Appendix A

CATASTROPHIC TERRORISM SCENARIOS

INTRODUCTION

This appendix describes the six types of scenarios that were created to examine the effects of catastrophic terrorist attacks: outdoor chemical release, indoor chemical release, dirty bomb, nuclear detonation, anthrax release, and smallpox release. The goal of these scenarios is to highlight the needs of individuals during such events by identifying the potential effects of the attacks. The scenarios do not assume the implementation of any individual strategy. To achieve catastrophic effects, the scenarios involve attacks with various weapons of mass destruction. They are based on a combination of previously existing scenarios, historical experiences, models, and publicly available literature. Estimates of exposures, casualties, and fatalities are included only to gain a sense of the impact on various services and infrastructure critical to individuals. These order-of-magnitude estimates should not be construed as the results of a rigorous evaluation of weapons effects. They merely represent a point in the range of possible effects.

We attempted to make the consequences of the various types of attacks plausible. We did not assess the probability of the attacks. In addition, there are many variations of how these weapons could be used and often much debate over the extent of the effects. Our analysis seeks solely to ascertain the needs of the individual, which we concluded to be sufficiently similar across variations in the scenarios.

Each scenario is organized as follows. First, a brief overview of the scenario is given in the background. Second, the event history describes the details of the attack and its consequences. Next, the scenario timescale is mapped to delineate the different periods of the attack—i.e., before, during, and after (the methodology for determining each of these is described below). Finally, an exhaustive examination of the effects of the attack on services, infrastructure, and other dimensions is summarized.[1]

To estimate timescales for each of the scenarios, we developed two timelines. The first is the actual timeline, which defines when the events occur from an "all-knowing" perspective. The second timeline estimates when individuals become aware and/or affected by events. In each timeline, "before," "during," and "after" periods were defined. To estimate when these periods occur, the following steps were taken for each scenario:

- The "before" period starts at any point prior to the attack.
- The time that the attack actually occurs is the end of the "actual before" period and the beginning of the "actual during" period.
- Because individuals may not be aware of an attack until after some time delay, the "perceived before" period ends and the "perceived during" period begins when people become aware of the attack. Note that this period is defined by when the general population, not authorities, becomes aware of the attack by direct experience, communications, or media.
- The "after" period begins and the "during" period ends when the agent used in the attacks is no longer a threat to the public and/or infrastructure. The "actual" and "perceived" "after" periods always coincide. This is based on the assumption that authorities will be sufficiently aware of the conditions in the affected areas to accurately determine the risk to the public.

It is important to note that in each scenario critical parameters affect the timescales. For example, the amount of agent used and its persistence are critical to determining the amount of time necessary to decontaminate the affected areas. Thus, the timescales estimated below should be treated as broad estimates for the type of agent considered.

In addition, in some scenarios the "after" period could have a large uncertainty associated with the estimate. For example, it is difficult to predict with any degree of certainty when a smallpox outbreak would completely cease. Thus, the estimated end for the "during" period does not indicate that smallpox cases have ceased but rather that they have diminished to a point where further outbreaks are not a major risk to the public and infrastructure.

---

[1]The economic impact of the various attacks was not considered because it is not critical to an individual's survival.

SARIN SCENARIO—AEROSOLIZED RELEASE BY A TRUCK IN A CITY

Sarin Scenario—Background

This scenario examines a sarin attack delivered by a truck sprayer just upwind of a prominent building in a city with a population of 1 million to 5 million people:

- A sprayer truck upwind of a prominent landmark releases 100 kilograms of aerosolized sarin.
- If a person inhales a lethal dose of sarin, death follows within a few minutes.
- The cloud spreads downwind at a rate of about 10 kilometers per hour from the west. After it travels approximately 2.5 kilometers downwind and about three-quarters of a kilometer cross wind, it becomes diluted enough that the agent is no longer a threat. Within the affected area, the agent remains effective up to four hours.
- The affected area is an ellipse about 2.5 kilometers long and 1.5 kilometers wide. Approximately one-quarter of that area has enough agent that 50 percent of those exposed will be injured or die. In the remaining area, about 10 percent of those exposed will be injured or die.
- News of the attack at the prominent building hits radio and television media within 15 minutes of the first release.

Table A.1

Parameters of Aerosolized Sarin Scenario

Parameter	Scale
Footprint (km^2)	3
Number of people exposed	30,000
Number of people injured (without preventive measures)[a]	3,000
Number of fatalities without preventive measures or treatment	100
Number of fatalities with prevention or treatment	?

[a]Number of people injured and killed assumes no protective measures are taken before or are in effect during the attack.

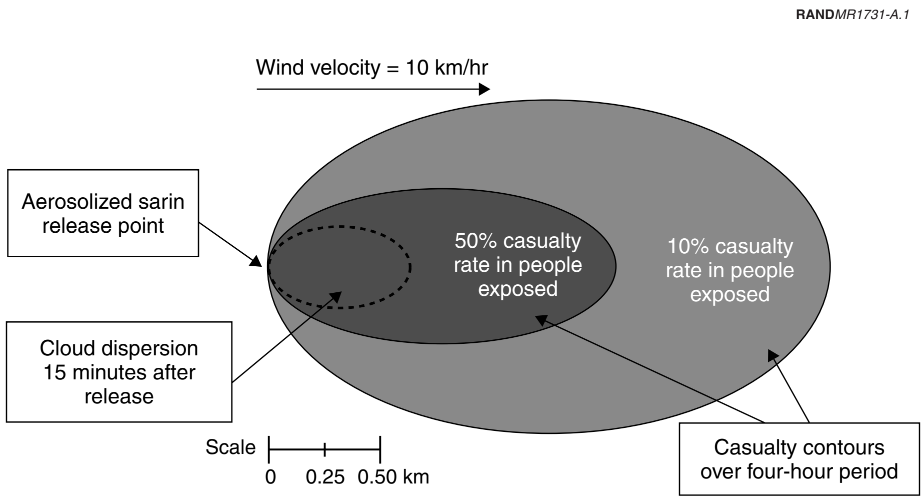


Figure A.1—Casualty Contours of Aerosolized Sarin over a Four-Hour Period

Table A.2

Sarin Scenario—Event History

Time	Events		
10:00 a.m.	A truck with a sprayer releases 100 kilograms of aerosolized sarin upwind of a prominent landmark.	No specific warning of the attack was given.	The attack is initially undetected.
10:05 a.m.	The first people begin to show symptoms. Symptoms include difficulty breathing, tightness in chest, vomiting, headache, drooling, runny nose, convulsions, and bleeding from nose and mouth.	First fatalities occur within one to ten minutes of inhaling the aerosolized sarin.	
10:10 a.m.	Increasing number of people around the landmark begin to fall victim to the aerosol.	The earliest first responders begin to arrive but are overcome by the aerosol.	The media begins to broadcast the first news of the attack, but are unsure of what agent was used.
10:10 a.m.	The toxic cloud continues to drift slowly to the East with the prevailing breeze of 10 km per hour.		
10:15 a.m.	Widespread media reports about a poison gas attack at the landmark.	Aerosol cloud begins to affect people around the office buildings east of the landmark.	First responders determine that a chemical release occurred. Casualties continue to mount there but fatalities begin to taper off.

Table A.2—continued

Time	Events		
10:15 a.m.	People inside buildings are better protected than those outside.		
10:20 a.m.	Media reports indicate that a chemical was released around the landmark and it is spreading. Network television news broadcasts cover the story but place less emphasis on providing instruction on what people in the affected areas should do. Local news and radio warn people in office buildings and houses near the landmark to take precautions.	People near the cloud, particularly those in the open, continue to be affected.	Some people in unaffected parts of the city self-evacuate the area on receiving the news of a chemical release.
11:00 a.m.	The cloud has spread 2.5 km east of the landmark and is 1.5 km wide. It will continue to spread, but will have been diluted enough that it has no effects outside of the 3 km^2 area.	Within the affected area, the effectiveness of the aerosol begins to degrade.	Through the media, city and federal officials continue to urge people to take precautions and outlines what the precautions should be.
12:00 noon	The effectiveness of the aerosol has largely been eliminated through dispersal in the air and environmental degradation.		
2:00 p.m.	The sarin has completely lost its effectiveness.		

Sarin Scenario—Timescales

- During: The during period for the actual and perceived timelines for many chemical scenarios will almost coincide. The timeline below shows a 15-minute difference between the actual and perceived attack. For many, this difference could be much shorter. The time difference between the perceived and actual timelines will decrease with distance from ground zero.
- After: While the sarin aerosol becomes ineffective after four hours, authorities will likely need 8 to 20 additional hours to investigate before allowing people back into the affected area. Extensive decontamination is not necessary since sarin is not persistent.

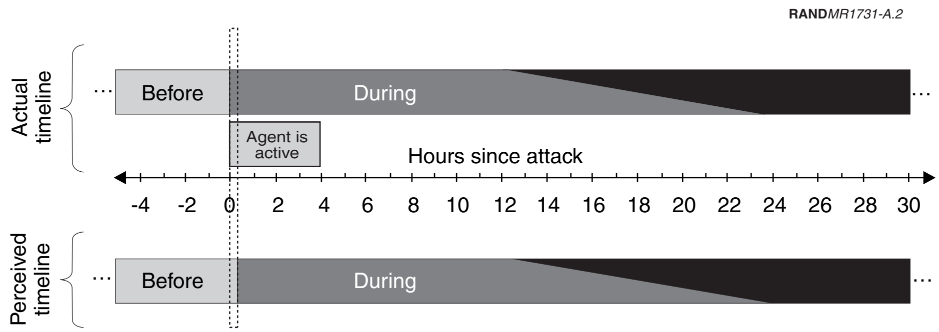


Figure A.2—Timeline of Sarin Scenario

Table A.3

Sarin Scenario—Summary of Effects

Weapon/agent	Aerosolized sarin release in a city.
Disruption of emergency services	
Law and order	First responders on the scene will be overwhelmed by the aerosol. Hazmat units take a little time to determine what the cause is. Not all law enforcement personnel will have personal protective equipment readily available. Will have an important role to play in warning people before the cloud arrives. Must deal with mass anxiety, spontaneous self-evacuation of the area, and establishing exclusion zones.
Fire services	First arriving units are overwhelmed by aerosol. Some put on their tanks and masks and are able to operate. Subsequent units are better prepared but hampered by the time limits of their air supplies.
Hazmat teams	Identify agent and characterize the cloud.
EMS	First arriving units are overwhelmed by aerosol. Many do not have personal protective equipment.
Disruption of health services	
Medical care	Overwhelmed with thousands of victims. Stressed by people exhibiting psychosomatic symptoms. Strained by decontamination issues.
Public health	Epidemiologic investigation is straightforward. Education is the largest issue. Quick recovery, but monitor those exposed for long-term effects.
Behavioral health	Initial confusion and anxiety. Possible depression and posttraumatic stress disorder issues. In addition, long-term neuropsychological deficits (cognitive, problems with emotion) might be significant.
Mortuary services	No major impact. Bodies are not hazardous.

Table A.3—continued

Disruption of infrastructure	
Power (electricity, gas, heat, etc.)	NA
Transportation	Potential for widespread anxiety, crowd control issues as some flee the city, but expected to be short-lived given the short duration of the attack.
Shelter	NA
Water and sewerage	Public may need to be reassured that water supplies are not contaminated.
Food	NA
Disruption of sanitation services	
Trash	NA
Biowaste	NA
Disruption of communications	
Telephone, TV, radio, computer, etc.	Cell phone, landlines, and e-mail might be overwhelmed, but short duration of attack reduces load quickly.
Environmental safety	
Clean air	Contaminated air disperses quickly. Agent can linger for about one to four hours depending on environmental conditions.
Soil, ground, and surfaces	Sarin on the soil degrades and loses its effectiveness after several hours.
Time to recovery	Initial recovery likely to take 24 hours. Decontamination of affected area not necessary; agent will dilute and lose effectiveness within 4 hours.
Evacuation needs/actions	Spontaneous self-evacuations of the area might cause traffic problems. Officials do not order evacuation of any area.
Quarantine	NA
Simultaneity	Multiple attacks could lead to panic as people might try to leave city. Could affect self-evacuation routes if events are close. Could also affect arrival of regional/federal resources. Potential to further strain hospitals.
Surprise nature	No warning time of the initial attack, but after the first 15 minutes, media warns others nearby to take precautions. This could be considered a warning for people located outside the dashed line in Figure A.1.
Threat of further attacks	Threats may cause people to self-evacuate affected city and perhaps other urban areas.
Lethality	
General (number of fatalities/injuries)	Casualties—3,000 Fatalities—100
Personal (family members)	?
Cyber consequences	NA

HYDROGEN CYANIDE SCENARIO—RELEASE INTO OFFICE BUILDING

Hydrogen Cyanide Scenario—Background

This scenario examines an attack on an office building in a city with a population of 1 million to 5 million people carried out by mixing potassium cyanide (KCN) with sulfuric acid (H_2SO_4), both commercially available chemicals. The resulting chemical reaction creates hydrogen cyanide (HCN), which is a highly toxic gas. Terrorists posing as maintenance workers mix the chemicals on the roof of the building such that the resulting hydrogen cyanide is drawn into the air intake.[2] The hydrogen cyanide could spread throughout the building in five minutes or less (see Figure A.3) (BOMA, 2003).

Hydrogen cyanide gas has a faint almond odor, however, 20 percent to 50 percent of humans are incapable of detecting hydrogen cyanide in any concentration. Estimates for the LC_{50} (the concentration that would be lethal for 50 percent of persons exposed to it) of hydrogen cyanide range from 2,500 to 5,000 mg-min/m^3. People who survive exposure to hydrogen cyanide should not display any long-term health effects stemming from the exposure.

Table A.4

Building Parameters

Parameter	Value
Height of building	10 stories (30 m)
Occupancy of building	1,000 people
Floor area of building	22,300 m^2
Volume of building	68,000 m^3
Air changes per hour (ACH)	1.0
Air flow rate through ventilation system	5,650 m^3/min
Outdoor air intake rate	1,130 m^3/min
Outdoor air intake percentage	20%

[2]Gas could also be introduced at the ground level if the air intake is located there.

Table A.5

Chemical Parameters

Parameter	Value
LC_{50}	5,000 mg-min/m^3
Amount of KCN	82 kg (180 lbs)
Amount of H_2SO_4	34 liters (140 lbs)
Amount of HCN produced by reaction	34 kg (75 lbs)
Concentration of hydrogen cyanide inside building after 10 minutes	500 mg/m^3

Table A.6

Hydrogen Cyanide Scenario—Event History

Time	Events		
10:00 a.m.	Terrorists posing as building maintenance personnel mix sulfuric acid with potassium cyanide to form hydrogen cyanide gas. The hydrogen cyanide is drawn into the air intake on the roof of an office building.		
10:01 a.m.	Some of the occupants notice smell of burnt almonds.		
10:02 a.m.	The first people in the office building begin to show such symptoms as rapid breathing, dizziness, nausea, headache, and convulsions. People begin to evacuate the building via staircases and elevators.	Someone in the building pulls a fire alarm after having trouble breathing and seeing others collapse.	Several 911 calls are placed.
10:05 a.m.	The gas has reached almost all parts of the building.	Victims who were first to inhale lethal concentrations of the hydrogen cyanide die.	Timely evacuation of people is hindered by higher concentrations of hydrogen cyanide in staircases and elevator shafts.
10:07 a.m.	First responders arrive but have difficulty gaining access to the building interior. Emergency staircases are crowded with people trying to escape.	Some people have died in the stairwell. Evacuees argue over whether to leave those who have fallen for dead or try to assist them in evacuating.	

Table A.6—continued

10:10 a.m.	The chemical reaction has stopped producing hydrogen cyanide.	Hydrogen cyanide gas still exists inside the building, but concentrations begin to decrease.	First responders begin to create a perimeter around the building.
11:00 a.m.	Almost all of the gas has dissipated.	Some people inside the building survived the incident because they remained in areas of the building that had relatively little circulation.	

Hydrogen Cyanide Scenario—Timescales

- During: The during period for the actual and perceived timelines for the hydrogen cyanide scenario almost coincide. There could be a slight delay between the real and perceived timeline for people who are not the first to be exposed to some concentration of the gas. If an alarm is sounded, some people may be given a slight warning time (minutes).
- After: The hydrogen cyanide dissipates after about one hour. Authorities would likely keep the building closed to facilitate investigation, but extensive decontamination is not needed. In addition, people who were exposed to hydrogen cyanide and survived will probably not suffer any long-term adverse health effects.

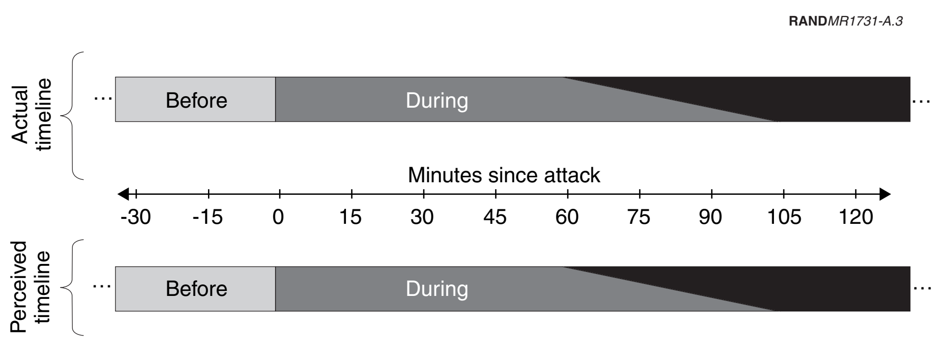


Figure A.3—Timeline of Hydrogen Cyanide Scenario

RANDMR1731-A.4

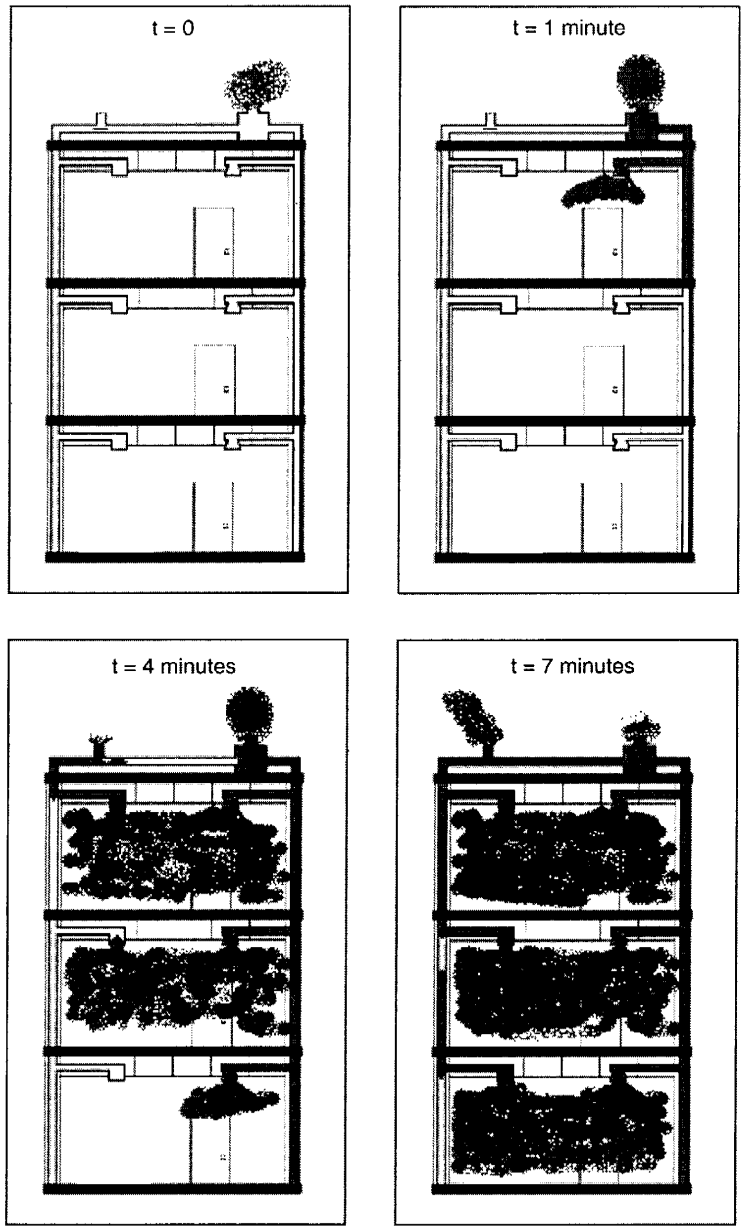


Figure adapted from *Advice for Safeguarding Buildings Against Chemical or Biological Attack*, Lawrence Berkeley National Laboratory, available at http://securebuildings.lbl.gov/printer.html, accessed on May 13, 2003.

Figure A.4—Hydrogen Cyanide Concentration Over Time

Table A.7

Hydrogen Cyanide Scenario—Summary of Effects

Weapon/agent	Hydrogen cyanide released into HVAC system of a building.
Disruption of emergency services	
Law and order	First responders on the scene will be overwhelmed by the gas. Will take hazmat units a little time to determine the cause. Not all law enforcement personnel will have personal protective equipment readily available. Responsible for establishing a perimeter.
Fire services	First arriving units are overwhelmed by gas. Some put on their tanks and masks and are able to operate. Subsequent units are better prepared but hampered by the time limits of their air supplies.
Hazmat teams	Identify agent and characterize any potential contamination.
EMS	First arriving units are overwhelmed by gas. Many do not have personal protective equipment.
Disruption of health services	
Medical care	Overwhelmed with hundreds of victims. Stressed by people exhibiting psychosomatic symptoms.
Public health	Epidemiologic investigation is straightforward. Education is the largest issue. Quick recovery.
Behavioral health	Initial confusion and anxiety. Possible depression and posttraumatic stress disorder issues.
Mortuary services	No major impact. Bodies are not hazardous.
Disruption of infrastructure	
Power (electricity, gas, heat, etc.)	NA
Transportation	Potential for widespread anxiety, crowd control issues as some might flee the city, but expected to be short-lived given the short duration and localized nature of the attack.
Shelter	NA
Water and sewerage	NA
Food	NA
Disruption of sanitation services	
Trash	NA
Biowaste	NA
Disruption of communications	
Telephone, TV, radio, computer, etc.	Cell phone, landlines, and e-mail might be overwhelmed, but short duration of attack reduces load quickly.
Environmental safety	

Table A.7—continued

Clean air	People in areas with less air flow fare better than those in areas with higher air flow. HVAC system dissipates the gas from the building in small concentrations over a few hours. Most of the gas is gone within one hour.
Soil, ground, and surfaces	Hydrogen cyanide disperses to nonlethal concentrations after approximately one hour.
Time to recovery	Building is safe for people to enter without protective equipment in less than one day. However, investigation will likely delay opening of building to the public.
Evacuation needs/actions	Difficulty evacuating the building. Potential for spontaneous self-evacuations of other buildings and/or parts of the city.
Quarantine	NA
Simultaneity	Multiple attacks could lead to mass anxiety as people try to leave city. Could affect evacuation routes if events are close. Potential to further strain hospitals.
Surprise nature	No warning time of the initial attack. After the fire alarm is sounded people know that there may be an emergency, however, they do not know the exact nature of the emergency.
Threat of further attacks	Threats may cause people to evacuate threatened buildings or stop going to work.
Lethality	
General (number of fatalities/injuries)	Potential exposures—1,000 Injuries—0 Fatalities—300
Personal (family members)	?
Cyber consequences	NA

RADIOLOGICAL ("DIRTY") BOMB SCENARIO—EXPLOSION IN A CITY

Dirty Bomb Scenario—Background

Physical Zones of Dirty Bomb Effects. A radiological weapon could be a relatively straightforward device in which a conventional high explosive is combined with a radioactive material and then exploded. There are two zones in such an explosion:

- Immediate zone: The surrounding area where the high explosive is detonated. Includes casualties from the explosion. Potential for large fragments of radioactive material to result in higher dose rates. People with shrapnel wounds have the potential for greater radiation exposure.
- Cloud zone: The area including the immediate zone and extending downwind where airborne radioactive materials are dispersed by the explosion. There are two primary categories of concern: latent cancer deaths years

after the incident stemming from short-term initial exposure (a few hours) during the incident and long-term contamination of the affected area.

In the immediate zone, the consequences are primarily caused by the explosion. While large fragments will increase radiation doses, it is very unlikely that any casualties will display symptoms of acute radiation sickness. Thus, there will probably not be any immediate fatalities as a result of a dirty bomb, other than those caused by the conventional explosive.

Types of Radiation. The nature of the potential health effects of nuclear radiation depends on the character of the radiation source. The three principle types of radioactive decay are shown in Table A.8.

Health Effects of Low-Level Radiation. The type of radioactive source used in a dirty bomb is the key factor that determines the nature of the consequences. While all radioactive material can be inhaled and pose health hazards, alpha emitters cause greater damage when inhaled. Because alpha particles are easily shielded, they only pose a hazard if they are inhaled or ingested. Inhaled radioactive materials can remain in the lungs indefinitely and continue to emit radiation. The danger of inhalation is likely to be on the order of hours. However, the consequences (e.g., cancer) of inhaling small amounts of radioactive materials that would likely result from a dirty bomb will probably not occur for decades, if at all.

Table A.8

Characteristics of Radioactive Decay

Type of Radiation	Characteristics
Alpha (α)	Alpha particles are very short range and are easily shielded by a single sheet of paper. Alpha particles cannot penetrate the outer layers of skin and are not an external hazard. Radioactive materials that emit them are an internal hazard if ingested or inhaled.
Beta (β)	Beta particles have a longer range and are less easily shielded. Aluminum foil or glass will stop beta particles. They can penetrate the outer layers of skin and are both an external and internal hazard.
Gamma (γ)	Gamma radiation has a very long range and is very difficult to shield. Unlike alpha or beta particles, gamma rays are electromagnetic energy waves (radio waves with a much shorter wavelength) similar to x-rays. Concrete, lead, or steel is needed to shield sources of gamma rays. The radiation can penetrate through the whole body. It is an external and an internal hazard.

SOURCE: NCRP, 2001.

Radioactive sources that emit high-energy gamma particles can create long-term contamination issues over large areas (greater than 500 square kilometers) because they are not shielded adequately by clothing or skin.

Radioisotopes of Potential Interest. There are a wide range of radioisotopes of potential interest and concern in addressing the prospect of a radiological weapon attack. Although an attack might in principle involve spent reactor fuel, it is more likely the radioactive source would be radioisotopes employed commercially (now or in the past) as sources of ionizing radiation in applications as diverse as medical diagnostics, medical therapy, sterilizing food and medical instruments, inspecting welds, and drilling for oil. Some are produced from the reprocessing of spent nuclear fuel. Others come from the direct irradiation of samples in nuclear reactors.

Most of the radioisotopes with current commercial applications emit high-energy gamma rays. However, some are beta particle emitters (some gamma emitters also incidentally produce beta particles) and some are alpha particle emitters. The effects of the different types of radiation on humans are very much a function of whether an individual suffers radiant exposure on the skin or inhales the radioactive material through breathing or ingests contaminated food. The radioisotopes of principal concern in terms of their applicability in radiological weapons are shown in Table A.9. The amount of radioactivity in a source is measured by the number of nuclear decays per second and expressed with a unit called the curie, which equals 37 billion decays per second.

Radiation Safety Standards. Various government entities have established radiation standards for public protection. These standards are based on a linear, no-threshold model for stochastic effects. In effect, these standards assume that low levels of ionizing radiation, well below natural background radiation, may cause an increased cancer risk. Considerable controversy has arisen within the health physics community whether the increased danger (in terms of risk of cancer) from low-radiation doses and dose rates, such as those expected from a dirty bomb, significantly affects the risk already present from natural background radiation. The issue is one of the validity of extrapolating from risks at high levels of radiation (based on experience and experiment) to low doses and low dose rates. As emphasized in the 1990 report issued by the National Research Council's Committee on Biological Effects of Ionizing Radiations Report (BEIR V), "it must be recognized that derivation of risk estimates at low doses and dose rates through the use of any type of risk model involves assumptions that remain to be validated" ("Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V," 1990). In effect, existing research data on low-level radiation effects are inadequate to either establish a safety threshold

Table A.9

Properties and Applications of Radioisotopes

Radioisotope	Half-Life	Type of Radiation: Alpha (α)	Beta (β)	Gamma (γ)	Application	Size of Source (curies)
Americium 241 (Am-241)	432 years	High-energy	NA	Low-energy	Oil exploration, soil testing, radiography (welds), moisture/density detection	0.03–22
Cesium 137 (Cs-137)	30 years	NA	Low-energy	High-energy	Radiation therapy, irradiation of products (blood, food, etc.), sterilization (medical instruments, etc.)	0.003–10,000,000
					Orphaned sources of the former Soviet Union used to examine the effects of radiation on agriculture	~ 3,000
Cobalt 60 (Co-60)	5.2 years	NA	Low-energy	High-energy	Radiation therapy, food preservation, sterilization, industrial radiography	0.003–10,000,000
Iridium 192 (Ir-192)	74 days	NA	High-energy	High-energy	Industrial radiography, high-dose-rate brachytherapy	3–135
Strontium 90 (Sr-90)	29 years	NA	High-energy	Low-energy	Low-dose-rate brachytherapy	0.01–0.11
					Radioisotope thermoelectric generators used in lighthouses of the former Soviet Union	30,000–300,000

SOURCES: *Categorization of Radiation Sources,* International Atomic Energy Agency; and *Commercial Radioactive Sources: Surveying the Security Risks,* Center for Nonproliferation Studies.

or exclude the possibility of no effects. As a result, in a radiological incident, state and local officials must make decisions in this context. Some agency standards are shown in Table A.10.

Modeling the Effects of a Dirty Bomb. The Lawrence Livermore National Laboratory Hotspot (Version 2.01) code has been used to produce simple deposition contours of radioactive materials from dirty bombs. The effects of two dirty bomb scenarios are examined for a city with a population of 1 million to 5 million people in the following section. These scenarios were chosen to illustrate:

- Scenario α: An attack that maximizes the area in which there is long-term (years), low-level residual radioactivity. This scenario creates issues of long-term contamination and raises the issue of relocation of people from a large area.

- Scenario γ: An attack that maximizes the initial radiation dose for a short period (a few hours) in a small region. This scenario demonstrates the necessity of taking appropriate shelter to avoid inhalation of radioactive materials. It also creates long-term relocation issues for a small area.

The initial parameters for the two scenarios are summarized in the Table A.11.

Table A.10

Standards for Radiation Exposure

Agency	Standard	Radiation Dose
EPA	Protective action guidelines: relocation standard for nuclear accidents	$<$2 rem for first year $<$0.5 rem each subsequent year $<$5 rem cumulative dose over 50 years
EPA	Regulation of cleanup of nuclear sites	$<$0.015 rem over first year
NRC	Annual relocation standard for general population	$<$0.025 rem over first year

Table A.11

Model Inputs

Parameter	Scenario γ	Scenario α
Radioactive source	Cs-137	Am-241
Source amount	10,000 Ci	50 Ci
High explosive	100 lbs TNT	100 lbs TNT
Half-life	30 years	432.2 years
Wind velocity (at 2 m)	5 m/s	5 m/s
Stability class (city)	C	C
Receptor height	1.5 m	1.5 m
Respirable release fraction	0.20	0.20
Respirable deposition velocity	0.30 cm/s	0.30 cm/s
Airborne fraction	1.0	1.0
Nonrespirable deposition velocity	8.0 cm/s	8.0 cm/s
Debris cloud top	240 m	240 m

Table A.12

Dirty Bomb Scenario—Event History

Time/ Day	Events		
10:00 a.m.	A car explodes on a highway in a major metropolitan area.	The explosion engulfs several nearby cars in flames.	Billows of smoke are carried downwind. Wind speed is approximately 5 m/s (11 mph).
	Scenario γ		Scenario α
	The smoke spreads downwind; however, this amount of Cs-137 is not sufficient to cause an initial hazard.		The smoke spreads downwind and causes an initial hazard estimated in Figure A.5 below. The cloud reaches all points in Figure A.5 in less than 20 minutes.
10:05 a.m.	A radiation detector on a fire truck arriving on scene alerts first responders that the explosion might have involved radioactive materials. They radio back to the fire department, police, and hazmat teams that the explosion could have been a dirty bomb.	Radiation detectors used by the first responders cannot determine the type or precise concentrations of radiation present. They begin to establish a perimeter surrounding the site of the explosion.	
10:15 a.m.	News of a dirty bomb explosion is released by the media.		
10:20 a.m.	Many residents spontaneously try to self-evacuate the city.	Highways and major roads experience extensive traffic delays caused by increased volume.	Reports are broadcast on the radio that additional explosions have occurred. Some of these reports are true, but many are false. None of the cases of additional explosions along highways involve radioactive material, but these incidents cause considerable panic in the bystanders.
11:00 a.m.	A hazmat team equipped with more elaborate radiation detectors confirms that a dirty bomb has been detonated.		

Table A.12—continued

	Local fire personnel or police release the following statement[a]: A release of radioactive material has been detected. The location of the release was ___________________. The highest levels of contamination are expected to be within the restricted area, which is also a crime scene. However, radioactive material may have been carried downwind beyond the perimeter of the restricted area. As a precaution, people within approximately five miles of the release location are advised to take shelter as quickly as possible. Appropriate protective actions include closing doors and windows and turning off ventilation systems. Officials will continue to monitor the area to establish the extent of contamination and determine the risk to the public. When it has been determined that the initial dispersal of radioactive material has ceased dispersion, officials will make another announcement to inform the public to exit shelters and ventilate buildings to minimize any potential settling of radioactive materials in structures. It is important that the movement of people into and out of the cordoned area is strictly controlled. Only members of the emergency services and local, state, and federal response forces are being allowed inside the area. The public should stay away to reduce the possibility of radiation exposure from this incident and to facilitate response efforts.		
12:30 p.m.	The public is informed that response teams have been working to identify the radioactive source(s) involved in the explosion and determine the clouds' characteristics. Aerial and ground surveys have been in progress since notice of a possible radioactive release was received.	Hazmat teams set up decontamination areas for first responders and those potentially directly exposed to radioactive materials.	

RANDMR1731-A.5

Am-241 (50 Ci)			
Region	Initial Radiation Dose from Exposure (rem)	Area (km^2)	Latent Cancer Deaths from Initial Exposure
Inner	2.5	0.037	1 death per 500 people
Middle	1.0	0.18	1 death per 1,250 people
Outer	0.25	1.0	1 death per 5,000 people

Figure A.5—The Initial Hazard of Americium 241

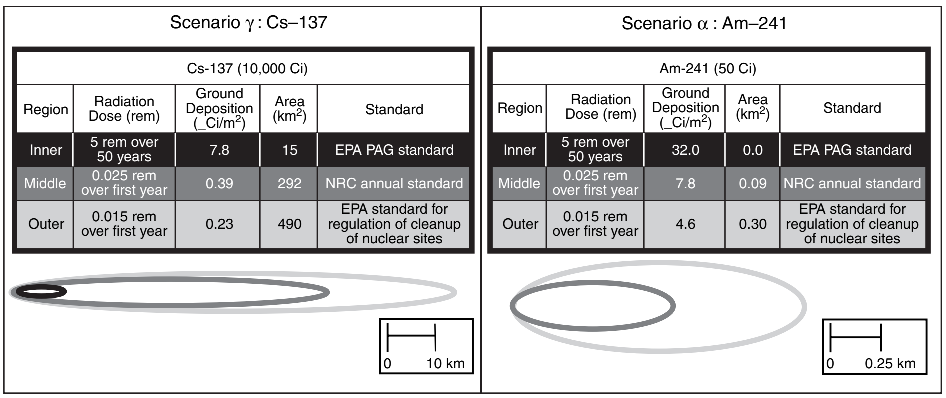
Table A.12—continued

	The following statement is issued by local emergency response personnel[a]: Until the amount of radiological contamination is determined, the following precautionary measures are recommended to minimize risk to the public: • Remain inside and minimize opening doors and windows. • Children should not play outdoors. • Fruit and vegetables grown in the area should not be eaten. • Turn off fans, air conditioners, and forced air heating units that bring in fresh air from the outside. Use them only to recirculate air already in the building. The inhalation of radioactive material is not an immediate medical emergency. In addition, taking potassium iodide (or KI) pills is not an effective treatment. Trained monitoring teams will be moving through the area wearing special protective clothing and equipment to determine the extent of possible radiological contamination. The dress of these teams should not be interpreted as indicating any special risk to those indoors. If you are outside, proceed to the nearest permanent structure. If you must go outside for critical or lifesaving activities, cover your nose and mouth and avoid stirring up and breathing any dust. It is important to remember that your movement outside could cause you greater exposure and possibly spread contamination to those already protected. Local, state, and federal personnel are responding to the potential terrorist attack. In the interest of public safety and to assist emergency response teams, authorities request that individuals within the vicinity stay inside, with doors and windows closed, unless advised to do otherwise by the police. Further statements will be made when there is more information. Please listen for announcements on local radio/television (name stations and frequencies). Check the Internet at (website).		
6:00 p.m.	A restricted zone boundary is created and access to this zone is controlled. Any people within the restricted zone are encouraged to relocate.		
Day 1	Ongoing surveying efforts have identified some areas that had been evacuated that are now deemed safe for citizens to reinhabit.	Decontamination and shielding evaluations are conducted for people who were not required to relocate. Procedures are suggested for reducing exposure to those who do not relocate.	
Day 3	Aerial and ground surveys have characterized the high-dose areas. The estimates for long-term contamination are shown for each scenario in Figure A.6 (note the different scales).		

Table A.12—continued

Day 4 to Year 50	Decontamination of affected areas.	Potential increase in cancer deaths due to initial exposure.	Potential increase in cancer deaths due to living in a contaminated area for an extended period exposure.
	The government will keep a catalog of people potentially affected by the radioactive materials and monitor their health status over time.	Authorities might call for relocation and/or decontamination of contaminated areas.	

[a]Adapted from NCRP, 2001.



Cs-137 (10,000 Ci)				
Region	Radiation Dose (rem)	Ground Deposition (_Ci/m^2)	Area (km^2)	Standard
Inner	5 rem over 50 years	7.8	15	EPA PAG standard
Middle	0.025 rem over first year	0.39	292	NRC annual standard
Outer	0.015 rem over first year	0.23	490	EPA standard for regulation of cleanup of nuclear sites

Am-241 (50 Ci)				
Region	Radiation Dose (rem)	Ground Deposition (_Ci/m^2)	Area (km^2)	Standard
Inner	5 rem over 50 years	32.0	0.0	EPA PAG standard
Middle	0.025 rem over first year	7.8	0.09	NRC annual standard
Outer	0.015 rem over first year	4.6	0.30	EPA standard for regulation of cleanup of nuclear sites

Figure A.6—Long-Term Contamination of Cesium 137 and Americium 241

Dirty Bomb Scenario Timescales

- The two dirty bomb scenarios described above will have similar timelines. While the effects of different radioactive materials may increase the urgency of protective actions and the footprint of potential consequences, the timescales for each dirty bomb scenario are almost identical. Decontamination issues could lengthen the time that an area might be considered uninhabitable or would require cleanup.
- During: The during period for the actual and perceived timelines for a dirty bomb scenario will almost coincide. This is based on the assumption that first responders to the incident will detect the presence of radioactive material in the explosion. In this scenario, the media reports the dispersal of radioactive materials 15 minutes after the explosion. Thus, the difference between the actual and perceived timelines for the public is 15 minutes. Detection of the radiation could take longer if first responders do not carry detectors.

- After: The initial cloud containing radioactive particles will pass all areas within several hours. However, relocation of people in contaminated areas will occur over several days following the attack, and they may remain relocated for months to years. The after period could last anywhere from years to decades for decontamination. Latent cancer deaths can occur from either the initial exposure (from being in the area in the hours following the attack) or continued exposure (from living in a contaminated area for extended periods after the attack). These risks would continue for the remainder of the lifetimes of people exposed to the radioactive materials.

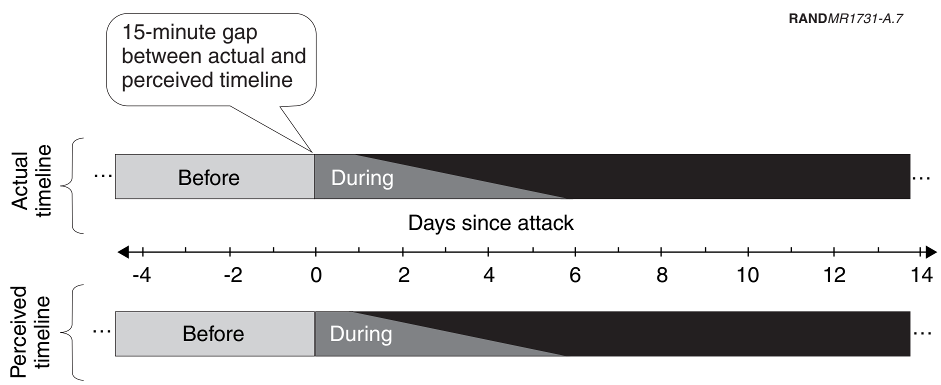


Figure A.7—Timeline of Dirty Bomb Scenario

Table A.13

Dirty Bomb Scenario—Summary of Effects

	Scenario γ	Scenario α
Weapon/agent	10,000 Ci Cesium 137 bomb explosion in a city.	50 Ci Americium 241 bomb explosion in a city.
Disruption of emergency services		
Law and order	Must deal with mass anxiety, relocation, and establishing exclusion zones. Investigation of possible nonradiological explosions and spurious events.	
Fire services	Strained by false incidents and decontamination procedures. An exclusion zone may be created where radiation levels are too high to allow first responders to enter until the extent of contamination can be better characterized. This zone could contain victims who will not be accessible to first responders (but would be accessible to hazmat teams). The NCRP report recommends setting a "turnaround" threshold radiation dose that exceeds 10 rem/hr or a total exposure of 10 rem.	

Table A.13—continued

Hazmat teams	Strained by need to characterize cloud and possible false incidents. Responsible for decontamination of those directly exposed. Exclusion zone could contain victims that will not be accessible to first responders and therefore must be handled by hazmat teams.
EMS	Strained by calls from people concerned they may become seriously ill. EMS concerned about exposure of its personnel. Need to provide treatment for people injured by the blast. Possibly strained by need to characterize cloud and possible false incidents. Exclusion zone could contain victims who will not be accessible to first responders.
Disruption of health services	
Medical care	Issues about how to decontaminate victims. Victims may begin receiving treatment for blast injuries before the event is discovered to involve radioactive materials. Some people coming into emergency rooms demand to be tested and treated for potential radiation exposure. Three categories of victims: immediate (blast victims), those exhibiting psychosomatic symptoms, and long-term (posttraumatic stress disorder).
Public health	Public health authorities responsible for keeping the public informed and determining appropriate areas from which citizens may be required to relocate. Inform public about how much radiation is harmful and how to avoid exposure. Responsible for monitoring the environment and the people exposed to radiation. If it is determined that the radioactive source does not contain radioactive iodine, people need to be made aware that medications, such as potassium iodide, will not be of any benefit.
Behavioral health	Initial confusion and anxiety. Emergency response teams wearing protective gear could lead people to believe significant risk is in the area. Long-term problems with people potentially exposed who may experience anxiety about whether they will develop cancer. Possible depression and posttraumatic stress disorder issues. Also impossible to distinguish between those who would have developed cancer otherwise and those who develop cancer as a result of the attack.
Mortuary services	Quantity of fatalities is not a problem, however concern arises that bodies killed in the explosion might be contaminated.
Disruption of infrastructure	
Power (electricity, gas, heat, etc.)	NA
Transportation	Potential for mass panic, crowd control issues. Self-evacuation issues (traffic). False incidents may cause further alarm on roadways.
Shelter	Potential issue with self-evacuees. Potential issue with relocation.
Water and sewerage	Potential issues with contamination of water.
Food	Food from farms and gardens inedible for large area within contaminated area. Ground water contamination is a possible concern.

Table A.13—continued

Disruption of sanitation services		
Trash	Services may be disrupted in contaminated zones. Issues about how to dispose of potentially contaminated personal items (e.g., clothing, etc.).	
Biowaste	NA	
Disruption of communications		
Telephone, TV, radio, computer, etc.	Cell phone, landlines, and e-mail might be overwhelmed, but short duration of attack reduces load quickly.	
Environmental safety		
Clean air[a]	Air may contain radioactive materials during cloud passage.	
Soil, ground, and surfaces	Soil affected by radioactive materials for long period, so it must be removed in some places. Cs-137 difficult to remove because it tends to bind to concrete. Takes time to assess extent of contamination. People might be unwilling to return home even if determined safe.	
Time to recovery	Initial recovery might take days. Decontamination of affected area, if economically feasible, might take years.	
Evacuation needs/actions	Public officials may order relocation from affected area. Potential for spontaneous self-evacuations of the area.	
Quarantine	NA	
Simultaneity	Could affect self-evacuation routes if events are close. Strain first responders and hazmat teams.	
Surprise nature	Slight negative warning time (i.e., people are not aware of attack even while it is happening; it takes on the order of tens of minutes to a few hours to realize a radiological attack has occurred). This takes place because a gap occurs between the time that the radioactive material is dispersed and the time that the public is made aware that the incident involved radioactive material.	
Threat of further attacks	Threats may cause people to self-evacuate the affected city and perhaps other urban areas. People may begin stocking medications and facemasks in an attempt to reduce potential risk of exposure.	
Lethality	Scenario γ	Scenario α
General (number of fatalities/injuries)	0—Initial Exposure greater than 0.25 rem Indeterminate—Long-Term Exposure	10,000—Initial Exposure greater than 0.25 rem 1,800—Initial Exposure greater than 1.0 rem 370—Initial Exposure greater than 2.5 rem Indeterminate—Long-Term Exposure
Personal (family members)	?	
Cyber consequences	NA	

[a]For Americium 241, there is also the problem of resuspension of radioactive materials.

NUCLEAR DETONATION SCENARIO—ONE-KILOTON WEAPON DETONATED IN A CITY

Nuclear Detonation Scenario—Background

This scenario examines one category of nuclear attack: a one-kiloton weapon in a truck detonated on the ground in the middle of a city with a population of 1 million to 5 million people without many skyscrapers. A larger-scale attack would have most of the same effects, but the scale would be larger. Initial conditions for the attack assume the following:

- That the city approximates a smooth surface and the effects of the weapon are not attenuated by the presence of many tall buildings (500-foot or higher). In a city with many tall buildings, the blast diameter can be reduced by one-third and the prompt radiation diameter can be reduced by up to two-thirds.
- The number of casualties is highly dependent on the density of the city and, to a lesser extent, the degree of local fallout. This scenario assumes that the population density is that of a medium-size American city. Much of the fallout remains localized in the greater metropolitan area.
- Casualty figures are dominated by prompt casualties and assume a city density of 10,000 people per square kilometer (~30,000 per square mile) at the city center. Casualties from fallout are likely to be lower by an order of magnitude or more because densities will be lower outside the city center.

Effects of Attack. Unlike biological weapons, many of the effects of a nuclear attack are felt instantaneously. Nuclear weapons have four primary effects: blast, prompt ionizing radiation, thermal radiation, and long-term radiation (fallout). The number of people exposed to any of the effects of the weapon is about 100,000 in this scenario.

Blast Effects. Blast effects are essentially instantaneous and the most destructive for physical structures and people. The effects on infrastructure and services can be severe and long lasting, particularly within the 5 psi ring (about 0.4 kilometers [0.25 miles] from detonation point). Disruptions will also be significant within the 2 psi ring (about 0.8 kilometers [0.5 miles] from detonation point) but can be overcome more rapidly. Figure A.8 (A) shows the overpressure rings caused by the blast.

Prompt Radiation Effects. Prompt radiation is also essentially instantaneous. With a one-kiloton weapon detonated on the ground, the radiation effects reach out farther than blast and thermal effects. For doses of 600 to 1,000 rem, it is estimated that 90–100 percent of casualties, respectively, will be fatal even with medical treatment. For doses of 300 rem, it is estimated that 10 percent of casualties will be fatal with treatment. Below 200 rem no fatalities will stem from prompt radiation but people will suffer symptoms of radiation sickness. See Figure A.8 (B) for a schematic of prompt radiation effects.

Thermal Radiation Effects. Thermal radiation (heat) will burn skin directly exposed to heat from the detonation. Figure A.8 (C) is a schematic of burn severity caused by thermal radiation. Secondary effects of nuclear weapons include fires started by thermal radiation and by gas and electrical lines damaged by the blast.

Local Radioactive Fallout Effects. Radioactive fallout starts to deposit in 10–15 minutes after the detonation in the area around ground zero and continues to deposit locally over the next 24–48 hours from a cloud determined by wind and other meteorological and geographic factors. The direction, intensity, and dispersal of the fallout are highly dependent on local conditions and cannot be predicted. Radiation has a cumulative effect on the body. Doses above 600 rem accumulated over a week or less are 90 percent fatal with treatment, 10 percent fatal at 300 rem with treatment, and nonfatal at 200 rem without treatment. Doses cause no acute symptoms at 50 rem. Exposures of 50 rem or lower will increase long-term cancer deaths, however, by 0.4 to 2.5 percent. Even nonfatal radiation effects can increase chances of death from burns, other traumas, and infection. The effects of long-term exposure to low levels of fallout radiation are primarily in increased incidence of cancer and genetic mutations, although the magnitude of the effect is a matter of debate. The standard approach used by U.S. regulatory agencies is to assume that the effect is linear and to use the factor of one additional cancer death for every 2,500 people exposed to a cumulative dose of 1 rem, whether it was absorbed in one month or 10 years. Areas within the fallout zone are likely to remain uninhabited for years.

The local radioactive fallout contours shown in Figure A.8 (D) were estimated using the Hotspot model (Version 2.01) created at Lawrence Livermore National Laboratory. An 18-km/hr (~11 mph) wind speed was assumed in the model. For a 24-hour exposure, Hotspot estimated that the 1,000 rem and greater area for a one-kiloton weapon detonated on the ground is 2.3 square kilometers (0.9 square miles), the 300 rem and greater area is 8.9 square kilometers (3.4 square miles), the 100 rem and greater area is 23 square kilometers (8.9 square miles), and the 10 rem and greater area is about 60 square kilometers (23 square miles). Note that the entire blast zone will be exposed to local fallout. The number of people exposed (10 rem or greater) to fallout outside the prompt radiation zone is about 60,000, assuming an average population density over that large area of 1,000 people per square kilometer (~2,600 people per square mile).

Other Effects. Another effect is an electromagnetic pulse (EMP), which will damage components attached to large antennas and power lines. EMP can also destroy computers. It is also likely to affect communications networks, but the duration of the disruption is unknown.

Table A.14

Parameters of Nuclear Scenario, Surface Burst

Parameter	Radius 1 kT	Radius 10 kT	Fatalities (%)	Injuries (%)	Safe (%)	Description
Overpressure (peak winds)						
12 psi (330 mph)	0.3 km (900 ft)	0.6 km (1,900 ft)	98	2	0	Most buildings collapsed, houses rubble
5 psi (160 mph)	0.4 km (1,450 ft)	1.0 km (3,200 ft)	50	40	10	Heavy construction severely damaged, houses destroyed
2 psi 70 mph)	0.8 km (2,500 ft)	1.8 km (5,800 ft)	5	45	50	Walls of building blown away, severe damage to residences
1 psi (35 mph)	1.1 km (3,700 ft)	2.5 km (8,400 ft)	0	10	90	Damage to structures, people injured by flying debris
Prompt radiation[a]						
1,000 rem	0.7 km (2,200 ft)	1.1 km (3,700 ft)	100			Palliative treatment only
600 rem	0.8 km (2,650 ft)	1.2 km (4,000 ft)	90	10	0	10 percent chance of survival with treatment
300 rem	0.9 km (3,000 ft)	1.3 km (4,500 ft)	10	90	0	90 percent survival with treatment
200 rem	1.0 km (3,150 ft)	1.4 km (4,800 ft)	0	100	0	Symptoms of radiation sickness, will recover without treatment
100 rem	1.1 km (3,700 ft)	1.5 km (5,000 ft)	0	100	0	Mild symptoms, little effect
50 rem	1.2 km (3,960 ft)	1.7 km (5,600 ft)	0	0	100	No noticeable effects
10 rem	1.5 km (4,800 ft)	2.1 km (6,900 ft)	0	0	100	
Thermal radiation[b]						
Third-degree burns	0.7 km (2,200 ft)	2.1 km (6,900 ft)				

Table A.14—continued

Parameter	Radius 1 kT	Radius 10 kT	Fatalities (%)	Injuries (%)	Safe (%)	Description
Second-degree burns	0.8 km (2,750 ft)	2.6 km (8,500 ft)				
First-degree burns	1.2 km (4,000 ft)	3.5 km (11,600 ft)				

SOURCES: Based on the following sources: OTA, 1979; Glasstone and Dolan, 1977; Fletcher (1977).

NOTE: For a smooth surface. The presence of many tall buildings (hundreds of feet high) would attenuate the effects.

[a]Fatality rates assume adequate medical treatment is available.

[b]In urban environments, particularly with tall buildings, thermal radiation can be significantly attenuated, limited to line of sight from the fireball. Many fewer fires would be expected from this source.

Table A.15

Nuclear Detonation Scenario—Event History

Day	Events		
0	A truck carrying a small nuclear weapon (1 kiloton) is detonated in the downtown section of a large U.S. city.	No specific warning of the attack was given.	Major disruptions of power, water, and other critical infrastructure.
	Many buildings near ground zero collapse.	Radioactive materials begin to be deposited on the ground downwind of the detonation over the next 24 hours.	Emergency responders cannot gain access to areas severely affected by the blast for several days because of high levels of radiation from local fallout.
	Surrounding areas (more than 1.5 km from ground zero) do not have major blast damage, however, mass panic ensues in this area and beyond from fear of exposure to radiation and further attacks.	Some try to evacuate by automobile immediately following the blast, however, roads quickly clog with traffic from vehicles attempting to flee the area.	
1	Power restored to parts of the city outside the blast zone.	Authorities slowly begin to regain control of the situation. Communications are being restored.	Roads outside the blast zone are still impassable due to abandoned vehicles. Inside the blast zone roads are impassable because of debris.

Table A.15—continued

Day	Events	
3	Most of the critical infrastructure essential to survival of the population has been restored except within the blast zone.	Refugee problem occurs because of people displaced by contamination in the fallout zone.
Day 4 to year 10	Contamination of fallout zone may require relocation and decontamination.	

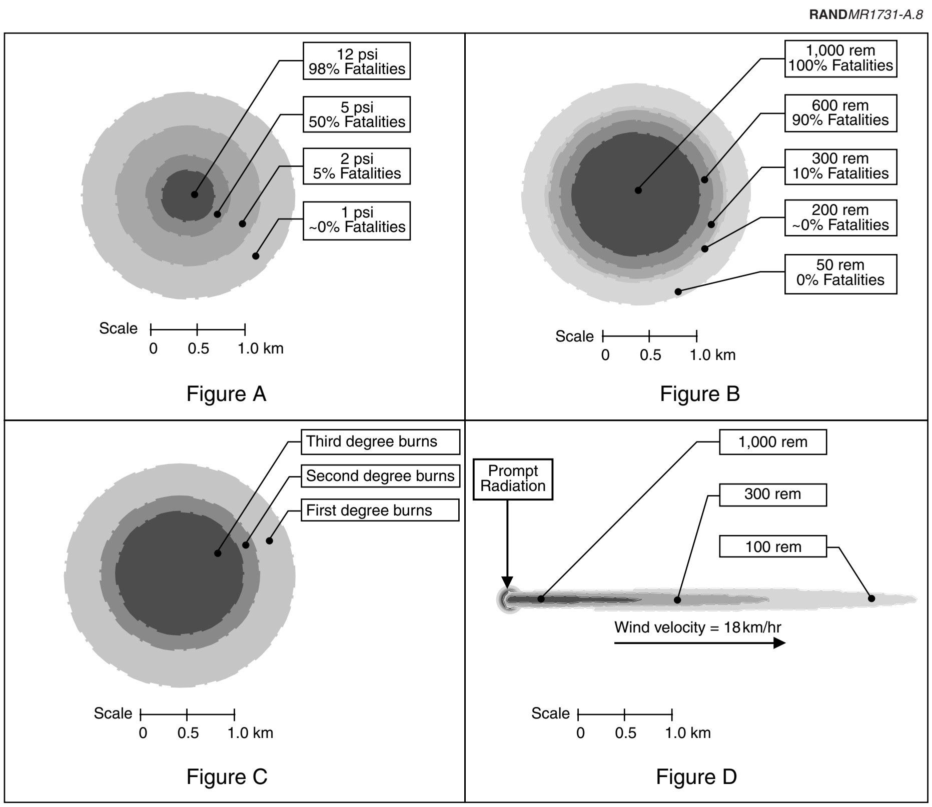


Figure A.8—One Kiloton Prompt Blast Effects—Overpressure Contours (A), Radiation Dose Contours (B), Burn Contours (C), and Local Fallout 24-Hour Radiation Dose Contours (D)

Nuclear Detonation Scenario—Timescales

- During: The transition from before to during periods for actual and perceived events will occur at identical times. This assumes that as soon as the weapon detonates, people realize the event has occurred.
- After: The during period may be subdivided into the time it might take for all people in the affected areas to evacuate (about three days after detonation) and the time until critical services and infrastructure can be restored to surrounding areas (about seven days after detonation). The after period could last anywhere from years to decades (decontamination, etc.)

RANDMR1731-A.9

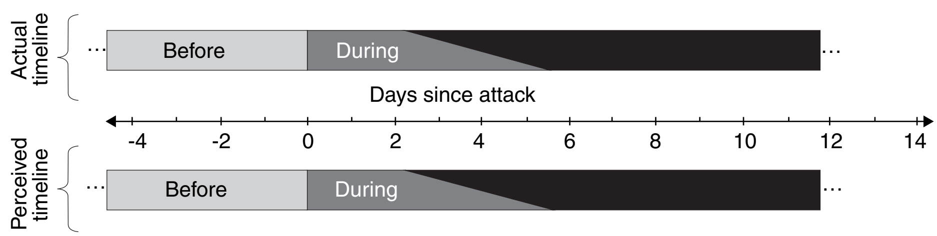


Figure A.9—Timeline of Nuclear Detonation Scenario

Table A.16

Nuclear Detonation Scenario—Summary of Effects

Weapon/agent	One-kiloton nuclear weapon detonated on the ground in a city.
Disruption of emergency services	
Law and order	Those who survive and are not incapacitated (outside 200-rem prompt-radiation ring) will be severely stressed dealing with establishing order; duty cycles will be limited by radiation environment. Must deal with mass anxiety, evacuation, and establishing exclusion zones. National Guard call up to support law enforcement.
Fire services	Those who survive and are not incapacitated (outside 200-rem prompt-radiation ring) will be severely stressed fighting fires; duty cycles will be limited by radiation environment. Fires a significant factor within 5-psi ring. More manageable within the 2–5-psi band, but many left to burn because radiation environment from early fallout may prohibit access. Fires started by thermal radiation (ignites furniture inside buildings), secondary fires started by downed power lines and broken gas lines. Firehouses might be inoperable. Water likely to be unavailable for at least 24 hours outside 1-psi ring. Available irregularly between 1- and 2-psi rings after power is reestablished.

Table A.16—continued

Hazmat teams	Characterize fallout cloud. Overwhelmed by need for rescue workers in radiation environment.
EMS	Those who survive and are not incapacitated (outside 200-rem prompt-radiation ring) will be severely stressed helping the injured; duty cycles will be limited by radiation environment.
Disruption of health services	
Medical care	Within 200-rem prompt-radiation ring, most people are killed or disabled by the various effects of the detonation. Hospitals in fallout zone are unusable. Surviving local hospitals overwhelmed by thousands of burn and radiation patients. Must rely on regional and national support. Burn facilities in region quickly overwhelmed. Hospitals must worry about contamination brought in by patients. Trauma centers are strained and could be damaged. Military provides support.
Public health	Local services quickly overwhelmed. Must contend with disease from bodies, lack of sanitation. Establish triage centers. Monitor cancer possibilities. Educate public about radiation and other health aspects of dealing with the disaster.
Behavioral health	Widespread confusion and mass anxiety. Significant and long-lasting behavioral health effects. Possible depression and post-traumatic stress disorder.
Mortuary services	Many fatalities from blast, radiation, and burns. Large number of fatalities stress mortuary services.
Disruption of infrastructure	
Power (electricity, gas, heat, etc.)	Shut down for 24 hours throughout metropolitan area. Restored to 1-psi ring within one to two days; 2-psi ring within two to four days. Repair personnel duty cycles are limited by radiation environment.
Transportation	Attack will not damage roads outside 12-psi ring, but debris and clutter on roads will be a problem within the blast zone. Can be cleared fairly easily on wide roads (highways). Bridges and overpasses likely to survive. Severe issues in evacuating the city.
Shelter	Severe housing and refugee crisis. Buildings within the 2-psi ring likely to be severely damaged. Buildings and houses within the larger 100-rem fallout zone likely to be uninhabitable for weeks or months.
Water and sewerage	No pressure, but distribution system largely intact. Pressure outside 1-psi ring restored as power restored. Closer in, service restored as broken connections fixed/capped. 12 psi, severe damage to mains, 5–12 psi moderate damage, 2–5, sporadic damage. Long-term contamination of water supplies from fallout is an issue.
Food	Services and delivery unlikely inside 10-rem prompt-radiation ring. Panic causes people to stockpile food in case of disruption of services and delivery. Refugees must be fed.

Table A.16—continued

Disruption of sanitation services	
Trash	Radioactive debris. Severe disruption of trash-collection services, restored up to the 10-rem zone within a week.
Biowaste	NA
Disruption of communications	
Telephone, TV, radio, computer, etc.	EMP and radiation will disrupt many communication systems, at least initially, but level of permanent damage difficult to estimate. Portable electronics less susceptible to damage.
Environmental safety	
Clean air	Air contaminated by radioactive airborne fallout particles.
Soil, ground, and surfaces	Serious problem in fallout zones, contaminated by radiation (short-term and long-term). Some areas may require extensive decontamination (e.g., soil removal).
Time to recovery	Recovery of services and infrastructure outside the blast zone might take weeks. Health-care reconstitution might take months. Decontamination and reconstruction of affected areas, some 8 km^2 (~3 mi^2) around detonation and several times more area in the fallout cloud, might take decades.
Evacuation needs/actions	Large portions of the population might want to leave affected area. Mass evacuations (spontaneous and ordered) might create a refugee problem.
Quarantine	NA
Simultaneity	Could affect evacuation routes if events are close. Could affect arrival of regional/federal resources. Could further strain hospitals.
Surprise nature	No warning time assumed. Warning likely to be ineffective if city, time of attacks, and specific target not known.
Threat of further attacks	Threats may cause people to evacuate affected city and perhaps other urban areas.
Lethality	
General (number of fatalities/injuries)	Casualties—20,000 Fatalities—10,000
Personal (family members)	?
Cyber consequences	Significant disruption of communication networks and automated control systems.

SOURCES: OTA, 1979; Glasstone and Dolan, 1977.

ANTHRAX SCENARIO—AEROSOLIZED RELEASE BY PLANE OVER CITY

Anthrax Scenario—Background

This scenario examines two categories of anthrax attack: (a) a large-scale, very efficient attack under ideal conditions and (b) a small-scale, inefficient attack under nonideal conditions. Where appropriate, differences between small- and large-scale events are distinguished. When consequences are not categorized as large- and small-scale, they can be assumed to be equivalent. Both attacks are assumed to have occurred in a city with a population of 1 million to 5 million. Initial conditions for large- and small-scale attacks are as follows:

- The large-scale attack has a larger footprint and thus affects a larger number of people because of release under ideal weather conditions and a more efficient dispersal method.
- The small-scale attack has a smaller footprint and thus affects fewer people because of release under adverse weather conditions and an inefficient dispersal method.

Table A.17

Parameters of Aerosolized Anthrax Scenario

Parameter	Large-Scale	Small-Scale
Footprint (km^2)	300	30
Number of people exposed	500,000	5,000
Number of people infected (symptomatic)	300,000[a]	3,000[a]
Number of fatalities without treatment	250,000[b]	2,500[b]
Number of fatalities with treatment	125,000[c]	1,250[c]

[a]Number of people infected assumes no protective measures are taken before or are in effect during the attack.

[b]The fatality figure without treatment assumes that 80 percent of symptomatic cases are fatal, according to a World Health Organization (WHO) study in 1970.

[c]The fatality figure assumes that treatment with antibiotics would reduce fatality rate by 50 percent, according to the 1970 WHO study. That figure is highly dependent on the details of the scenario, particularly the time it takes to detect the attack and the speed and comprehensiveness of the antibiotic campaign.

Table A.18

Anthrax Scenario—Event History

Day	Events		
0	A small airplane flying northward near a city releases 50 kg of aerosolized anthrax spores.	No specific warning of the attack was given.	The attack remains undetected for several days.
	The cloud of spores maintains a potentially infectious density for several hours after release.		
	Large-Scale		Small-Scale
	It is a calm, clear night—weather conditions ideal for anthrax dissemination.		It is a clear and sunny day with a light breeze—inefficient weather conditions for anthrax dissemination.
	Dispersal method is very efficient.		Dispersal method is inefficient.
	An invisible cloud spreads over a 300-km^2 area of the city. See Figure A.10.		An invisible cloud spreads over a 30-km^2 area of the city. See Figure A.10.
3	Symptoms of exposure to inhalational anthrax begin to appear.	Because symptoms are similar to cold or flu (e.g., fever, coughing, and chest pains), initial indicators of anthrax go unnoticed.	Most of the infected do not seek medical attention because they believe their illness is not severe.
4	Increasing numbers show signs of infection; however, the increase is not large enough to be noticed yet and symptoms are not severe enough to warrant concern.		
5	First symptomatic people begin to go to hospitals.	Some public health officials suspect anthrax after numerous cases with similar symptoms are noticed.	Abnormal chest x-rays are the first indication that anthrax might be the cause of the patients' illness.
	The scale, delivery method, and potentially affected areas of the attack are still unknown.	The media begins coverage of the event, but the public remains relatively calm.	
6	Blood cultures are ordered to determine the probability of anthrax as a potential agent.		

Table A.18—continued

7	Large-Scale		Small-Scale
	Blood cultures yield positive results for anthrax. Some results are negative because of use of antibiotics. However, the number of cultures is large enough that sufficient quantities of positive cultures for anthrax appear.		Conclusive results of blood cultures are delayed because some patients used antibiotics to treat their symptoms. After only a few doses of antibiotics the patients' blood cultures were sterilized, resulting in negative cultures.
	Anthrax is determined to be the cause of illness.	Anyone who begins to show flu-like symptoms is immediately given antibiotics.	All first responders in the city begin taking antibiotics as a precautionary measure.
	The scale, delivery method, and potentially affected areas of the attack are still unknown, but efforts to characterize the dimensions of the attack continue.	Media coverage increases, public anxiety heightens.	
8	Increasing number of people fall ill.	First fatalities begin to occur.	Hospitals begin to get overwhelmed by a large number of patients experiencing somatic symptoms and psychological distress. These effects increase proportionally with the population of the city.
	Public health officials, federal biological warfare experts, and the intelligence community have identified a suspected time and area contaminated by the attack.	People within the suspected contaminated area are urged to relocate, but the rest of the city's population is assured that there is no need for alarm or mass evacuation of the entire city.	Antibiotics are given to those within the suspected footprint of the attack.
	Some of the public begins to take antibiotics from home supplies.	Media coverage of relocation and initial deaths causes some who are not in the affected areas to self-evacuate the city.	
9	Large-Scale		Small-Scale
	Estimates released that 500,000 people were exposed to an aerosolized anthrax attack on Day 0.		Estimates released that 5,000 people were exposed to an aerosolized anthrax attack on Day 0.

Table A.18—continued

	Severe traffic on highways as people who are not in affected areas experience mass anxiety and choose to self-evacuate city.		Moderate traffic on highways as some people who are not in affected areas experience mass anxiety and choose to self-evacuate city.
	Mass anxiety among population; large numbers of those experiencing somatic symptoms and psychological distress severely overwhelm hospitals.		Moderate numbers of those experiencing somatic symptoms and psychological distress strain hospitals, but as the moderate scale of the attack is realized by the public, this strain is relieved fairly soon.
10–40	Last cases become symptomatic at approximately Day 40.	City begins to decontaminate affected area. Decontamination efforts could last for a year or more.	
	Large-Scale		Small-Scale
	Exposed—500,000 Infected—300,000[a] Fatalities (without treatment)—250,000[b] Fatalities (with treatment)—125,000[c]		Exposed—5,000 Infected—3,000[a] Fatalities (without treatment)—2,500[b] Fatalities (with treatment)—1,250[c]

[a]Number of people infected assumes no protective measures are taken before or are in effect during the attack.

[b]The fatality figure without treatment assumes that 80 percent of symptomatic cases are fatal, according to the 1970 WHO study.

[c]The fatality figure assumes that treatment with antibiotics would reduce fatality rate by 50 percent, according to the 1970 WHO study. That figure is highly dependent on the details of the scenario, particularly the time it takes to detect the attack and the speed and comprehensiveness of the antibiotic campaign.

Anthrax Scenario—Timescales

- During: While the actual during period begins on the day of the attack (Day 0), the perceived attack (i.e., when the attack is realized by government, health community, and citizens) does not begin until Day 7.
- After: When citizens will stop showing symptoms of infections is *not* well known. The timeline and graph below follow the general pattern suggested from the experience in Sverdlovsk. The critical parameters in determining how long an affected area will be uninhabitable are the amount of anthrax released and the degree to which it was "weaponized." The concern is whether the anthrax on the ground and other surfaces could be

reaerosolized. From British military experience with explosion tests on Gruinard Island, Scotland, decontamination took approximately eight years (Inglesby et al., 2002).

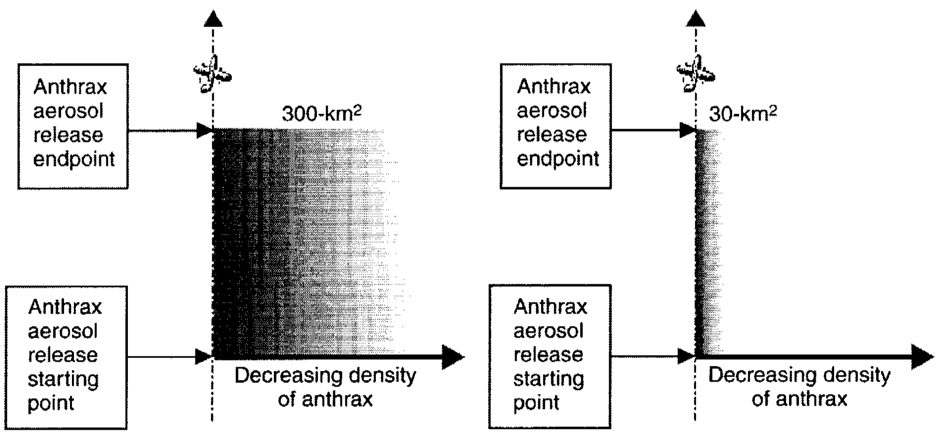


Figure A.10—Efficient and Inefficient Anthrax Dispersal Density

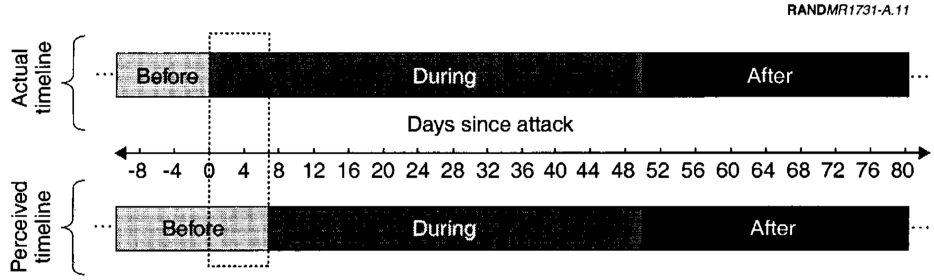


Figure A.11—Timeline of Anthrax Scenario

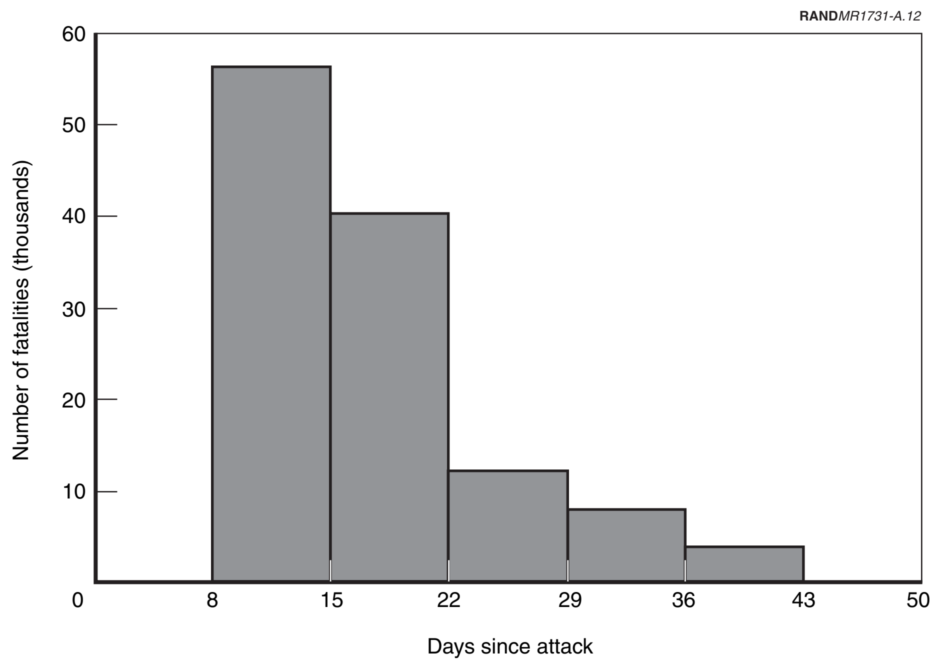


Figure A.12—Fatalities per Week for Large-Scale Anthrax Scenario

Table A.19

Anthrax Scenario—Summary of Effects

	Large-Scale	Small-Scale
Weapon/agent	Aerosolized anthrax, efficient airplane release.	Aerosolized anthrax, inefficient airplane release.
Disruption of emergency services		
Law and order	Deal with mass anxiety, spontaneous self-evacuations of urban areas. Investigations of white powder incidents that citizens might fear are further anthrax attacks. May need to enforce restricted zones and prevent looting.	
Fire services	Strained by real and false incidents, but they are not critical to survival of individuals.	
Hazmat teams	Strained by real and false incidents, but they are not critical to survival of individuals.	
EMS	Strained by calls concerning seriously ill and false alarms. EMS concerned about exposure of personnel. Absenteeism stemming from fear of exposure may cause personnel shortages.	

Table A.19—continued

	Large-Scale	Small-Scale
Disruption of health services		
Medical care	Seriously affects response capabilities of medical care system. Recovery might take several months and continue to be affected because of anxiety and fear of uninfected people and those exhibiting psychosomatic symptoms. Assumption: the majority of infected people will be treated in hospitals. National Pharmaceutical Stockpile resources are used.	Slow recovery for hospitals, large numbers of people coming into emergency rooms demanding to be tested and demanding antibiotics. National Pharmaceutical Stockpile resources are used.
Public health	Testing and distribution of antibiotics, surveillance, and responding to white powder incidents will all strain public health resources. Laboratory services also strained. Public health also responsible for educating the public.	
Behavioral health	Uncertainties about the disease, exposure, and treatment may cause widespread anxiety. Possible depression and posttraumatic stress disorders.	
Mortuary services	Large-Scale	Small-Scale
	Mortuary services could be overwhelmed. Bodies may create a biohazard.	Bodies may create a biohazard.
Disruption of infrastructure		
Power (electricity, gas, heat, etc.)	NA	
Transportation	Potential for mass anxiety, crowd control issues. Relocation issues (traffic).	
Shelter	Large-Scale	Small-Scale
	Potential shelter, feeding issues (refugee crisis).	NA
Water and sewerage	Public may need to be reassured that water supplies are not contaminated.	
Food	Large-Scale	Small-Scale
	Mass anxiety causes people to stockpile food in case of disruption of services and delivery. Farms and garden food inedible.	Initial mass anxiety causes food runs, but this quickly abates.
Disruption of sanitation services		
Trash	NA	
Biowaste	NA	

Table A.19—continued

Disruption of communications	Large-Scale	Small-Scale
Telephone, TV, radio, computer, etc.	Strained at times, but the lack of a narrow pinnacle of events broadens the time of peak usage.	NA
Environmental safety		
Clean air	Potential for resuspension of anthrax spores in affected area. However, the risk from the initial aerosol is much greater.	
Soil, ground, and surfaces	Soil affected by anthrax for long period, soil must be removed. People might be unwilling to return home even if homes are determined safe. It will take time to assess extent of contamination.	
Time to recovery	Initial recovery of people might take weeks. Decontamination of affected area, if economically feasible, might take years.	
Evacuation needs/actions	Public officials order relocation of affected area. Potential for self-evacuation of area before officials can implement an organized relocation plan.	
Quarantine	NA	
Simultaneity	Large-Scale	Small-Scale
	Could affect relocation routes if events are close. Could affect arrival of regional/federal resources.	NA
Surprise nature	Negative warning time (i.e., people are not aware of attack until several days after it has occurred).	
Threat of further attacks	Threats may cause people to self-evacuate affected city and perhaps other cities. People begin stocking antibiotics and masks to reduce risk of exposure.	
Lethality	Large-Scale	Small-Scale
General (number of fatalities/injuries)	250,000—without treatment 125,000—with treatment	2,500—without treatment 1,250—with treatment
Personal (family members)	?	
Cyber consequences	NA	

SMALLPOX SCENARIO—AEROSOLIZED RELEASED IN ENCLOSED ARENA

Smallpox Scenario—Background

This scenario examines the consequences of covert release of aerosolized smallpox on January 1 inside an arena in a city with a population of 1 million to 5 million. As an audience of 20,000 people gathers in the arena for a New Year's celebration, several terrorists release aerosolized smallpox sufficient to cause first-generation infection in 300 people. The consequences of first-generation illness assume an unprepared public. The consequences from the second generation forward assume some level of successful crisis response by isolation, contact tracking, and vaccination.

Table A.20

Smallpox Infection and Fatality History

	First Generation	Second Generation[a]	Third Generation[b]	Fourth Generation	Fifth Generation[c]	Total[d]
Days since attack	28	42	56	70	70+	—
Infections	300	900–1,500	90–150	10–15	~ 0	1,000–2,000
Fatalities[e]	60	180–300	18–30	2–3	~ 0	200–400

[a]Second-generation infections assume that every first-generation infection is responsible for infecting three to five additional people.

[b]From the third generation onward infections assume that every infection is responsible for infecting 0.1 additional people in the following generation. The decrease in transmission rate as compared to first generation stems from crisis response by isolation, contact tracking, and vaccination.

[c]The fifth generation will experience very few if any further outbreaks of smallpox. A combination of successful isolation, contact tracking, and vaccination and weather becoming warmer and more humid cause outbreaks to cease.

[d]Totals are rounded and not additive to reflect that they are order-of-magnitude estimates and not the result of a rigorous evaluation.

[e]Fatality rate among those infected is assumed to be 20 percent.

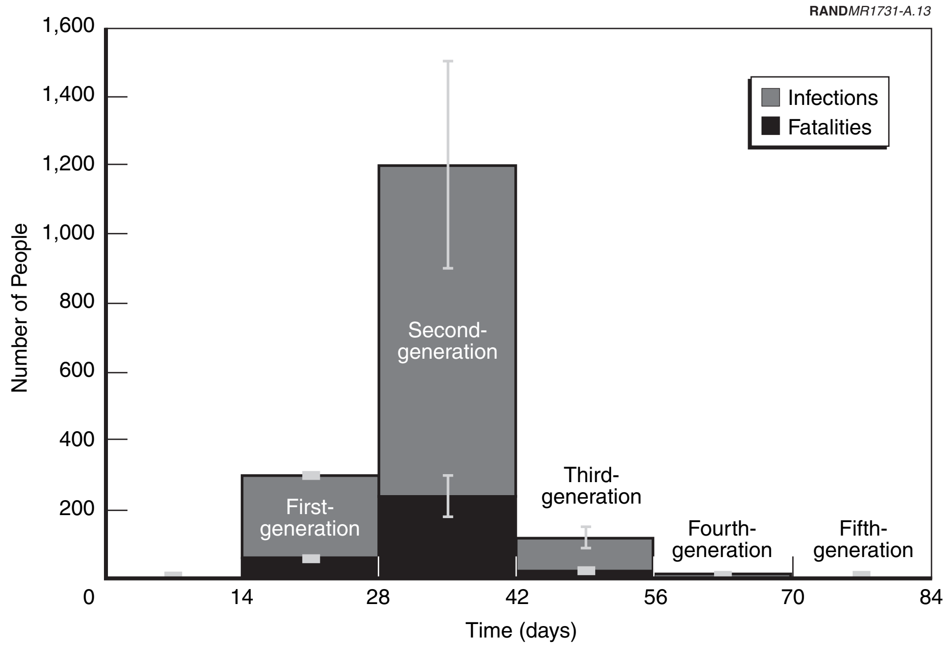


Figure A.13—Smallpox Infections and Fatalities per Generation

Table A.21

Smallpox Scenario—Event History

Day	Events		
1	January 1		
	An audience of 20,000 gathers for a New Year's celebration in an arena.	Several terrorists walk throughout the venue dispersing smallpox from small backpacks with a battery-powered aerosolizer.	300 people in attendance receive an infectious dose of smallpox (i.e., they will become symptomatic).
	No one at the event notices the attack and there are no immediate indications that an attack has taken place. First signal will be the first people to become symptomatic. The incubation period for smallpox is 12 to 14 days (range 7–17 days). A characteristic rash will begin to appear on extremities of body one or two days after incubation period (Henderson et al., 1999).	The aerosolized smallpox in the arena will be inactivated (can no longer cause infection) in a maximum of two days.	In the days following the event, many people in attendance leave the city on business, vacation, or return to their home cities.

Table A.21—continued

12	January 12		
	First symptoms begin to appear in twelve patients that seek medical attention: fever over 101°F, headache, backache, and fatigue.	One patient had recently traveled abroad. The doctor suspects this patient may be suffering from malaria, orders a malaria test and admits the patient to a hospital.	Other patients are sent home, assumed to have a viral infection, and instructed to drink fluids and take aspirin or ibuprofen.
	Patients are seeking medical attention at different health-care facilities. Thus, no one notices an abnormal frequency of these symptoms.		
13	January 13		
	Twenty-four additional patients seek medical attention for influenza-like symptoms.	Some health-care facilities begin to see multiple cases. However, a biological attack is not suspected.	
14	January 14		
	One of the first patients returns to the hospital after noticing a rash. The patient's rash on her arms and face is presumed to be adult chickenpox. She is isolated in the hospital.	Two other patients, each in separate hospitals, seen on January 12 are misdiagnosed with adult chickenpox.	Rash appears one or two days after incubation period. Patients can be contagious when the rash appears and remain contagious until rash begins to scab. Scabbing occurs approximately 13 days after appearance of rash (Henderson et al., 1999).
15	January 15		
	6:00 p.m.: Test results for the patient suspected to have malaria were negative. To exclude a diagnosis of malaria, extensive testing was required because of difficulty of diagnosing malaria (Casalino, et al., 2002). When tests exclude malaria and patient develops a rash on his face and arms, doctors talk about the possibility of adult chickenpox. One doctor recalls hearing of another case of adult chickenpox recently and begins to consider the possibility of a biological attack.	6:30 p.m.: Doctors worry because the symptoms seem to be too severe for chickenpox. They also note that the rash is concentrated on extremities of the body. This makes the doctors suspect a potential smallpox outbreak. Doctors in the hospital begin to exchange information with other area hospitals on recent cases of patients with high fevers and possible rashes. They find at least two other hospitals treating possible smallpox cases.	7:00 p.m.: An infectious disease specialist at each hospital takes a swab specimen from a skin lesion on the patients and orders an electron microscopy examination of the specimen to determine if the specimen shows an orthopoxvirus consistent with smallpox.

Table A.21—continued

	8:00 p.m.: Electron microscopy reveals an orthopoxvirus in specimen. The three hospitals immediately go into a lockdown. No one is allowed to enter or exit the building. The hospital notifies the Centers for Disease Control and Prevention (CDC) of the outbreak. The CDC prepares vaccinations for release but does not release any vaccinations until its laboratories confirm the presence of smallpox in specimens. The three patients are isolated in negative pressure rooms installed with air purifiers.	10:30 p.m.: CDC receives specimens from hospitals and begins electron microscopy and growth of virus in cell culture in Biosafety Level 4 facilities.	10:30 p.m.: Patients, visitors, and employees of the hospitals begin to get frustrated by the lockdown. No information has been given to them about the reason for the lockdown. When the hospital staff begins to collect address information from all people inside the hospital, rumors begin to circulate that a biological attack has occurred. People in the hospitals demand an explanation, but the security and police that were called to enforce the lockdown do not have any knowledge of the situation. People begin calling friends and family from the hospitals. News of the lockdowns eventually reaches the media.
	11:00 p.m.: CDC electron microscopy confirms orthopoxvirus, but the CDC holds vaccinations until cell cultures definitively confirm smallpox. At the hospitals, violent altercations occur between people in the hospitals and police enforcing the lockdown. The media begins to show coverage of the events on the evening news. Authorities are not commenting on the matter. Stories of potential biological terrorism and consequences on the news seriously alarm citizens of the city and cause concern for citizens outside of the city.	12:30 a.m. (Day 16): CDC laboratories definitively confirm the presence of smallpox in the specimens. They schedule release of vaccinations to area hospitals early the following morning. Through the night, arrangements are being considered for dealing with the outbreak and how to treat and inform the public of the outbreak.	

Table A.21—continued

16	January 16		
	Early in the morning, the CDC makes a public announcement that a biological attack using smallpox has been detected in the city. They assure the public that vaccinations will be given to close contacts of infected persons to limit spread of the disease. Three hospitals that have diagnosed cases of smallpox are declared "smallpox hospitals" and only treat smallpox patients. People will be vaccinated when they enter these hospitals to minimize the risk of an uninfected person who suspects infection entering the hospital and subsequently being infected by others. All staff members at these hospitals are vaccinated as they arrive for work. Patients seeking hospital care that are not suspected to be infected with smallpox will not be admitted to "smallpox hospitals."	A foreign nation asserts that the CDC might be responsible for the outbreak and that the government is attempting to disguise the event as a terrorist act.	All schools and offices are closed for fear of spreading virus.
	Many people decide to self-evacuate the city. Traffic on highways becomes severe.	Many businesses in other cities, even those without any suspected cases, are closing offices until the crisis passes.	Schools are prepared as vaccination centers.
	By early afternoon, most of the people present at the three hospitals with cases of smallpox have been vaccinated.	The public is told to monitor all persons suspected of having had contact[a] with an infected person for fever of more than 101°F closely for a minimum of 17 days, until vaccination can be given.[b]	Some media reports speculate that U.S. vaccine stockpiles might not be sufficient, especially if secondary outbreaks occur.

Table A.21—continued

	By the end of the day, more than 200 additional cases have been diagnosed nationwide. Approximately 40 of these cases are in other cities. This raises severe public concern that other cities have been the target of a biological attack.	10,000 vaccinations are given to health-care workers and those suspected of close contact with an infected person.	
17	January 17		
	"Smallpox hospitals" are severely strained for staff members. Many staff members do not show up to work because of fear of infection. Authorities ask the public to reduce contact with other people unless they are symptomatic in which case they should go to a smallpox hospital. People who have close contact with suspected infected persons are to be vaccinated. Some people suspected of contact with an infected person are refusing vaccination because of media reports that vaccination could cause illness or even death.	The FBI and health-care providers have determined that the smallpox attack took place on January 1 at the arena.[c]	An additional 100,000 people are vaccinated by the end of the day.[d] Public debate arises about the vaccine being dangerous to some.[e]
19	January 19		
	A total of 300 cases of smallpox have been confirmed nationwide. All these cases were infected at the arena. No more first-generation cases appear.	A total of 310,000 people have been vaccinated.	The first deaths begin to occur among those first diagnosed.

Table A.21—continued

	A child, whose parents were infected and was given a vaccination a few days earlier, dies. Widespread public debate occurs over whether the vaccination is dangerous.	The public demands estimates on the numbers of people that can be expected to become infected in subsequent outbreaks. Claims surface in the media that the limited supply of U.S. vaccine might not be sufficient to protect the public from further outbreaks. Some claim that fatalities could approach one million if the outbreak is not handled adequately by the government.	
26	January 26		
	First symptoms of second-generation infections begin to appear.	By the end of the day, approximately 200 to 350 second-generation cases appear nationwide.	Hospitals quickly become overwhelmed.
	A total of 1,000,000 people have been vaccinated.		
28	January 28		
	The first generation of smallpox infection has ended. No more deaths from first-generation cases. First-generation cases are no longer contagious.	Nationwide, 300 people were infected, 60 died.	Second-generation patients begin to develop rash and become contagious.
	Public anxiety is severe. Total number of people believed to have second generation infections is estimated to be 900 to 1,500 nationwide.		
32	February 1		
	Crowds form outside “smallpox hospitals” and vaccination centers. Cases of violent altercations occur outside these venues. Control of crowds seeking help has become a major problem. Some policemen stop going to work because they worry about their safety.	Placebos claiming to be a “magic cure,” “used by top level officials and the military” to reverse the effects of smallpox are widely advertised on the Internet.	

Table A.21—continued

33	February 2		
	First fatalities of second generation begin to occur.	A popular college basketball athlete dies in a distant U.S. city. He did not develop the characteristic smallpox rash. This sparks severe public anxiety that another, different biological agent has been part of further attacks.	Rumors surface that different types of vaccines exist. Some people believe that the government is holding a separate stockpile for itself of more effective vaccine. These reports surface when vaccinia immune globulin (VIG) is given to patients that have negative reactions to the vaccine.[f]
	The public questions the actions of the government in distributing vaccines. Some claim the authorities limited the quantity of vaccines distributed in areas with high concentrations of ethnic minorities. Some claim that too many vaccines have been reserved for the military, when those vaccines could save lives of citizens in immediate danger.	Authorities insist that the scale of the attack was limited and that strict isolation of ill people in their homes combined with vaccination of contacts will diminish the scale of subsequent outbreaks.	
40	February 9		
	First symptoms of third-generation infections begin to appear.	By the end of the day, approximately 25 to 40 third-generation cases appear nationwide.	A total of 2,000,000 people have been vaccinated.
42	February 11		
	The second generation of smallpox infection has ended. No more deaths from second-generation cases. Second-generation cases are no longer contagious.	Nationwide, 900 to 1,500 people were infected, 180 to 300 died in second-generation cases.	Third-generation patients begin to develop rash and become contagious.
47	February 16		
	First fatalities of third generation begin to occur.		
54	February 23		
	First symptoms of fourth-generation infections begin to appear.	By the end of the day, approximately two to four fourth-generation cases appear nationwide.	A total of 3,000,000 people have been vaccinated.

Table A.21—continued

56	February 25		
	The third generation of smallpox infection has ended. No more deaths from third-generation cases. Third-generation cases are no longer contagious.	Nationwide, 90 to 150 people were infected, 18 to 30 died in third-generation cases.	Fourth-generation patients begin to develop rash and become contagious.
61	March 2		
	First fatalities of fourth generation begin to occur.		
70	March 11		
	The fourth generation of smallpox infection has ended. No more deaths from fourth-generation cases. Fourth-generation cases are no longer contagious.	Nationwide, 9 to 15 people were infected, two or three died in fourth-generation cases.	No further major outbreaks of smallpox occur as a result of successful isolation, contact tracking, and vaccination efforts and increasingly warm weather and higher humidity, although they continue in isolated cases for up to one year.

[a]Close contact is defined as living in the same home as someone who has smallpox or spending at least three hours in the same room with someone who has smallpox (CDC, 2002a).

[b]Postexposure vaccination can be an effective response because production of protective antibodies in response to the vaccine have been detected as early as 10 days after vaccination, which is shorter than the incubation period. Thus, even if given within three to four days after exposure, vaccination could offer complete or partial protection (Henderson and Moss, 1999; Henderson et al., 1999).

[c]Because the attack described here is identified well beyond the three- to four-day window during which postexposure vaccination could be used as an effective response, vaccination of the people present in the arena at the time of the release will not prevent infection from the initial release.

[d]CDC Smallpox Response Plan and Guidelines projects the capability of vaccinating 100,000 per day.

[e]Vaccination is likely to cause about 250 illnesses and about one death per million vaccination (Henderson et al., 1999).

[f]The United States has limited supplies of VIG. However, plans have been made to increase supplies (Fauci, 2003; Henderson et al., 1999).

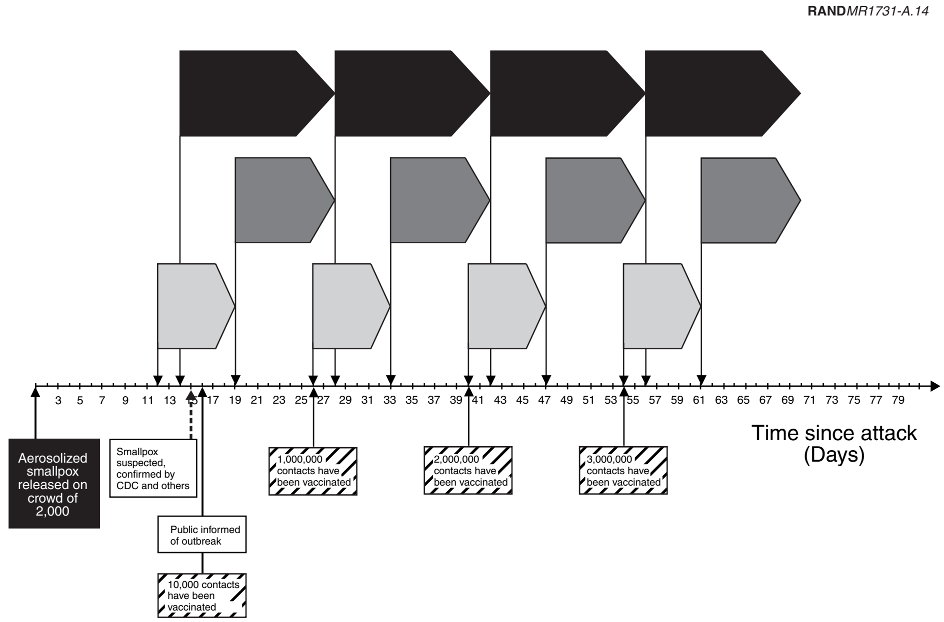


Figure A.14—Timeline of Events in Smallpox Scenario

Smallpox Scenario—Timescales

- During: While the actual during period begins on the day of the attack (Day 0) the perceived attack (i.e., when citizens are informed of the attack) does not begin until Day 16. Note that a gap of several hours occurs when the government and health officials are aware of the attack, but citizens have not been informed. Because the timeline is concerned with the public's perspective, the perceived during period begins when the public is informed of the attack.
- After: When future generations of infections will cease is *not* well known. We speculate in the scenario that by Day 70 spread to future generations approaches zero. Sporadic cases may continue to appear for up to a year. However, the primary impact of the attack will have been felt by ~Day 70.

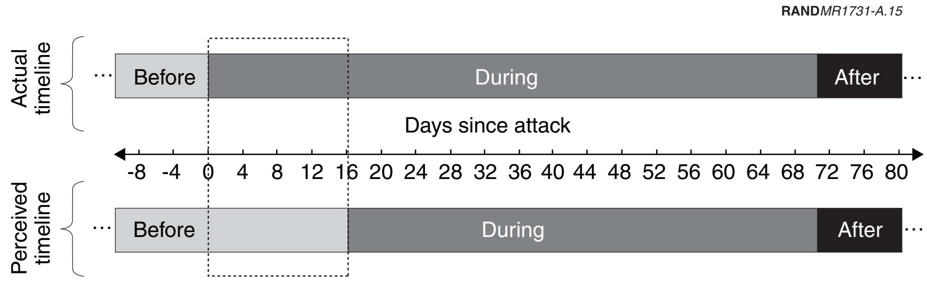


Figure A.15—Timeline of Smallpox Scenario

Table A.22

Smallpox Scenario—Summary of Effects

Weapon/agent	Aerosolized smallpox release in an arena.
Disruption of emergency services	
Law and order	Services are stretched after public learns of the attack. Local police provide security around hospitals and vaccination centers. They might also be called on to enforce quarantines or curfews if they are imposed. Personnel may stop going to work because of fear of infection. May be supplemented by National Guard within a few days.
Fire services	Strained by real and false terrorist incidents, but they are not critical to survival of individuals.
Hazmat teams	Strained by false incidents, but they are not critical to survival of individuals.
EMS	Severe consequences: system overwhelmed by calls, many of them false alarms. Personnel may stop going to work because of fear they are infected. When symptoms of first generation become severe, possibility exists for transmission of infection to personnel before they are vaccinated. As personnel begin to feel psychological effects, more absenteeism occurs. National Guard may be mobilized.
Disruption of health services	
Medical care	Severe consequences: hospitals overloaded, smallpox hospitals established. Hospital personnel may stop going to work because of fear of infection. Many private practices closed by fear of smallpox. Stress felt by medical personnel concerned about their own lives and the lives of loved ones. National Guard may be mobilized.

Table A.22—continued

Public health	Severe consequences: public health system undertakes investigation and surveillance activities. Smallpox response plan is implemented. Ring vaccination is initiated. Medical and other personnel may stop going to work because of fear of infection. When symptoms of first generation become severe, possibility exists for transmittal of infection to personnel before they are vaccinated. Potential for long-term unexplained medical maladies in affected community. National Guard may be mobilized.
Behavioral health	Uncertainties about the disease, exposure, and treatment may cause widespread anxiety. Possible depression and posttraumatic stress disorders.
Mortuary services	Assumption: Mortuary services can handle the given number of fatalities. But challenged in the capability to handle biohazard bodies.
Disruption of infrastructure	
Power (electricity, gas, heat, etc.)	NA
Transportation	People might avoid public transportation for fear of becoming infected by neighboring passengers. Additionally, staff absenteeism may make public transportation unreliable. Potential for large spontaneous self-evacuation of the area might cause severe traffic jams because it will not be organized by authorities. Potential for spontaneous self-evacuation of multiple, neighboring cities if simultaneous releases of smallpox agent.
Shelter	Some people will be displaced by infections in their home. Potential shelter, feeding issues (refugee crisis) from spontaneous self-evacuations. Concerns may occur in host area that self-evacuees from the infected area are contagious.
Water and sewerage	Public may need to be reassured that water supplies are not contaminated.
Food	Panic causes people to stockpile food supplies. Disruption of delivery system because drivers refuse to enter city. Potential for looting of stores as situation becomes more severe. Government may have to establish food distribution centers. People that elect to shield or isolate themselves in their homes will need access to adequate food supplies.
Disruption of sanitation services	
Trash	Could be disrupted if workers are concerned about potential biowaste in trash from homes.
Biowaste	Biowaste in homes a concern. Hospitals may be strained by amount of biowaste.
Disruption of communications	
Telephone, TV, radio, computer, etc.	Communications infrastructure may be strained but probably not severely disrupted.

Table A.22—continued

Environmental safety	
Clean air	Primary mode of transmission is by contaminated saliva droplets in the air.
Soil, ground, and surfaces	NA
Time to recovery	~70 days for large outbreaks to cease. Perhaps up to one year for isolated cases to end.
Evacuation needs/actions	Not recommended but might occur spontaneously. Authorities advise against self-evacuation.
Quarantine	Officials are not likely to impose quarantine because people will either be vaccinated or isolated. Self-isolation may be spontaneous or urged by authorities. Raises food and medicine distribution problem.
Simultaneity	Raises pressure to do mass vaccinations. Potential to cause self-evacuations of urban areas. Real or suspected simultaneity might diminish trust in ability of authorities to manage the consequences. Epidemiological investigation is complicated by simultaneous attacks.
Surprise nature	Negative warning time (i.e., people are not aware of attack until several days after it has occurred). For second generation, 10-day warning before symptoms. For third generation, 24-day warning before symptoms. For fourth generation, 38-day warning before symptoms.
Threat of further attacks	Causes severe problems because people may fear shortage of vaccines. May cause people to self-evacuate urban areas.
Lethality	
General (number of fatalities/injuries)	Infections—1,000–2,000. Fatalities—200–400.
Personal (family members)	Family members stricken raise a number of issues.
Cyber consequences	NA