The Facts About

"DIRTY BOMBS"

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"DIRTY BOMBS"

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EXECUTIVE SUMMARY

- Dirty bombs," more correctly called radiological dispersal devices, are weapons that are designed to spread potentially harmful radioactivity. The principal type combines a conventional explosive with radioactive material.

- Dirty bombs are not nuclear weapons. Unlike a nuclear bomb, which could cause hundreds of thousands of deaths and devastate an entire city, a dirty bomb would most likely cause a few hundred deaths at the most. Physical damage would be comparable to that produced by other conventional explosions, and radioactive contamination would probably affect an area of only a few city blocks.

- Most deaths and injuries from a dirty bomb attack would result from the explosion itself, rather than the radioactive material. However, the presence of radioactive contamination could lead to panic, disruption, and the need for costly and time-consuming cleanup.

- The cost of recovery after a dirty bomb attack could be reduced, without increasing risks to human health, by modifying regulations pertaining to permissible levels of residual radioactivity so that they are based on real risk rather than the ability to detect ever-lower levels of contamination.

- In the event of an explosion, experts advise people to move away from the immediate area (by walking at least several blocks from the explosion), go indoors, and turn on local radio or TV for instructions (including instructions about testing for radioactive contamination). If it is determined that the explosion involved radioactivity, people who were in the immediate area should remove and save clothing and take a shower if possible. Experts recommend that people should *not* handle any object thrown off by an explosion and should not take potassium iodide unless specifically advised to do so. Driving away from an attack is also unwise, since it can hamper emergency response and cause crashes.

INTRODUCTION

Of all the possible types of terrorist attacks, those involving radioactivity are among the most feared. One type of attack that involves radioactivity is the use of a radiological dispersal device (RDD) or "dirty bomb." Misconceptions about dirty bombs may lead people to be more anxious than the facts justify and might even prompt some people to take inappropriate actions in the event of a dirty bomb explosion.

This report by the American Council on Science and Health summarizes the scientific facts about radiological dispersal devices — what they are, how they might be made, the possible health and economic consequences of an attack, the actions that citizens should and should not take if a radiological attack occurs, and the types of policy changes that may need to be considered to facilitate prevention of radiological attacks and recovery from them. The principal source of information for this booklet was a technical manuscript entitled "Radiological Terrorism," written by Dr. P. Andrew Karam of the Rochester Institute of Technology. Additional information sources are listed at the end of this report.

RADIOLOGICAL DISPERSAL DEVICES

Radiological dispersal devices, also called radiological weapons, are devices that are designed to spread potentially harmful radioactivity as part of a hostile act. The principal type of radiological dispersal device combines a conventional explosive, such as dynamite, with radioactive material. This is the type of device that is often referred to as a "dirty bomb." When a dirty bomb explodes, the explosion itself can cause considerable damage — just as any explosion can. In addition, the area surrounding the explosion may become contaminated by radioactive material.[1]

Although the exact details would vary depending upon the type and amount of radioactive material used, as well as the nature of the explosive device, most deaths and injuries from a dirty bomb would almost certainly result from the explosion itself, rather than the radioactive material. People who were closest to the explosion — and therefore most likely to have been injured by it — would also be the most likely to be exposed to dangerous amounts of radioactivity. Some radioactive material might be spread beyond the damaged area — perhaps to a distance of a few city blocks — but the intensity of contamination would be much less than that in the immediate vicinity of the explosion. Experts expect that there would be few, if any, deaths or serious illnesses caused by radiation in individuals who had not been in the immediate vicinity of the blast for a prolonged period of time.

Although the radioactive component of a dirty bomb would probably cause few deaths or injuries, problems of other kinds would result. The presence of radioactivity would make the jobs of firefighters and rescue personnel who respond to the emergency more difficult. Healthcare facilities might have to cope with injured patients who are also contaminated with radioactivity. Large numbers of people might seek care out of concern over possible contamination, possibly overloading healthcare facilities. Widespread panic could develop, and this might prompt people to take unwise or even unsafe actions. (For example, people who mistakenly believed that they would need to get many miles away from a dirty bomb attack in order to be safe might drive away at dangerous speeds or crowd the roads with their cars, thus interfering with access to the scene by emergency vehicles and also causing a risk of death and injury from motor vehicle crashes far greater than the risk of death or injury from the attack itself.) Costly cleanup efforts would almost certainly be necessary, and the buildings and facilities in the affected neighborhood (probably several city blocks) might be unavailable for a prolonged period of time. In addition, as has been seen in incidents of accidental radioactive contamination, anxiety and economic disruption due to stigmatization of the affected area might continue for long periods of time.

Dirty bombs are not classified as Weapons of Mass Destruction because the number of deaths and injuries they are likely to cause is relatively small. However, they are sometimes referred to as "Weapons of Mass Disruption" because of the many disruptive effects that they could have on a community.

Although there have been no successful radiological attacks, it is possible to get a rough idea of the type and extent of problems that might result from the radioactive component of a dirty bomb from instances of accidental radioactive contamination.

One well-known incident that involved widespread radioactive contamination occurred in Goiania, Brazil, in 1987. A cancer treatment facility had closed, and its radiation therapy source, which contained radioactive cesium, had been left behind.[2] Unsuspecting residents found the abandoned equipment, and someone opened the canister containing the radioactive cesium. Fascinated by the blue powder they found, residents played with it and spread it on their bodies, unaware of its radioactivity. By the time the nature of the mate-

1. It is also possible to design a radiological attack that does not involve an explosive. For example, a powerful source of radioactivity might be hidden in a public place. Terrorists might also spread radioactivity covertly or try to contaminate the food or water supply.

2. Obviously, this should not have happened. Regulations should be in place in all countries to require that sources of radioactivity no longer in use are disposed of safely. Unfortunately, the extent of control over radioactive sources, both at the time of the Goiania incident and today, varies greatly in different parts of the world.

rial was known, nearly 250 people had been exposed to elevated radiation levels; four died of radiation sickness.

During the response to the Goiania incident, more than 3,000 cubic meters of contaminated materials were removed for disposal and over 100,000 persons were surveyed for contamination at the city's soccer stadium (of whom only a few hundred were actually contaminated). The recovery process was time-consuming and expensive. However, the social impact was far greater; even a decade later, Goiania residents were stigmatized by their association with the region. This stigmatization included an economic impact because sales of agricultural products from Goiania declined for absolutely no reason related to food safety or health.

DIFFERENCES BETWEEN RADIOLOGICAL AND NUCLEAR WEAPONS

A radiological weapon (dirty bomb) is very different from a nuclear weapon (atomic bomb). In a nuclear weapon, energy is produced by splitting uranium or plutonium atoms in such a way that enormous amounts of energy are released in a very brief period of time. The resulting explosion is huge and can devastate a very large area. In a radiological weapon, the explosive itself is a conventional one; it releases a much smaller amount of energy and causes much less destruction. The radioactive material present in the bomb is dispersed by the explosion, but it does not cause or participate in the explosion; the explosion in this instance is not a nuclear blast.

Nuclear bombing of Hiroshima during World War II.
Photo by US Army

To understand the difference in magnitude between conventional and nuclear bombs, it may be helpful to compare a large conventional bombing — the bombing of the Alfred P. Murrah Federal Building in Oklahoma City in 1995 — with the nuclear bombing of Hiroshima during World War II. The bomb used in Oklahoma City was equivalent to a few tons of TNT; the bomb detonated over Hiroshima was approximately 10,000 times more powerful. In Oklahoma City, 168 people were killed, the target building was destroyed, and nearby buildings were seriously damaged. In Hiroshima, nearly 100,000 people were killed, and an entire city was virtually destroyed.

Alfred P. Murrah Federal Building after bombing attack.
Photo by Oklahoma City Police Department

An attack with a large radiological weapon might combine the physical destruction and casualty level of an Oklahoma City-type bombing with a small number of additional radiation-related casualties and substantial radiation-related disruption similar to that resulting from the Goiania incident.

HISTORY OF RADIOLOGICAL DISPERSAL DEVICES

The idea of radiological weapons is not new. The possibility of using bombs that would distribute radioactivity in enemy territory as military weapons was considered as early as 1941. Today, radiological weapons are no longer considered practical for military use; instead, they are potential terrorist weapons.

No radiological dispersal device has ever been successfully used as a weapon. However, attempts have been made. In 1997, Chechen terrorists set but did not explode a device containing radioactive cesium in a Moscow park. In 2002, an arrest was made in the U.S. of a person involved in an alleged dirty bomb plot. In several instances, radioactive materials that might be suitable for use in a radiological dispersal device have been stolen, and attempts have been made to smuggle or sell such materials. Thus, it is clear that terrorists continue to be interested in the possibility of radiological attacks.

Constructing and detonating a dirty bomb are not easy tasks, however. First, radioactive materials must be obtained — most likely either by theft or by smuggling them from countries where they are available for legal or illegal purchase. Second, the materials must then be incorporated into a bomb — a difficult task, since working with radioactive materials can be hazardous. Obviously, many terrorists are not deterred by sacrificing their lives, but a terrorist would need sufficient working time to complete his work; it is hard to construct a device if the terrorists working on it receive an incapacitating radiation dose within 15 minutes, for example. Finally, once constructed, the device must be transported to the destination and detonated without being discovered.

Each of the steps in this process suggests ways in which radiological attacks may be prevented. For example, increased security at facilities that use radioactive materials, such as hospitals and research laboratories, can help to deter theft, and increased use of radiation detectors at border crossings can make it easier to detect smuggling of radioactive materials.

HEALTH EFFECTS OF RADIATION

The health effects of radiation exposure vary, depending upon the type of radioactive material, the dose of radiation to which a person is exposed, and the route of exposure (e.g., inhalation, ingestion, external exposure). Exposure to very high doses of radiation can cause radiation sickness, which is fatal at very high doses but is milder and temporary at lower doses. Contact with radioactive material can also cause radiation burns, which can also range from mild to severe. In most dirty bomb scenarios, however, radiation exposure levels would be far lower than those shown to cause these effects, except perhaps for individuals in immediate proximity to the blast. Unlike the situation with a nuclear attack, widespread radiation sickness would not result from a dirty bomb attack.

In the event of a radiological attack, people are likely to find themselves in situations where they have an opportunity to aid a victim of the attack, and they may wonder whether it is safe to do this in spite of the possibility of radioactive contamination. For example, a bystander might see an injured person with dust on his clothing coming out of a building where an explosion had taken place. Would it be safe for the bystander to help the victim move to a safe place or to provide first aid? Experts say that the answer is yes; contaminated patients do not pose a hazard to those who are helping them. Emergency responders and medical personnel can and should help these people; bystanders can do so as well without jeopardizing their own health.

It is often reported that the initial symptoms of radiation sickness include nausea, vomiting, and diarrhea. This is correct, but it is important to remember that these are nonspecific symptoms that can also be produced by many other causes, including stress (as millions of people who have become "sick to their stomachs" in response to upsetting events can attest). In the aftermath of a dirty bomb incident, it is likely that many people would experience such symptoms. However, in all or practically all cases, the symptoms would prove not to be the result of radiation exposure.

Exposure to radiation doses lower than those that cause radiation sickness, but much higher than those normally found in the environment, may increase a person's risk of developing cancer later in life, especially if exposure is prolonged. However, although radiation is known to be a carcinogen (cancer-causing agent), it is a weak carcinogen, and even radiation levels significantly in excess of natural background levels do not significantly raise cancer risks. Just because a person is near a source of radioactivity for a short time or comes in contact with a small amount of dust that contains radioactive material does not mean that the person will develop cancer. The increase in risk resulting from such exposures would be quite small. In most instances, the detonation of a radiological dispersal device would not lead to a substantial increase in the number of cases of cancer in the affected population in later years.

Some recent news accounts have predicted that exposure to even small amounts of radiation from a radiological attack would cause some additional cases of cancer. Such predictions are based on the faulty assumption that effects that occur at high doses of radiation can be directly extrapolated to much lower doses. Increasing scientific evidence indicates, however, that this type of extrapolation is not valid, and that the health risks associated with low-level radiation exposure are smaller than such extrapolation would predict.

Another health issue that is often misunderstood is the effect of radiation exposure during pregnancy. People often believe, incorrectly, that any exposure to radiation during pregnancy, no matter how small, will have disastrous effects on the unborn child. Thus, women who had routine dental X-rays before realizing that they were pregnant sometimes panic and consider abortion, even though this is unnecessary (routine dental X-rays result in insignificant radiation exposure to the unborn child). Low doses of radiation pose much less risk to an unborn child than most people (and even some physicians) realize. In the event of a dirty bomb attack, most pregnant women in the affected area would not be exposed to amounts of radiation sufficient to cause harm and would not need to consider terminating their pregnancies.

ECONOMIC CONSEQUENCES OF A RADIOLOGICAL ATTACK

Although the number of casualties from a radiological attack would probably be relatively small (tens to hundreds), the economic impact could be very great. Some experts think that the cost of recovery from a dirty bomb attack could equal or even exceed the $30 to $40 billion cost of restoring lower Manhattan after the September 11 attack, despite a much smaller amount of physical damage and fewer casualties.

The high costs would result primarily from the need to clean up and decontaminate the affected area. Much of this effort would consist of physically removing contaminated material (perhaps including a layer of soil, as was done in Goiania) and hauling it away to a low-level radioactive waste depository. Buildings would also need to be decontaminated — a process that is difficult and in some instances not technically feasible with current technology. If a structure could not be decontaminated successfully, it might be necessary to demolish it, even if it was not physically damaged by the attack.[3]

In addition to being expensive, cleaning up an area after a radiological attack would be very time-consuming; it is likely that normal activities in physically undamaged areas surrounding an attack site would not be able to resume for much longer than in the case of a non-radiological attack. After the September 11 attack, much of the surrounding area was reoccupied within days or weeks; in the case of a radiological attack, it could be months or longer because of the need for decontamination.

It may be possible to substantially reduce the extent of the area that would receive extensive decontamination after a radiological attack without increasing risks to human health by changing the regulatory standards for the amount of radiation permitted to remain after cleanup. This type of change, which is discussed in more detail below under "Policies and Regulations," could decrease the cost of recovery after a radiological attack and allow normal activities to resume more quickly.

People's fears of radiation could add to the economic impact of a radiological attack. The biggest long-term economic problems faced by people in Goiania (an agricultural region) resulted from the refusal of people from outside the region to buy its agricultural products, even though those products were safe. In the case of a radiological attack on an urban area, similar fears might lead to a reluctance to purchase industrial products, conduct business in the area, or visit tourist attractions, all of which could cause lasting economic damage.

3. Alternatively, a building or area could be abandoned and fenced off, but this option is unlikely to be practical in a major metropolitan area.

WHAT TO DO IN CASE OF A DIRTY BOMB ATTACK

It is important to note that radioactivity cannot be seen, felt, or smelled. Therefore, the fact that an explosion involved radioactivity would not be immediately obvious (unless a terrorist group announced it). In most instances, emergency responders, who routinely have access to radiation detectors, would be able to conduct radiation surveys and determine fairly quickly, probably within a half hour, that a radiological attack had taken place. This information would then allow the authorities to issue correct instructions to the public via the news media.

If a dirty bomb attack occurred, people would find out about it in two different ways. Some individuals would be close enough to hear, see, or feel an explosion. Others, who were farther away, would hear about the attack through the news media or official announcements.

- For those people who were not close enough to the explosion to hear, see, or feel it, the most important thing to do would be to turn on a local radio station or television channel and wait for advice from emergency response authorities. In all likelihood, people in this situation would not be at any immediate risk. However, just as with any other type of emergency, the authorities might have important instructions for the public to follow. For example, people might be advised to stay away from an affected area to avoid interference with emergency personnel and perhaps also to avoid exposure to radioactive contamination.
- For people who heard, saw, or felt an explosion, the situation would be different. These individuals would know that an emergency had occurred, but they would not know immediately whether radioactivity was involved. Because these individuals were close to an explosion and might continue to be in danger, they would need to take some actions that people farther away from the explosion would not.

After an explosion, experts recommend that people should do the following:

- Move away from the immediate area — at least several blocks from the explosion — and go indoors.
- Turn on local radio or TV channels for advisories from emergency response and health authorities.
- If it is determined that an explosion involved radioactivity and if facilities are available, people who were within sight of or downwind of the explosion should consider changing clothes and showering if possible. These actions will remove at least 90 percent of external contamination. Contaminated clothing should be placed in plastic bags and sealed until the amount of contamination can be measured.
- If radioactive material was released, local news broadcasts will advise people where to report for radiation monitoring and blood and other tests to determine whether they were in fact exposed and what steps to take to protect their health.
- Because inhaling any kind of dust, and especially dust that may be contaminated with radioactive material, is unhealthful, some experts recommend that people take simple precautions to avoid inhaling contaminants during the immediate aftermath of an explosion, such as breathing through a folded cloth if one is readily available and going indoors and closing doors and windows as soon as possible.
- Another important precaution is to not handle or pick up any object thrown off by an explosion. In the event that the object was part of the radioactive source used in a dirty bomb, it could be quite dangerous. Handling things without knowing what they were is what got people into trouble in Goiania; the same could occur after a dirty bomb explosion.

People sometimes wonder whether they should take potassium iodide to protect their health if a radiological attack occurs. The answer in almost all possible dirty bomb scenarios is no. Potassium iodide protects only against damage to the thyroid gland from radioactive iodine; it does not protect other parts of the body, and it is of no use against other radioactive materials. It is very unlikely that radioactive iodine would be used in a dirty bomb.

Another course of action that is usually unwise (unless specifically advised by authorities) is driving away from the area of an attack. People can move to a safe distance from a radiological attack by walking rather than driving; staying off the roads reduces the risk of traffic congestion that can hamper response to the emergency or cause crashes. Also, an automobile that was in the immediate vicinity of a dirty bomb explosion could be contaminated with radioactivity. People who drive away in that automobile might expose themselves to more radioactivity than they would if they walked to a safe location.

POLICIES AND REGULATIONS

As societies make efforts to prevent radiological attacks and to ensure the most effective response if an attack occurs, consideration may be given to modifying some policies and regulations that were not designed with radiological attacks in mind. Citizens need to understand the rationale behind such proposals in order to make informed decisions about their merits. A proposal that appears "overly restrictive" or "insufficiently protective" on the surface might well be found to be beneficial when all its advantages and disadvantages are taken into consideration. The following examples may help to illustrate this point.

Legal purchase of radioactive materials in the U.S. requires possession of a radioactive materials license. These licenses are considered public documents and therefore are available for public scrutiny. This means that a terrorist organization may be able to obtain copies of the documents and use these to identify likely targets for theft. Thus, it may be worthwhile to consider prohibiting public access to these documents. The government — and by extension, the public — would need to decide whether the potential benefits of this regulatory change justify limiting citizens' freedom of access to this particular type of information.

If terrorists are to construct and transport a radiological dispersal device with reasonable safety to themselves, they would need to obtain large quantities of lead to use as shielding. Accordingly, a case could be made for requiring lead vendors to report large sales of their products. If such a proposal is considered, its potential benefits would have to be weighed against the additional burdens that would be placed on the lead industry and the likely resulting increases in the cost of this industry's products.

Some current regulations pertaining to permissible levels of radioactive contamination may have been based more on what is achievable or what is detectable than on what is truly necessary to protect health and the environment. In the event of an attack, these unnecessarily stringent regulations might hamper a community's ability to recover by increasing the amounts of time and money mandated for cleanup without providing any benefits that would offset these costs. Therefore, society may wish to revisit regulatory guidance so that regulations are based on real risk rather than the ability to detect ever-lower levels of contamination.

It has been proposed, for example, that the standard for the amount of added radioactivity allowed to remain after cleanup from a radiological attack be increased tenfold.[4] This might decrease the cost of recovery by perhaps 90 percent and somewhat decrease the time needed for cleanup.

The current standard set by the Nuclear Regulatory Commission is 25 mrem (millirems) of added radioactivity per year[5]; the Environmental Protection Agency's standard is 15 mrem per year. For comparison, it helps to know that the natural background radiation to which people are normally exposed is several hundred millirems per year, with substantial variations from place to place. Residents of Washington, D.C., for example, are exposed to 300 mrem/year, which is close to the national average. Residents of Denver, Colorado, which is at a higher altitude (therefore allowing more exposure to cosmic radiation) and has underground uranium deposits, are exposed to about 500 mrem/year.

Increasing the standard for residual radioactivity tenfold would mean allowing about 200 mrem/year of added radiation to remain in the environment after cleanup from a radiological attack; this is the same as the additional exposure that would come from living in Denver rather than Washington. No radiation-associated health risks have been associated with living in Denver; cancer rates there are similar to those in Washington. Similarly, no adverse effects on human health would be expected if a residual radioactivity standard of around 200 mrem/year were adopted.

4. This proposal is recommended and discussed in detail in Zimmerman, Peter D. with Cheryl Loeb, Dirty Bombs: The Threat Revisited, National Defense University, January 2004. Available online at http://hps.org/documents/RDD_report.pdf

5. A rem is a unit that relates the absorbed dose of radiation in human tissue to the effective biological damage of the radiation. Different types of radiation have different biological effects; expressing amounts of exposure in rems allows these different types of radiation to be compared.

SUMMARY

Dirty bombs, more correctly referred to as radiological dispersal devices or radiological weapons, are conventional explosive devices with added radioactive material. They are designed to spread radioactive contamination — and with it, panic, anxiety, and social and economic disruption — in a community. To ensure appropriate responses in the event of a radiological attack, citizens need to understand that the principal danger from a dirty bomb lies in the explosion itself; in most scenarios, few if any people who were not close enough to the blast to be injured by it would experience any adverse health effects from radiation exposure. Citizens can help to minimize the harmful impact of a radiological attack by following the instructions of emergency response authorities and by avoiding hasty actions prompted by panic or unwarranted fears of even small amounts of radioactivity.

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