NEWS & TERRORISM
COMMUNICATING IN A CRISIS

A fact sheet from the National Academies and the U.S. Department of Homeland Security

NUCLEAR ATTACK

WHAT IS IT?

Unlike a "dirty bomb" which disperses radioactive material using conventional explosives,[1] a **nuclear attack** is the use of a device that produces a nuclear explosion. A nuclear explosion is caused by an uncontrolled chain reaction that splits atomic nuclei (fission) to produce an intense wave of heat, light, air pressure, and radiation, followed by the production and release of radioactive particles. For ground blasts, these radioactive particles are drawn up into a "mushroom cloud" with dust and debris, producing fallout that can expose people at great distances to radiation.

Nuclear Devices

Traditional cold-war concerns were focused on the possible use of military nuclear weapons. A nuclear terrorist attack might be carried out with an improvised nuclear device (IND), which is a crude nuclear device built from the components of a stolen weapon or from scratch using nuclear material (plutonium or highly enriched uranium).

Access and Use of Nuclear Materials or Weapons

The primary obstacle to a nuclear attack is limited access to weapon-grade nuclear materials. Highly enriched uranium, plutonium, and stockpiled weapons are carefully inventoried and guarded. Nuclear attack is also impeded because:

- Building nuclear weapons is difficult—general principles are available in open literature, but constructing a workable device requires advanced technical knowledge in areas such as nuclear physics and materials science.
- Crude nuclear weapons are typically very heavy, ranging from a few hundred pounds to several tons, and are difficult to transport, especially by air. Specially designed small nuclear weapons, including the so-called "suitcase nuclear weapons" are much lighter, but they are difficult to acquire and to construct.

WHAT IS THE IMPACT OF A NUCLEAR ATTACK?

A nuclear attack could cause substantial fatalities, injuries, and infrastructure damage from the heat and blast of the explosion, and significant radiological consequences from both the initial nuclear radiation and the radioactive fallout that settles after the initial event. An electromagnetic pulse from the explosion could also disrupt telecommunications and power distribution. The energy released by a nuclear explosion is distributed roughly as 50% shockwave; 35% heat; 5% initial nuclear radiation; and 10% fallout radiation. This distribution varies depending on the design of the weapon and the altitude of the explosion. Box 1 describes the characteristics of a nuclear explosion.

Size of Nuclear Explosions

Nuclear explosions are classified based on the amount of energy they produce, or "yield." A nuclear attack by terrorists would be expected to have a yield of less than one to several kilotons. A kiloton is not the weight of the bomb but rather the equivalent energy of an amount of the explosive TNT (1kT=1,000 tons of TNT). Large military nuclear weapons are in the megaton (MT) range (1MT=1,000kT).

Box 1. Characteristics of a Nuclear Explosion

A **fireball**, roughly spherical in shape, is created from the energy of the initial explosion. It can reach tens of millions of degrees.

A **shockwave** races away from the explosion and can cause great damage to structures and injuries to humans.

A **mushroom cloud** typically forms as everything inside of the fireball vaporizes and is carried upwards. Radioactive material from the nuclear device mixes with the vaporized material in the mushroom cloud.

Fallout results when the vaporized radioactive material in the mushroom cloud cools, condenses to form solid particles, and falls back to the earth. Fallout can be carried long distances on wind currents as a plume and contaminate surfaces miles from the explosion, including food and water supplies.

The ionization of the atmosphere around the blast can result in an **electromagnetic pulse (EMP)** that, for ground detonations, can drive an electric current through underground wires causing local damage. For high-altitude nuclear detonations, EMP can cause widespread disruption to electronic equipment and networks.

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[1] The effects of RDDs (radiological dispersal devices, including "dirty bombs") are discussed in another brief in this series entitled, Radiological Attack: Dirty Bombs and Other Devices.

The Area Affected

The area affected depends on the yield of the nuclear device, the topography at the explosion site (buildings and geological structures), the altitude of the explosion, and weather conditions. The range of significant effects is shown in Table 1 for 1-kT and 10-kT bombs. The general pattern of damage, shown in Figure 1 for a 10-kT bomb, is as follows:

- Initial effects (or prompt effects) of the nuclear explosion—the shockwave, thermal (heat) energy, and initial radiation—cover an approximately circular area of devastation. Effects decrease with distance from ground zero. For nuclear devices with a higher yield, heat damage becomes the primary initial effect of concern, eclipsing both the damage from the shockwave and the initial radiation.
- Radioactive fallout spreads in an irregular elliptical pattern in the direction the wind blows. The most dangerous fallout would occur near the explosion site within minutes of the explosion, but fallout carrying lethal radiation doses could be deposited several miles away. Fallout could potentially travel hundreds of miles, but its concentration and radiation dose decrease as it spreads and as time passes.

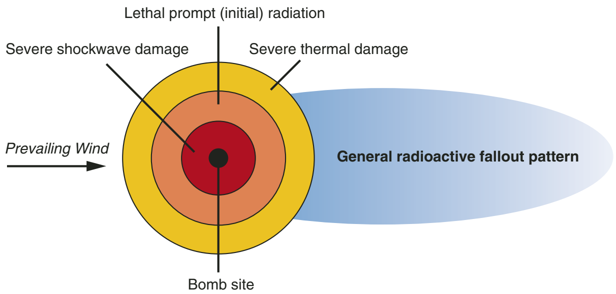

Figure 1. Representation from above of the general patterns of damage from a 10-kT nuclear explosion on the ground. The destruction from the initial effects— shockwave, thermal (heat) energy, and initial radiation—expands in a circular pattern. Severe shockwave damage could extend to about a half a mile. Severe thermal damage would extend out about a mile. Flying debris could extend up to a few miles. Initial (prompt) nuclear radiation for a 10-kT blast could expose unprotected people within about $^{3}/_{4}$ mile of the explosion site to a lethal radiation dose. Radioactive fallout occurs in an irregular elliptical pattern in the direction the wind is blowing; lethal radiation could extend up to 6 miles.

Secondary Hazards

The intense heat of the nuclear explosion will produce fires throughout the immediate blast zone. Damaged buildings, downed power and phone lines, leaking gas lines, broken water mains, and damaged roads, bridges, and tunnels are among the hazardous conditions that could exist. The detonation can also produce an electromagnetic pulse (EMP, see Box 1) that interferes with electronic equipment.

Persistence of Radioactivity Levels

The mixture of radioactive elements formed in a nuclear explosion is so complex, with both short- and long-lasting isotopes, that radioactive decay can only be estimated. During the first hour after a nuclear explosion, radioactivity levels drop precipitously. Radioactivity levels are further reduced by about 90% after another 7 hours and by about 99% after 2 days.

WHAT IS THE DANGER?

The number and type of fatalities and injuries depend on many factors including the yield of the nuclear device, the population near the site of the explosion and in the fallout path, and weather conditions. Even a partial nuclear detonation could produce many casualties in a densely populated area. An extensive weapons effects testing program and studies of the 1945 bombings of Hiroshima and Nagasaki provide what we know about the effects of nuclear explosions (see Box 2).

Health Effects from the Shockwave and Thermal Energy

Fatalities and injuries will result from the pressure of the shockwave, bodies being thrown, falling buildings, and flying debris. Thermal (heat) energy including the fireball can cause fatalities and severe burns to the skin and eyes.

Health Effects from Radiation

People who survive the physical shockwave and heat may suffer health effects from radiation. The health effects of radiation depend on the:

- Amount of radiation absorbed by the body (the dose, measured in unit called rads),
- Type of radiation,
- Route of exposure (absorbed by the body, inhaled, or ingested),
- Length of time exposed.

If a reasonable estimate can be made of a person's dose, health effects at that dose can be predicted with good accuracy. There are both short- and long-term effects of radiation.

Short-term Effects

Acute Radiation Syndrome (ARS) may develop in those who are exposed to radiation levels of 50-100 rad, depending on the type of radiation and the individual. Symptoms of ARS include nausea, vomiting, diarrhea, and reduced blood cell counts. Radiation, especially beta radiation, can also cause skin burns and localized injury. Fatalities begin to appear at exposures of 125 rad, and at doses between 300-400 rad, about half of those exposed will die without supportive treatment.[2] At very high doses, greater than 1000 rad, people can die within hours or days due to effects on the central nervous system. Radiation exposure inhibits stem-cell growth; for those who die within weeks to months, death is usually caused by damage to the gastrointestinal lining and to bone marrow where stem cell growth is crucial. Fetuses are more sensitive to radiation; effects may include growth retardation, malformations, or impaired brain function.

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[2] *Hall, E.J., 2001*

[3] *National Council on Radiation Protection and Measurements, Report No. 138, 2001.*

Long-term Effects

Radiation exposure increases the risk of developing cancer, including leukemia, later in life. The increased cancer risk is proportional to radiation dose. The survivors of the Hiroshima and Nagasaki atomic bombs have about a 10% increased risk of developing cancers over normal age-specific rates, some occurring more than 50 years following the exposure. A long-term medical surveillance program would likely be established to monitor potential health effects of survivors of a nuclear attack. There is no evidence of genetic changes in survivors' children who were conceived and born after the bombings in Hiroshima and Nagasaki.

WHAT SHOULD PEOPLE DO TO PROTECT THEMSELVES?

The three basic ways people can reduce exposure to radiation are through time, distance, and shielding:

Time: Decrease the amount of time spent in areas where there is radiation.

Distance: Increase your distance from a radiation source. Doubling your distance from a point source divides the dose by four. If sheltered in a contaminated area, keep your distance from exterior walls and roofs.

Shielding: Create a barrier between yourself and the radiation source with a building or vehicle. Buildings—especially those made of brick or concrete—provide considerable shielding from radiation. Exposure is reduced by about 50% inside a one-story building and by about 90% a level below ground.

Practical Steps

If there is advanced warning of an impending nuclear attack, people should listen to authorities about whether to evacuate the area or to seek shelter underground as soon as possible.

People outside when a blast occurs should:

1. Lie face down on the ground and protect exposed skin (i.e., place hands under the body), and remain flat until the heat and shock waves have passed.
2. Cover the mouth and nose with a cloth to filter particulates from the inhaled air.
3. Evacuate or find shelter:
   a. Evacuation: If a cloud of debris is moving toward them, leave the area by a route perpendicular to the path of the fallout.
   b. If a cloud is not visible or the direction of the fallout is unknown, seek shelter. A basement or center of a high-rise building away from windows or doors would be best.
4. If possibly exposed to contaminated dust and debris, remove outer clothing as soon as is reasonable; if possible, shower, wash hair, and change clothes before entering a shelter. Do not scrub harshly or scratch skin.
5. Listen for information from emergency responders and authorities.

People sheltering-in-place should:

1. Go as far below ground as possible. Shut off ventilation systems and seal doors or windows until the fallout cloud has passed, generally a matter of hours.
2. Stay inside until authorities say it is safe to come out.
3. Use stored food and drinking water.
4. Listen to the local radio or television for official information. Broadcasts may be disrupted for some time as a result of power outages.

For those in the path of the fallout who have survived the initial effects of the explosion, protection from fallout radiation is the most important life-saving measure. Because the material can travel high into the atmosphere, the fallout dispersal pattern cannot be accurately predicted using surface winds. Authorities will advise people to either shelter-in-place or to evacuate.

People advised to evacuate should:

1. Listen for information about evacuation routes, temporary shelters, and procedures to follow.
2. If there is time before leaving, close and lock windows and doors and turn off air conditioning, vents, fans, and furnace in order to keep radioactive material from being sucked inside.

Box 2. The Nuclear Bombs at Hiroshima and Nagasaki, Japan

The August 1945 bombings of Hiro-shima and Nagasaki have been the only use or detonation of nuclear weapons except for testing purposes. The Hiroshima bomb was approximately a 16-kiloton uranium bomb; the Nagasaki bomb was approximately a 21-kiloton plutonium bomb. Both were detonated in the air at an altitude of approximately 1,600 feet. The bomb at Hiroshima destroyed buildings over roughly 4 square miles of the city, and about 60,000 people died immediately from the blast, thermal effects, and fire. Within 2–4 months of the bombings, a total estimated 90,000 to 140,000 deaths occurred in Hiroshima and about 60,000 to 80,000 deaths occurred in Nagasaki, mostly as a result of the immediate effects of the bomb and not to fallout.

In a group of 87,000 survivors ex-posed to radiation who were followed in health studies over the past 60 years,* there were about 430 more cancer deaths than would be expected in a similar but unexposed population (there were 8,000 cancers from all causes compared to an expected 7,600). The additional cancer deaths are attributable to radiation. Nearly half of the people in those studies are still alive.

**The mean dose of those survivors was 16 rad.*

Table 1. Range in miles for significant effects.[3]

Significant effects are 50% mortality from shockwave and heat, and a radiation dose of 400 rads.

Yield (KT)	Shockwave	Heat	Initial radiation	Fallout radiation (downwind)
1	0.2	0.4	0.5	up to 3.4
10	0.4	1.1	0.8	up to 6.0

Medical Treatment

Medical treatment would be provided to people with burns and injuries and to those suffering from radiation sickness. Treatment for acute radiation syndrome would include the prevention and treatment of infections, stem cell and platelet transfusions, psychological support, and careful observation of skin injury, weight loss, and fever. Exposed and contaminated people can be safely handled by trained responders and medical personnel. If people ingest or inhale fallout, treatment could include the use of various diluting or mobilizing agents that help rid the body of radioactive elements. Potassium iodide or KI pills are not a general cure-all; they are only effective in blocking the uptake of inhaled or ingested radioactive iodine into the thyroid gland if taken before or just after inhalation or ingestion. (Radioactive iodine can cause thyroid cancer and disease.)

WHAT ARE THE LONG-TERM CONSEQUENCES?

Monitoring and Clean-up of Affected Areas

Most of the fallout will dissipate after a few weeks to months. Clean-up activities would focus on areas near ground zero contaminated with long-lasting radioactive isotopes, such as certain plutonium and uranium isotopes. There are temporary measures that can be taken to "fix" radioactive materials in place and stop the spread of contamination. These include "fixative" sprays such as flour and water mixtures, road oil, or water that can be used to wet ground surfaces. In the days and weeks following the attack, officials might be expected to:

- Establish a plan for careful monitoring and assessment of affected areas.
- Impose quarantines on contaminated areas as necessary to prevent further exposures.
- Remove contamination from areas where people might continue to be exposed.
- Keep citizens informed about the situation.

Control of Contaminated Food Supplies

Public health officials should be able to identify contaminated water and food, such as milk and produce, and replace them with clean food from outside the area.

Economic Impact

Economic impacts would result from deaths, illnesses, loss of jobs, and destruction of workplaces and homes. Increased government spending and stock market swings could significantly impact the national economy. Clean-up, rebuilding, and replacement of lost property and goods could cost many billions of dollars. Local economic impacts could continue even after the site has been cleaned up if people are reluctant to return to the affected area.

Psychological Impact

The psychological impacts of a nuclear attack will vary. Most individuals will prove resilient. Some will experience post-traumatic chronic distress and fear. Many of those who were or believe they were exposed will likely worry about delayed radiation health effects. Depending on how the attack evolves and its aftermath is handled, there may be loss of confidence in societal institutions. If severe damage to the communications network disrupts communication from authorities, public anxiety and fear could be heightened.

ADDITIONAL INFORMATION

Centers for Disease Control and Prevention—**http://www.bt.cdc.gov/radiation**
See fact sheets: "Radioactive Contamination and Radiation Exposure" and "Radiation Measurement"
Radiation Emergency Assistance Center—**http://www.orau.gov/reacts/**
U.S. Department of Energy, National Nuclear Security Administration—**http://www.nnsa.doe.gov**
U.S. Department of Homeland Security—**http://www.dhs.gov/dhspublic/** • **http://www.ready.gov**
U.S. Nuclear Regulatory Commission—**http://www.nrc.gov/what-we-do/safeguards.html**
Armed Forces Radiobiology Research Institute (AFRRI)—**http://www.afrri.usuhs.mil**
Health Physics Society—**http://hps.org/publicinformation/radterms**
Radiation Effects Research Foundation—**www.rerf.jp**

This report brief was prepared by the National Academy of Engineering and the National Research Council of the National Academies in cooperation with the U.S. Department of Homeland Security. For more information, contact Randy Atkins at 202-334-1508, atkins@nae.edu, or visit www.nae.edu/factsheets.

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