Effects of Nuclear Radiation: A Silent Killer

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Abstract:

Nuclear radiation is the worst effect of a nuclear explosion. Radiation is perhaps the most frightening direct effect of nuclear explosions. Blast can be seen, heat can be sensed but ionizing radiation cannot be detected so, a person can die without knowing what caused it. It not only damages the health but through its effect on reproductive cells and fetuses, it also has prospective effect on health.

This paper will analyze the kinds of radiation and its effect on the human society. Roughly, during the first six months after the explosion, for every sevenfold increase in time, the radiation dose received is decreased by a factor of 10.

The next section of the paper will be dedicated to the medical effects of nuclear radiation. The medical effects of ionizing radiation depend on the dose i.e. the amount of energy actually deposited in the body. The more energy absorbed, the greater are the risk of irreparable damage. Within the intermediate range of exposure, a victim may develop a variety of symptoms, including loss of appetite, nausea, vomiting, intestinal cramps, diarrhea, apathy, fever, and headache. The incidence of stillbirths, infant mortality, mental retardation, malformations, and cancer among human beings exposed to intermediate radiation during their embryonic stage of development will be higher. There might also be an increased number of genetic defects among the survivors' descendants. There is no effective cure for radiation sickness. Further, the paper concludes and emphasizes on the need to have a check and balance system on the use of nuclear weapons and provides suggestions for improving the present state.

Keywords*: radiation, ionization, energy, medical effects, radiation dose, stillbirths*

Introduction

The consequence of a nuclear explosion is quite drastic. Numerous nuclear explosions have occurred in the last five decades like the accident at Three Mile Island nuclear power plant in the USA, March 1979, caused some people near the plant to receive very minor doses of radiation, immediately after the Chernobyl nuclear power plant disaster in 1986, much larger doses were experienced, apart from the residents of nearby Pripyat, who were evacuated within two days, some 24,000 people living within 15 km of the plant. In this explosion a total of 14,000 PBq of radioactivity (iodine-131 equivalent) was released. In 1987 at Goiania in Brazil, an old radiotherapy source stolen from an abandoned hospital caused four deaths, 20 cases of radiation sickness and significant contamination of many more. Another accident which is more recent occurred in the March 2011 accident at Fukushima Daiichi nuclear power plant in Japan which released more radioactivity than Three Mile Island, but much less than Chernobyl.[1] As can be seen that even a small nuclear is a cause of great anxiety among the people then, imagine what will happen if this explosion is caused deliberately by a person on a large scale. Nuclear weapons are not the safest of weapons for mankind. Nuclear energy is very good for the development but in the wrong hands, it is a weapon of massive destruction. So, proper care should be taken while handling nuclear energy or a nuclear weapon.

There are two basic types of nuclear weapons. In an A-bomb (atomic or fission bomb), atoms of heavy elements (uranium-235 or plutonium-239) break up (fission) into lighter elements and release energy. In an H-bomb (hydrogen, fusion, or thermonuclear bomb), two isotopes of the lightest element (hydrogen) are fused into a heavier element (usually helium, the next lightest) and produce an enormous explosion[1].

[11] Nuclear radiation and health effect

Several variations of these two bombs exist. For any given weight of explosives, the yield of nuclear bombs is roughly 3.5 million times greater than the yield of conventional explosives [2]. The physical characteristics and effects of a single nuclear explosion are determined by many variables, including the type of bomb used, its yield, the height at which detonation occurs, weather conditions, and the type of target[3]. Any brief description is therefore abstract and simplified. The following the main effects of a nuclear explosion:

Ultraviolet Pulse: For a person standing outdoors some distance from ground zero, the first indication that a nuclear explosion has occurred is a blinding flash of intense ultraviolet radiation.[4] This flash can dazzle observers miles away and temporarily blind them.

Electromagnetic Pulse: Wherever this pulse occurs, it can be absorbed by power lines, antennae, long wires, and other collectors, and carried to the electrical and electronic devices to which these collectors are attached.[5] EMP can therefore lead to temporary interference in communication and power. However, its direct effects on people are negligible: only the few people who happen to hold a pipe, long wire, or similar collector at the moment of explosion could die of severe shock.

Heat: Some 35 percent of the bomb's energy is given off as heat (thermal radiation). The heat pulse given off by the fireball starts fires over a large area. Fires may also start as an indirect result of the blast. These fires increase the number of casualties[6].

Blast: Some 50 percent of the bomb's energy is taken up by the blast. The blast lasts a few seconds. As is the case with all nuclear bombs' effects, its severity and physical characteristics depend on the bomb's yield.

The most dangerous effect is that of a radiation. Radiation is energy in the process of being transmitted, which may take such forms as light, or tiny particles much too small to see. [7] Radiation particularly associated with nuclear medicine and the use of nuclear energy, along with X-rays, is 'ionizing' radiation, which means that the radiation has sufficient energy to interact with matter, especially the human body, and produce ions, *i.e.* it can eject an electron from an atom. About 15% of the energy released in a nuclear air burst is in the form of ionizing radiation: neutrons, gamma rays, alpha particles and electrons moving at speeds up to the speed of light.[8] Blast and thermal injuries in many cases will far outnumber radiation injuries. However, radiation effects are considerably more complex and varied than are blast or thermal effects.[9] From the psychological point of view, and from the point of view of humankind's long-term future, radiation is perhaps the most frightening direct effect of nuclear explosions. We can sense blast, heat, and fire, but we can't detect ionizing radiation (except at very high intensities when it produces a tingling sensation) without the aid of special instruments; we can be irradiated to death without knowing it. Unlike fire and blast, ionizing radiation not only damages our health, but, through its potential impact on fetuses and on reproductive cells, it may damage the health of our descendants. Though the heat and the blast wreak incredible havoc, their direct effects are gone within seconds, or, in the case of the fires they cause, within hours or days. In contrast, poisonous radioactivity may linger for years.[10]

The character of the radiation received at a given location also varies with distance from the explosion. Radiation consists of three types of rays, each with a different capacity to penetrate bodies. These are alpha, beta and gamma rays. Radiation is not harmful in all cases. In fact, some types of radiations are unavoidable, like cosmic radiation which originates from stars. The Sun too, radiates cosmic energy produced by nuclear reactions on its surface, consisting of short wavelength emissions of electrons and neutrons.[11]

Nuclear radiation arises from hundreds of different kinds of unstable atoms. While many exist in nature, the majority are created in nuclear reactions. Ionizing radiation which can damage living tissue is emitted as the unstable atoms (radionuclides) change ('decay') spontaneously to become different kinds of atoms.

The principal kinds of ionizing radiation are[12]:

Alpha particles

These are helium nuclei consisting of two protons and two neutrons and are emitted from naturally-occurring heavy elements such as uranium and radium, as well as from some man-made transuranic elements. They are intensely ionizing but cannot penetrate the skin, so are dangerous only if emitted inside the body.

Beta particles

These are fast-moving electrons emitted by many radioactive elements. They are more penetrating than alpha particles, but easily shielded – they can be stopped by a few millimetres of wood or aluminium. They can penetrate a little way into human flesh but are generally less dangerous to people than gamma radiation. Exposure produces an effect like sunburn, but which is slower to heal. Beta-radioactive substances are also safe if kept in appropriate sealed containers.

Gamma rays

These are high-energy beams much the same as X-rays. They are emitted in many radioactive decays and are very penetrating, so require more substantial shielding. Gamma rays are the main hazard to people dealing with sealed radioactive materials used, for example, in industrial gauges and radiotherapy machines. Radiation dose badges are worn by workers in exposed situations to detect them and hence monitor exposure. All of us receive about 0.5-1 mSv per year of gamma radiation from cosmic rays and from rocks, and in some places, much more. Gamma activity in a substance (*e.g.*rock) can be measured with a scintillometer or Geiger counter.

X-rays are also ionizing radiation, virtually identical to gamma rays, but not nuclear in origin.

Cosmic radiation consists of very energetic particles, mostly protons, which bombard the Earth from outer space.

Neutrons are mostly released by nuclear fission (the splitting of atoms in a nuclear reactor), and and hence are seldom encountered outside the core of a nuclear reactor. Thus they are not normally a problem outside nuclear plants. Fast neutrons can be very destructive to human tissue.

All nuclear explosions release radiation, both initial radiation and residual or fallout radiation. The initial radiation makes up about 5% of the total energy released by a nuclear explosion and is released well within the first minute following the detonation. The threat of exposure to injurious levels of this initial radiation are confined typically to within a radius of about 1.50 miles from the nuclear detonation of anything less than a 1 MT bomb. Within this range, and out in the open and exposed without blast and thermal pulse protection, you most likely would also suffer lethal injuries from the blast impact and burns.[13]

Initial and fallout radiation

Initial radiation is released within the first minute of an explosion. It accounts for about 5 percent of the bomb's energy. The initial radiation of a 12.5 kt explosion will knock unconscious people standing in the open at a distance of less than half a mile from ground zero. These people will die from radiation sickness within two days. People standing in the open three-quarters of a mile away will die within one month.

What will be of concern to the greatest number of people, though, is the remaining 10% of the energy unleashed by a nuclear explosion, the residual or fallout radiation. Any nuclear detonation on the ground, or where an airburst was low enough that the fireball touched the ground, will create tons of radioactive materials that will be sucked up into the classical mushroom shaped cloud to then be spread far downwind. These radioactive particles carried by the wind then later fall out many miles away from ground zero and are the source of what we know as radioactive fallout. Each of these trillions of contaminated particles continuously gives off invisible radiation while in the mushroom cloud, while descending, and after having fallen to earth.[14]

Fallout is emitted by fission products such as radioactive iodine, weapon residues such as plutonium and radioactive hydrogen, and substances in the vicinity of the explosion which became radioactive as a result of exposure to the bomb's initial radiation.

Radioactive fallout is usually classified into two components, early and delayed. Early fallout reaches the ground within 24 hours of the explosion. Delayed fallout reaches the ground after 24 hours. Early fallout is also called local fallout because it tends to remain in the vicinity of the explosion site. Delayed fallout is also called global fallout because it can take months or years to come down to earth, during which time it can be carried to all corners of the globe.[15]

When an atomic bomb explodes, as in Hiroshima and Nagasaki during World War II, people receive two doses of radiation: one during the explosion, and another from fallout. Fallout refers to the radioactive particles that float in the air after the explosion; they rise and then gradually descend to the ground. A dose of 100 rems will have probably cause some initial signs of radiation sickness, such as loss of white blood cells, nausea, vomiting and headache.[16]

Local fallout poses more serious problems than global fallout because it is concentrated in a much smaller area and because it settles quickly, before much of its radioactivity has decayed. However, global fallout has its fair share of adverse effects too. Some radioactive substances released by a bomb, e.g., strontium-90 or plutonium, remain radioactive for many years, taking their toll on the global environment. For a single bomb, the global effect is negligible. But the effect was significant during the 1950s and early 1960s, when hundreds of nuclear bombs were exploded in the atmosphere. It may be deadly if thousands are exploded in an all-out war.

The effect of radiation on a human being differs according to the amount of radiation dose received. A strong dose (over 5,000 rads) of radiation, such as the initial radiation given off near ground zero, can knock people unconscious on the spot and kill them within a day or two. In contrast, the health of people receiving a weak dose (less than 100 rads) will be little affected in the near term.

The **medical effects of a nuclear blast** upon humans can be put into four categories[17]:

- Initial stage—the first 1–9 weeks, in which are the greatest number of deaths, with 90% due to thermal injury and/or blast effects and 10% due to super-lethal radiation exposure
- Intermediate stage—from 10–12 weeks. The deaths in this period are from ionization radiation in the median lethal range
- Late period—lasting from 13–20 weeks. This period has some improvement in survivors' condition.
- Delayed period—from 20+ weeks. Characterized by "numerous complications, mostly related to healing of thermal and mechanical injuries coupled with infertility, sub-fertility and blood disorders caused by radiation." Also, ionizing radiation from fallout can cause genetic effects, birth defects, cancer, cataracts and other effects in organs and tissue.

Exposure to radiation can cause devastating damage to the immune system and to the tissues of the body. The effects are known as radiation sickness or syndrome. Radiation can also cause little understood changes to the body's genes, which can be manifested through the development of diseases such as cancer later in life, and possibly as birth defects in future generations.

Intermediate doses (100-500 rads) cause radiation sickness. The severity of this sickness and the chances of surviving it depend, among other things, on the total radiation dose accumulated (the higher the dose, the more severe the symptoms and the lower the probability of survival), and on the age of the victim (the very young and very old are especially vulnerable).[18]

Within this intermediate range of exposure, a victim may develop a variety of symptoms, including loss of appetite, nausea, vomiting, intestinal cramps, diarrhea, apathy, fever, and headache. When the accumulated dose is on the low side of this intermediate range (100-200 rads), only a few mild symptoms are felt. They disappear within days and recovery is apparently complete. As the accumulated dose rises, more symptoms appear in more severe form. Because there is no effective cure for radiation sickness, a rough prognosis can already be made in the first two days: if you suffer from a severe case of nausea, vomiting, and diarrhea during this time, you are unlikely to survive.

After the first two days, the victim may begin to feel better, though still experiencing fatigue and lack of appetite. This apparent recovery is often deceptive, for the number of blood cells during this two-week period often falls to dangerously low levels. This results in resurgence of some of the old symptoms. New symptoms often appear as well, including internal and external bleeding, increased susceptibility to infections, and temporary hair loss (mostly from the scalp). Depending on many variables, but especially on the radiation dose, the victim may die at this stage or gradually get better.[19]

Recovery of people exposed to radiation in this intermediate range is often incomplete. For years after the exposure, their chances of experiencing infections, cancers, cataracts, and reduced body vigor are higher than they were before the exposure. The incidence of stillbirths, deaths during the first year of life, mental retardation, malformations, and cancer among human beings exposed to intermediate radiation during their embryonic stage of development will be higher. There might also be an increased number of genetic defects among the survivors' descendants.

Exposure to radiation makes our bodies produce fewer blood clotting agents, called blood platelets, increasing our risk of internal bleeding. Any cut on the skin will take much longer to stop bleeding.

Experts say that approximately 50% of humans exposed to 450 rems will die, and 800 rems will kill virtually anyone. Death is inevitable and will occur from between two days to a couple of weeks.

Millisieverts per hour (mSv) - this is a measure used more commonly by the International Commission on Radiological Protection. For example:

A gastrointestinal series X-ray investigation exposes the human to 14 mSv

Recommended limit for volunteers averting a major nuclear escalation - 500 mSv (according to the International commission on Radiological Protection)

Recommended limit for volunteers rescuing lives or preventing serious injuries - 1000 mSv (according to the International commission on Radiological Protection)

Below is a list of signs and symptoms likely to occur when a human is exposed to acute radiation (within one day), in mSv[20]:

0 to 250 mSv - no damage

250 to 1,000 mSv. Some individuals may lose their appetites, experience nausea, and have some damage to the spleen, bone marrow and lymph nodes.

1000 to 3000 mSv - nausea is mild to severe, no appetite, considerably higher susceptibility to infections. Injury to the following will be more severe - spleen, lymph node and bone marrow. The patient will most likely recover, but this is not guaranteed.

3,000 to 6,000 mSv - nausea much more severe, loss of appetite, serious risk of infections, diarrhea, skin peels, sterility. If left untreated the person will die. There will also be hemorrhaging.

6,000 to 10,000 mSv - Same symptoms as above. Central nervous system becomes severely damaged. The person is not expected to survive.

10,000+ mSv - Incapacitation. Death. Those who do survive higher radiation doses have a considerably higher risk of developing some cancers, such as lung cancer, thyroid cancer, breast cancer, leukemia, and cancer of several organs.

A summary of above can be given in the following way on the basis of high and low doses of radiation[21]:

High Doses

Exposure to high doses of radiation--at least 80 rem--kills human cells, damaging tissue and organs immediately. This anatomical response, referred to as "acute radiation syndrome," was seen in many atomic bomb survivors in 1945 and about 134 plant workers and firefighters in Chernobyl, Ukraine, the site of the world's worst nuclear power plant disaster. Of the 134 workers, exposure rates of 80 rem to 1,600 rem killed 28 within three months of the accident. Exposures up to100 rem can damage the stomach lining, interfering with its water and nutrient intake function. The immune system sustains damage at exposure rates up to 300 rem, subjecting the subject to infection and disease, and exposures of 400 rem and above are expected to kill 50 percent of subjects within 60 days of exposure, largely due to infection.

Lower Doses

Exposure to lower doses of nuclear radiation--less than10 rem--can have a cumulative effect on human cells. Though no immediate cell damage is apparent at these dosage levels, continued exposure for long periods can change the structure of the cell. It usually takes five to 20 years for appreciable change to occur, with the main health concerns being cancers and abnormal genetic mutation. Radiation-altered genes can cause stillbirths, congenital abnormalities, infant mortality, decreased birth weight and childhood mortality. Genetic effects due to radiation exposure can be passed on to the exposed person's children, or can affect children born several generations later. Exposure to nuclear radiation is five times more likely to cause cancer than genetic alteration. No evidence of genetic mutation was found in the offspring of Hiroshima or Nagasaki atomic bomb survivors.

Certain body parts are more specifically affected by exposure to different types of radiation sources. Several factors are involved in determining the potential health effects of exposure to radiation. These include[22]:

- The size of the dose (amount of energy deposited in the body)
- The ability of the radiation to harm human tissue
- Which organs are affected

The most important factor is the amount of the dose - the amount of energy actually deposited in your body. The more energy absorbed by cells, the greater the biological damage. Health physicists refer to the amount of energy absorbed by the body as the radiation dose. The absorbed dose, the amount of energy absorbed per gram of body tissue, is usually measured in units called rads. Another unit of radation is the rem, or roentgen equivalent in man. To convert rads to rems, the number of rads is multiplied by a number that reflects the potential for damage caused by a type of radiation. For beta, gamma and X-ray radiation, this number is generally one. For some neutrons, protons, or alpha particles, the number is twenty.

There are many symptoms of radiation sickness, and their severity varies greatly depending on the dosage. The initial symptoms include:

- Nausea
- Vomiting
- Diarrhoea
- Fatigue

These symptoms may be followed by:

- Headache
- Shortness of breath
- Rapid heartbeat
- Inflammation of the mouth and throat
- Worsening of tooth or gum disease
- Hair loss
- Dry cough
- Heart inflammation with chest pain
- Burning
- Permanent skin darkening
- Bleeding spots anywhere under the skin
- Haemorrhage
- Anaemia

The main affected body parts are:

Hair

The losing of hair quickly and in clumps occurs with radiation exposure at 200 rems or higher.

Brain

Since brain cells do not reproduce, they won't be damaged directly unless the exposure is 5,000 rems or greater. Like the heart, radiation kills nerve cells and small blood vessels, and can cause seizures and immediate death.

Thyroid

The certain body parts are more specifically affected by exposure to different types of radiation sources. The thyroid gland is susceptible to radioactive iodine. In sufficient amounts, radioactive iodine can destroy all or part of the thyroid. By taking potassium iodide can reduce the effects of exposure.

Blood System

When a person is exposed to around 100 rems, the blood's lymphocyte cell count will be reduced, leaving the victim more susceptible to infection. This is often refered to as mild radiation sickness. Early symptoms of radiation sickness mimic those of flu and may go unnoticed unless a blood count is done.According to data from Hiroshima and Nagaski, show that symptoms may persist for up to 10 years and may also have an increased long-term risk for leukemia and lymphoma. For more information, visit Radiation Effects Research Foundation.

Heart

Intense exposure to radioactive material at 1,000 to 5,000 rems would do immediate damage to small blood vessels and probably cause heart failure and death directly.

Gastrointestinal Tract

Radiation damage to the intestinal tract lining will cause nausea, bloody vomiting and diarrhea. This is occurs when the victim's exposure is 200 rems or more. The radiation will begin to destroy the cells in the body that divide rapidly. These including blood, GI tract, reproductive and hair cells, and harms their DNA and RNA of surviving cells.

Reproductive Tract

Because reproductive tract cells divide rapidly, these areas of the body can be damaged at rem levels as low as 200. Long-term, some radiation sickness victims will become sterile

Thus, the dose and its respective effect can be properly summarized in the following table:

Dose-rem	**Effects**
5-20	Possible late effects; possible chromosomal damage.
20-100	Temporary reduction in white blood cells.
100-200	Mild radiation sickness within a few hours: vomiting, diarrhea, fatigue; reduction in resistance to infection.
200-300	Serious radiation sickness effects as in 100-200 rem and hemorrhage; exposure is a Lethal Dose to 10-35% of the population after 30 days (LD 10-35/30).
300-400	Serious radiation sickness; also marrow and intestine destruction; LD 50-70/30.
400-1000	Acute illness, early death; LD 60-95/30.
1000-5000	Acute illness, early death in days; LD 100/10.

Blood transfusions may be necessary for patients suffering from anaemia.

Radiation-related illnesses tend to show themselves about 10 to 15 years after a radiation disaster. The body's endocrine, or hormone-secreting, glands appear to be particularly sensitive to radiation.

It is now widely accepted that the Chernobyl nuclear disaster has led to a massive increase in thyroid cancers in the three countries most affected. Already, 680 cases of thyroid cancer have been recorded in Belarus, Russia and Ukraine. Belarus has shown a 100-fold increase, from 0.3 per million in 1981-85 to 30.6 per million in 1991-94.

Unicef has noted significant increases in many types of health disorders in Belarus since the disaster. For example, problems of the nervous and sensory organs have increased by 43%; disorders of the digestive organs by 28%; and disorders.

There is no specific treatment once exposure has occurred but management is generally supportive whilst the body recovers from the damage done - anti-nausea drugs and painkillers can be used to relieve symptoms of radiation sickness. Antibiotics may also be needed to fight off secondary infection.

Thus nuclear energy or weapon must b properly used. There many advantages to this energy like

- Radio therapy (for treatment of cancers) and X-rays employ controlled exposure to radiation.
- Radio carbon dating is another application, where nuclear radiations are used to determine the properties and uses of several radioactive elements, and also determines the age of fossil samples.
- Level detectors, smoke detectors and leak detectors employ the use of radiation.
- Sterilization of medical equipment, food and detecting malfunctioning body parts can also be

achieved through a limited exposure to radiation.

Radiation, like many other scientific discoveries, can be put to both constructive and destructive uses. It is the responsibility of humanity to use this powerful tool for the benefit of nature and all of its elements. It can be a tool of massive destruction if in the wrong hands, while it can be put to a good cause like that of the development of the human society on the other hand. It is all upto the person who uses this resource.

References:

[1] Consequences of nuclear war

[2] ibid

[3] Effects of nuclear explosion

[4] Consequences of nuclear war

[5] Effects of nuclear explosion

[6] ibid

[7] Nuclear Radiation and health effect

[8] Effects of nuclear explosion

[9] Nuclear weapon radiation effect

[10] Consequence of nuclear war

[11] Effects of nuclear radiation

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[13] Nuclear radiations and fallout effects

[14] ibid

[15] Consequences of nuclear war

[16] Effects of radiation on humans

[17] Effects of nuclear explosion on human health

[18] Consequences of nuclear war

[19] Consequences of nuclear war

[20] Effects of radiation on human health

[21] Nuclear radiation effects on humans

[22] Radiation effects on human