# Radiological Terrorism

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## Abstract

The continued proliferation of nuclear materials and technology make nuclear terrorism more probable than ever. After the attacks of September 11, 2001 in United States of America, the whole world was under the shadow of nuclear terrorism. A radiological terrorist attack on the Taiwan is a possibility. It could involve the dispersal of radioactive material by deployment of a radiation dispersal device, an attack on a nuclear power plant or detonation of a nuclear weapon. But the possibility of latter is less likely. To decrease the vulnerability to the threat of radiological terrorism, the assessment of risk and the medical teams should have a basic understanding of radiation hazards and medical management. They should be prepared to interact with appropriate government agencies to facilitate the employment of emergency response plans. *(Ann Disaster Med. 2003;2:S46-S52)*


**Key words:** Radiation Dispersal Device; Radiological Terrorism; Medical Teams

## History of Radiation Incidents

Three Mile Island, Pennsylvania on March 28, 1979, equipment malfunction compounded by human error led to the worst commercial nuclear accident in U.S. That catastrophe resulted in nuclear industry reform and a antinuclear movement burgeon. Chernobyl reactor accident on April 26, 1986 is now known to have exposed more than 116,500 persons and resulted in at least 28 deaths from acute radiation sickness.[1,2] September 30,1999, technicians at a nuclear fuel reprocessing plant in Japan accidentally set off a series of uncontrolled chain reactions and released radiation by pouring too much uranium solution into a holding tank. Despite the best medical care, two technicians eventually died from the exposure.[3] According to the record of radiation accidents under Radiation Emergency Assistance Center-Training Site (REACTS),[4] the number of radiation accidents has reached 403 with 133,617 victims, of which 2,965 had significant exposures and 120 persons died in the world since 1994 to 2002 June.

As these emergencies illustrate, significant health risks are associated with exposure to ionizing radiation and radioactive contamination from nuclear accidents. The fears related to nuclear energy, nuclear weapons, and now nuclear terrorism have also had significant adverse psychological effects. Without question, any large-scale release of radioactive material into the environment, whether accidental or

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intentional, has long-range and complex effect.

## Possible Types of Attacks

While the end of the Cold War has drastically reduced the likelihood of nuclear warfare, the continued proliferation of nuclear materials and technology make nuclear terrorism more probable than ever.[5] The types of radiological terrorist attacks could occur as follows.

### *Radiological dispersal events*

Deployment of a radiation dispersal device (RDD) is a device used to disperse radioactive materials without a nuclear detonation is called a radiation dispersal device (RDD) or dirty bomb. RDDs employ conventional explosives or other mechanisms to disperse radioactive materials.

The second possibility is attack on a nuclear facility. Small or highly localized larger amounts of radioactivity may be dispersed with an bomb or other attacks to cause fear and social disruption. Small radioactive sources, such as those used in common medical applications, could be placed in a small container and dispersed by bomb or moving vehicle. Individual exposure would be low. The effects would be primarily psychosocial, with no immediate health effects and a small risk of long-term adverse health effects. Industrial sources contain higher quantities of radioactive materials than those found in medical settings. Powerful explosives in a nuclear facility could spread large quantities of radioisotopes over a large area. Many of the injured would be contaminated by radiation. Life-threatening injuries could result from both the explosive event and radiation exposure. The area of dispersion depends on the amount of explosive, atmospheric conditions, and adherence of radioactive material to dust and other dispersed materials. Finely dispersed particles or metal debris could cause ground contamination and adhere to structural surfaces. The psychosocial effects would be tremendous. Commercial nuclear reactors contain large quantities of radioactive materials, but are very well protected. In the unlikely event of a successful attack on a nuclear reactor resulting in there release of radiation. Other potential targets, such as spent fuel storage depots, nuclear-fuel reprocessing facilities, transport vehicles, or high-level waste sites contain much less radioactive material than do reactors.[6]

### *Nuclear weapons*

A nuclear bomb constructed by a terrorist organization would probably be a single device with a low yield of 0.01 to 10 kilotons (kt). A more sophisticated, compact, higher yield device, with a yield of 10 kt or higher, might be acquired by buying or stealing a stockpiled nuclear weapon. So deployment of a nuclear weapon is much less likely than a radiation dispersal event. The effects of the detonation of a high-yield device include:

1. Air blast is a shock wave of air that travels outward from the point of explosion and is associated with strong winds that cause personal injuries and structural damage. Injuries and fatalities can be caused directly by the blast and indirectly by air-borne objects and falling debris.
2. Heat results from the fireball generated by a nuclear explosion. It is extremely hot, igniting materials and projecting heat over long distances, causing thermal burns.
3. Intense light can damage to eyesight and cause temporary or permanent blindness.

4. Ionizing radiation can cause acute radiation syndrome of different degrees of severity. Initial radiation is from the initial intense pulse of radiation produced in the first minute following detonation. It includes gamma rays and neutrons. Residual radiation results from radioactive decay after the first minute following detonation. Large amounts of radioactive materials are propelled into the atmosphere, contributing to radioactive fallout. Radiation injuries are the predominant cause of death in lower-yield detonations.
5. Ground shock can cause extensive damage to structures and infrastructure.[6] The destruction of structures and infrastructure can cause damage of people.

## The Potential Impact of a Major Nuclear Attack

According to the CATS (Consequences Assessment Tool Set) software created by the US Federal Emergency Management Agency and the Defense Threat Reduction Agency, the expected casualties from a 12.5 kiloton nuclear explosion at ground level in New York City was calculated. The blast and thermal effects of such an explosion would kill 52,000 people immediately, and direct radiation would cause 44,000 cases of radiation sickness, of which 10,000 would be fatal. Radiation from fallout would kill another 200,000 people and cause several hundred thousand additional cases of radiation sickness.[7]

Casualties on this scale would immediately overwhelm medical facilities leading to a high mortality rate among those injured but not killed by the initial blast and thermal effects. Over 1000 hospital beds would be destroyed by blast, and 8700 beds would be in areas with radiation exposures high enough to cause radiation sickness.[7] The remaining local medical facilities would quickly be overwhelmed, and the advance outside help would be delayed. For example, after the 1995 earthquake in Kobe, Japan, in which 6500 died and 34900 were injured, there were long delays before outside medical assistance arrived,[8] and this disaster had few of the complicating factors that would accompany a nuclear attack with extensive radioactive contamination.

## Types of Radiation and the Damage

Ionizing radiation can produce charged particles (ions) in any material it strikes. X-rays, for example, are a form of ionizing radiation. At high doses, these charged particles can cause damage to molecules, cells, or tissue. Although different types of nuclear weapons or materials will emit various kinds of radiation, alpha, beta particles, gamma rays and neutrons are the types most likely to be encountered after a nuclear terrorist attack. Alpha particles are large, heavy, charged particles containing two protons and two neutrons. The ability of penetrate is poor, causing minimal external radiation. Beta particles are small, light, charged particles found in radioactive fallout. The ability of penetrate is fair, causing similar to thermal burns. Gamma rays are uncharged, highly energetic photons similar to X-rays. The ability of penetrate is high, causing whole-body exposure. Neutrons are uncharged particles with virtually the same mass as a proton. They are emitted during nuclear detonations, but are not present in fallout. Due to their mass, they can cause significant biological damage---up to twenty times the damage caused by gamma ray. The effects of radiation depend on whether the patient was exposed or contaminated, and if contaminated, how much radiation the patient has absorbed.

The effects that radiation depends on how much radiation the contaminated patient has absorbed. This amount of absorbed radiation used to be measured in rads-radiation absorbed doses. It's now measured by the gray (Gy). One Gy equals 100 rads.

Patients who absorb less than 0.75 Gy are not likely to experience any symptoms of exposure. Those who absorb more than 0.75 Gy can develop acute radiation syndrome (ARS). A dose of 30 Gy or more is always fatal.[9]

## Tentative Assessment of the Risk of Radiological Terrorism

The assessment of the risk itself, consisting in interpreting the product of the probability of occurrence with the effects, is important. It is not an easy case, because quite different quantities have to be multiplied. The risk assessment of radiological terrorism shown in Table.[10]

Despite the fact that the damage of a successful nuclear weapon would be disastrous, the risk is extremely low probability. Although still difficult and a high-tech-business to RDD or dirty bomb, radiological terrorism is incomparably more feasible than the other cases. The scale of possible effects is lower, but the effects on the economics could be extremely large, and the psychological effects on the public would in any case be huge indeed.[10]

## Governmental Response to Radiological Terrorism

### *In America*

The Federal Radiological Emergency Response Plan (FRERP) set up an organized and integrated capability for timely, coordinated response by federal agencies to peacetime radiological emergencies. FRERP covers any peacetime radiological emergencies that has actual, potential, or perceived radiological consequences within the United States that could require a response by the federal government. The level of response is based on the type and quantity of radioactive material, the location of the emergency, the impact on the public and

**Table.** Qualitative assessment of the risk of radiological terrorism

| Option | Technical feasibility: respectively probability of occur (P) | Effects and damage (E) | | | | Risk (R) |
|---|---|---|---|---|---|---|
| | | Area affected | Effects on Man' health | Environment/ Economics | Psychological effect | |
| Nuclear Weapon ( Home made bomb) | Extremely low | Large (<50Km$^2$) | Very large to catastrophic | Disastrous | Traumatic | Very low |
| Attacking a nuclear facility | Security measures make it (very difficult) | Very large (< 100km$^2$) | limited | Very large | Tremendous | Very low |
| RDD(dirty bomb) | Still difficult and a high-tech business but feasible | For long term effects large to very large | Actually limited | Large to very large especially on economics | The dominant effect | High |

the environment, and the size of the affected area.

When the terrorists start the radiological terrorism, the Atomic Energy Act directs the Federal Bureau of Investigation (FBI) to investigate all alleged or suspected criminal violations of the act. In addition, the FBI is legally responsible for locating any nuclear weapon, device, or material and for restoring nuclear facilities to their rightful custodians. So, the FBI would be the lead federal agency for any terrorist event, and all other federal agencies would provide technical support and assistance to the FBI. The federal response would be adapted to the specific circumstances of the event. Agencies supporting the FBI include the Nuclear Regulatory Commission (NRC), the Department of Agriculture, the Department of Energy (DOE), the Department of Health and Human Services, the Department of Justice, the Federal Emergency Management Agency (FEMA), and the Environmental Protection Agency (EPA). Each supportive agency would coordinate and manage their technical portion of the response, and implement measures to protect public health and safety. The FBI would manage and direct law enforcement and intelligence aspects of the response, coordinating activities with appropriate federal, state, and local agencies within the framework of FRERP and as provided for in established interagency agreements or plans.[6]

### In Taiwan

When the terrorists start the radiological terrorism, the National Security Bureau (NSB) is authorized to convene Coordination Meeting for National Security Intelligence (CMNSI) to directs the Bureau of Investigation, Ministry of Justice and National police Administration, Ministry of Interior to investigate all alleged or suspected criminal violation of the act.

The Atomic Energy Council (AEC) of the Republic of China promulgated a nuclear emergency response plan in November 1981 under the approval of the Executive Yuan. The national nuclear Emergency management Committee (NNEMC) was also established. Efforts of all government authorities concerned have been integrated to organize a systematic arrangement for the nuclear emergency response plan. The responsibility of nuclear emergency planning and implementing are demarcated according to the site boundary. Taiwan Power Company is responsible for on-site areas under the supervision of the AEC. Central and local government agencies are responsible for off-site areas with the supports of TPC. This off-site nuclear organization is referred to as the NNEMC which comprises all government authorities concerned. NNEMC reports to the Executive Yuan and makes decisions on public protection actions, directs and coordinates the supporting center as well as the rescue center. The directing and coordinating center is composed of AEC and TPC personnel and subdivided into technical group, radiation monitoring team and logistic group with the responsibility of collecting and submitting accident information, assessing the accident consequences and dosage, monitoring and controlling off-site radiation and contamination, respectively. The rescue center is composed of relevant units of the local governments that is responsible for notifying and helping the public to take protective actions, arranging accommodations and providing medical care. The supporting center is composed of military units which are responsible for providing transportation means, carrying out decontamination in affected areas, and establishing temporal communication networks, traffic control and safeguard.

## Conclusion

The continued proliferation of nuclear materials and technology make nuclear terrorism more probable than ever. The attacks of September 11, 2001 in United States of America have provided a wake-up call for facing the threat of nuclear terrorism. In addition to vigilance and preventive measures, preparation is needed for a prompt and effective response in the event of a terrorist attack involving radiation. Government agencies have well-defined roles and responsibilities in the event of a nuclear emergency. The medical teams must be prepared to participate as part of a team effort to mitigate the effects of radiological terrorism.

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# 輻射恐怖事件

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**摘要**

恐怖主義的盛行,核子原料不斷的增殖和科技的發展，使得招受核子恐怖攻擊事件的機率更勝以往。在美國911事件之後，全球籠罩在一片恐怖主義的陰霾之下，台灣亦不能幸免。可能發生的形式可能藉由攻擊核能發電廠和製造散佈輻射能量的裝置來散佈輻射能量，另外也可能以核子武器展開攻擊。但後者的機率是非常低的。為了將輻射恐怖事件的傷害降低，事前風險的評估和醫療團隊對於輻射傷害及處理應有基本的了解，同時也應該隨時準備與負責相關的行政機構配合，以利於緊急反應計劃的部署。*(Ann Disaster Med. 2003;2:S46-S52)*


**關鍵詞:** 散佈輻射能量的裝置；輻射恐怖事件；醫療團隊

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