patient data and tracking of patients who receive chemoprophylaxis.

5.2. Veterinary Disease Surveillance

Veterinary and food surveillance for zoonotic pathogens is important for bioterrorism preparedness. Participants from the State Veterinarian's and Public Health Veterinarian's agency should be included in bioterrorism planning and training exercises. Some of the diseases associated with bioterrorism are endemic in the United States. Recently, both the ingestion of anthrax-contaminated meat *(50)* and a case of cutaneous anthrax *(51)* have occurred because of nonpurposeful naturally occurring anthrax exposures of animal origin. Anthrax, tularemia, Q fever, brucellosis, and pneumonic plague all can be acquired from wild or domestic animals. It is important to rapidly determine whether a disease is naturally acquired or the result of purposeful events caused by potential biological warfare agents. With the heightened awareness of bioterrorism, the recent naturally occurring incidents of brucellosis *(52)* and tularemia *(53,54)* have also been intimately examined for the potential of having been purposeful events.

5.3. Epidemiological Surveillance

Epidemiological surveillance for bioterrorism must operate continuously to be effective and should be sensitive enough to detect abnormal disease activity in a population, whether from a nonendemic disease (e.g., anthrax in postal workers) or an increase in a naturally occurring disease that has been purposefully introduced (e.g., hundreds of salmonellosis cases in Oregon) *(7)*. Databases that may be monitored include hospital admissions, 911 calls, unexplained deaths, use of over-the-counter medications, emergency department volume, and selected emergency department discharge diagnoses. The surveillance system must also possess the specificity to detect *any* of the reportable bioterrorism diseases. Although it is possible to construct a passive disease monitoring system to detect disease levels above those anticipated, it is exceedingly difficult to construct a passive surveillance system with specificity for bioterrorism diseases that identifies patients exposed to life-threatening illnesses with rapid symptom onset in time to administer potentially life-saving treatment or prophylaxis. The recent cases from exposure to anthrax-contaminated mail demonstrate this point *(35,36)*. Only an extremely rapid response can diagnose and identify cases of inhalational anthrax and pneumonic plague; however, this still may not be possible, even under the best of circumstances.

Initial disease detection, investigation and response usually occur at the local health department level *(55)*. An active epidemiological bioterrorism surveillance system includes the intense search for new or nonreported cases. An enhanced regional or statewide epidemiological surveillance system should be instituted following the report of any bioterrorism-related illness. Enhanced surveillance may uncover cases in areas where they have not yet been identified. To accomplish this, public health personnel must communicate with hospital infectious disease specialists; infection control managers; emergency, pharmacy, and laboratory departments; and nontraditional investigative partners such as veterinarians, medical examiners, funeral directors, law enforcement personnel, and others. Any profession that can contribute information toward the identification of new cases, those exposed to an infectious agent, and the origin of the disease are important allies in the public health investigation of a bioterrorism event.

5.4. Coordinate and Track Clinical and Laboratory Surveillance Activities

Laboratory capacity is a vital part of the public health network and is necessary to discover and respond to the occurrence of a bioterrorism event *(56)*. Electronic laboratory-based reporting is currently being developed and integrated into the public health infrastructure of seven states through CDC grant funding *(57)*. Perhaps the most important surveillance activity within the acute care hospital is the interaction between the hospital-based clinician and the clinical laboratory. However, even the best-designed reporting system can produce erroneous results. Misidentification errors, reporting errors, and lack of laboratory or clinical understanding or ability to characterize the pathogen all can contribute to pathogen misidentification or mischaracterization and have severe consequences for the patient *(58,59)*. In November 2001, although 10 inhalational anthrax cases had already occurred nationally in a 2-mo period *(35)*, a Connecticut hospital laboratory with a finding of Gram-positive rods isolated from a blood culture of a seriously ill patient did not report this discovery to state health authorities until 2 d later *(37)*. This laboratory finding was in fact from the 11th national case of inhalational anthrax. The nonreporting of this isolate to state authorities is perhaps not surprising, given that the finding of Gram-positive rods in a bacterial culture from a clinical specimen is routinely considered a contaminant. To be successful, active syndromic surveillance must incorporate laboratory reporting and seek to inculcate timely and accurate laboratory identification of bioterrorism pathogens. In the case of bioterrorism, the fear of reporting a false-positive should be overweighed by the necessity for enhanced alertness by other clinical laboratories in the reporting state.

5.5. Use of Quarantine

Certain highly contagious infectious diseases on the bioterrorism threat list (e.g., pneumonic plague, smallpox) necessitate the use of isolation and possibly quarantine measures and travel restrictions. The issues surrounding these extreme public health measures should be considered if these diseases are modeled in a tabletop or field exercise. A rapid response is of utmost importance. Should a highly contagious disease be released on a civilian population, a very small amount of time exists in which to detect and verify the infection, locate the time and place of attack, identify the affected population, and begin intervention *(40)*.

Rapid evaluation of the outbreak can determine the extent of exposure and help develop the most effective disease containment strategies. Public health authorities must conduct a thorough search for those exposed and for close contacts of those infected (e.g., immediate household members). Other important tasks include the identification and/or estimation of the population at risk and the development, in advance, of protocols for isolation and surveillance of cases. Hospital and public health authorities need to maintain case ascertainment surveillance data and conduct active prospective disease surveillance.

5.6. Psychosocial Effects

The importance of psychosocial effects was driven home by the horrific events of September 11, 2001. The entire nation felt the impact of the terrorist attacks. The psychosocial effects of an infectious disease outbreak on a large population was demonstrated during the 1994 pneumonic plague outbreak in Surat, India *(60)*. This outbreak caused an exodus of 600,000 people from the city of Surat, followed by a mass anxiety in the city of Delhi, about 600 miles away *(60)*. Hospitals in Delhi became flooded, and "chaos reigned supreme, rumor was the ruler" *(60)*. One important effect of fear and uncertainty was the purchase and hoarding of tetracycline. Similarly, there was a substantial increase in ciprofloxacin use in the United States following the anthrax spore mailings in 2001, and a resulting shortage in certain areas.

It is probable that for every person seeking care in a hospital for physical injuries or infection following a biological or chemical terrorist incident, at least 6–10 will present with psychological concerns *(61)*. Therefore, management of psychological casualties following a WMD incident must be incorporated into a tabletop exercise or live disaster drill. The use of bioterrorism in particular presents complex psychosocial challenges for a civilian population *(62)*. Features of bioterrorism may make group panic more likely *(62)*. Importantly, a lack of realistic training increases the possibility of a disorganized, ineffective response that will heighten the public's fear and break down trust in public institutions *(62)*. Even in the recent anthrax scare, some in the postal system were questioning the recommendations of the federal public health authorities.

5.7. Media Relations

Closely tied to psychosocial effects are the methods used by government officials when dealing with the media. Both the style and content of the news that people receive will influence how they react to news of a WMD event *(63)*. Some of the potential problems are illustrated by the response to media coverage of the Chernobyl accident *(64)*. Those who generate or transmit news should be intimately familiar with and use sound principles of risk communication. One useful source is an emergency response communications plan for bioterrorist events that has been written with input from the principal US public health and emergency response organizations and subsequently distributed to all state health department communications offices *(65)*.

A website for effective risk communication is maintained by the CDC's Agency for Toxic Substances and Disease Registry (ATSDR) at http://www.atsdr.cdc.gov/HEC/primer.html., and other websites have been specifically designed to provide information on bioterrorism-related issues (e.g., http://www.psandman.com/col/part1.htm). Government officials need to express empathy to the affected communities and not merely provide facts; they must also appreciate that the public's desire for risk knowledge may be different from an expert's opinion *(63)*. Information provided to the media by official sources should be accurate, honest, and timely *(63)*.

Given the impact that the media has on any disaster event, it would behoove tabletop or field exercise participants to include media representatives. Any fear of dealing with the media should be negated by the fact that the media is also the vehicle through which large numbers of people can be spoken to on an immediate basis *(66)*.

5.8. Hospital Needs

Community hospitals are a vital partner in the identification, triage, and treatment of those affected by bioterrorism. Rapid casualty care is of utmost importance immediately subsequent to a mass casualty incident. Patient transportation needs will increase greatly and the local EMS may become readily overwhelmed. Any bioterrorism exercise should consider auxiliary replacement of casualty transport through the use of state military or other resources. A statewide communications network should be in place to provide advance notification and coordinate movement to hospitals of incoming casualties *(43)*.

Hospitals should take the following initiatives to best prepare for a bioterrorism event *(43)*.

- Address casualty admission until maximum capacity is reached.
- Be able to redirect noncritical admissions.
- Conduct patient screening, triaging, and release of asymptomatic individuals, based on potential for exposure and illness.
- Obtain pertinent information for public health personnel.
- Establish contacts and agreements in advance with law enforcement so that information can be shared in a crisis situation.
- Identify a backup or overflow emergency evaluation and triage facility.
- Establish alternate care.

- Identify infection control capabilities.
- Establish training programs to decrease the potential that hospital personnel might also panic or fear their own safety from patient contact.

5.9. Mortuary Concerns

Fatality management is an important concern associated with the use of a bioterrorism agent. Disaster planning should always incorporate the state mortician's associations and the state medical examiner's office. During a catastrophic disaster, it is important to maintain a mortuary registry of similar deaths, manage familial visits, use morgues to provide central processing, establish long-term fatality storage facilities, determine final disposition for fatalities, establish family assistance centers, implement mass cremation if necessary, coordinate release of remains to families, and establish temporary internment options as appropriate *(43)*.

6. RECOMMENDATIONS FOR THE FUTURE

According to Congressional Subcommittee testimony given in July 2001: "We're much more likely to have low-consequence scenarios—the kind of thing that the guy down the street will do if he's mad at his neighbors or the IRS, and that won't be anthrax. You can't do smallpox or weaponized anthrax in your garage" *(67)*. Following the events of purposeful release of anthrax from September through November 2001, this statement may demonstrate the difficulty of predicting with any certainty a future terrorist scenario. However, those tabletop exercises that involve as many of the various local, state, and federal emergency response partners as possible should promote understanding between participants and help them to acquire the skills necessary to develop a team response approach to a WMD event.

It would be especially useful at this time to establish a national WMD bioterrorism gaming/exercise think-tank. This type of group could develop reasonable scenarios that could be used by state and local offices of emergency preparedness and health departments to consider likely resource-demanding events. The military model for these activities has been incorporated into war gaming training curricula with great success *(68)*. Incredibly, the collapse of World Trade Center by a terrorist group was predicted during a 2000 scientific symposium: "…not just disruption and some damage to the World Trade Center towers in Manhattan but the total destruction of both buildings and the surrounding area" *(69)*. However, this advice was not published until after the events of September 11, 2001.

7. CONCLUSION

First responders, hospital, health department, and law enforcement personnel from local, state, and federal agencies need enhanced training for bioterrorism events. Unique challenges are presented by the purposeful use of a biological pathogen on an unprotected and unsuspecting population. The training gap must be addressed at the local, state, and federal response level. This can be best accomplished if comprehensive bioterrorism response plans are developed and regular mutual training exercises occur. One productive format for mutual training in anticipation of a bioterrorism event is the use of a tabletop exercise. This scenario-driven training is quite flexible and can incorporate the training goals of the participating agencies. Importantly, a scenario can be devised to reflect the difficulties that will be encountered during a bioterrorism event, including laboratory and clinical identification of the disease, abnormal case-patient load, acceptance and distribution of the national pharmaceutical stockpile, monitoring the spread of disease, and a host of other community, state, or areawide problems. Once a comprehensive bioterrorism plan has been developed and training and resource gaps have been identified through conducting multiple tabletop exercises, one or more field exercises should be conducted to assess the ability of all participating agencies to respond in person to a bioterrorism event. Through plan development and training by use of comprehensive tabletop and field exercises, the various agencies involved will come to understand each others' organizational abilities and roles in response to these events. Although predicting the next bioterrorism event is difficult, if not impossible, there is no excuse why the organizations that are responsible for responding to such a crisis can not now develop and practice plans and response.

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