Volume 4, Issue 2, February 2026 ISSN (E): 2938-3765

EFFECTS OF IONIZING RADIATION ON THE HUMAN BODY AND MODERN PROTECTION STRATEGIES

Sardor Qurbonboyev Sunnatilla o‘g‘li
2nd-Year Student, Faculty of General Medicine
Tashkent State Medical University, Tashkent, Uzbekistan
sardorqurbonboyev07@gmail.com

Abstract
In the modern era of technological progress, radiation has become an integral part of human life. It is widely used in medicine, energy production, and industry, playing a key role in disease diagnosis and treatment, electricity generation, and scientific research. However, when exposure is uncontrolled or safety standards are violated, radiation poses a serious threat to human health and the environment.
This work examines the nature and sources of radiation, the mechanisms of its interaction with living tissues, and the biological effects that arise from exposure. Special attention is given to modern methods of radiation protection, including engineering, medical, and organizational approaches.
Based on scientific data and analysis of real cases, it is shown that radiation is a double-edged force: on one hand, a powerful tool that saves lives and contributes to human progress, and on the other hand, a potentially lethal factor when handled carelessly. Thus, the key task of modern society is the responsible and safe use of radiation technologies in the interest of health and sustainable development.

Keywords: Radiation Types: Ionizing radiation, non-ionizing radiation
Dosimetry & Measurement: Radiation dose, sievert (Sv), dosimetry, ALARA principle
Biological Effects: DNA damage, cellular mutations, free radicals, acute radiation syndrome (ARS), chronic exposure, genetic mutations, carcinogenesis, radiobiology
Protection & Safety: Radiation protection, radioprotective agents, potassium iodide, radiation shielding
Sources & Applications: Radioisotopes, nuclear contamination, natural radiation, radon, cosmic rays, gamma radiation, X-ray radiation, radiotherapy.

Introduction

In the modern era of scientific and technological progress, radiation has become an integral part of human activity. It is widely applied in medicine, energy production, industry, and scientific research. Radioisotopes are used for disease diagnosis and treatment, particularly in radiotherapy and nuclear medicine, as well as for quality control of materials and electricity generation. However, despite its undeniable benefits, uncontrolled exposure to ionizing radiation can pose a serious threat to human health and the biosphere as a whole.

Ionizing and non-ionizing radiation affect cells in different ways, causing DNA damage, free radical formation, and cellular mutations, which in some cases can lead to carcinogenesis and genetic

Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

disorders. The biological effects of radiation depend on the dose (measured in sieverts, Sv), exposure duration, and the nature of exposure—acute or chronic. Acute radiation syndrome (ARS) manifests as severe systemic disorders, whereas chronic exposure may result in long-term consequences, including the development of cancer.

Modern radiobiology pays particular attention to radiation protection and the development of radioprotective agents, such as potassium iodide and antioxidant compounds that mitigate the damaging effects of free radicals. The key safety principle remains the ALARA (As Low As Reasonably Achievable) concept, aimed at minimizing radiation doses.

Significant attention is also given to issues of radioactive contamination of the environment, including the effects of radon, cosmic rays, gamma, and X-ray radiation. Contemporary methods of dosimetry and radiation shielding provide monitoring and control of radiation risks, contributing to the protection of public health and the sustainable development of society.

Materials and Methods

This study is based on an analytical review of existing scientific data and international reports concerning the effects of radiation on humans and the environment. Information materials were obtained from official sources, including the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2020), the International Atomic Energy Agency (IAEA), as well as peer-reviewed scientific literature in the fields of radiobiology and radiation medicine.

To assess the real consequences of radiation exposure, case studies of major nuclear accidents—the Chernobyl disaster (1986) and the Fukushima Daiichi nuclear accident (2011)—were analyzed. These events were examined in terms of dose loads, biological effects, and long-term impacts on human health and ecosystems.

Statistical data on radiation doses, exposure sources, contamination levels, as well as biological and genetic consequences, were systematized and interpreted to form a comprehensive understanding of the current state of the problem and existing radiation protection strategies.

Additionally, comparative analytical methods were employed to identify trends in risk assessment, dosimetry, and the application of the ALARA principle, as well as in the use of modern radioprotective technologies

Results

1. Understanding the Nature of Radiation

Radiation is the process of emitting or transferring energy through space or matter in the form of waves or particles. It can have a natural origin or result from human activities.

Broadly, all types of radiation are divided into two main categories:

Non-ionizing radiation – includes low-energy electromagnetic waves such as radio waves, microwaves, infrared, and visible light. These types of radiation do not possess enough energy to remove electrons from atoms or molecules and generally do not cause ionization of matter.

Ionizing radiation – characterized by high energy and the ability to ionize atoms, i.e., to remove tightly bound electrons. This category includes X-rays and gamma rays, as well as radiation emitted by radioactive elements such as uranium, radium, and thorium.

Ionizing radiation poses the greatest risk to human health because it can damage biological tissues at the molecular level, particularly cellular DNA, potentially leading to mutations, malignant tumors, and genetic disorders.

2. Sources of Radiation Exposure

Humans are constantly exposed to both natural and artificial sources of radiation.

a) Natural sources

Cosmic radiation: Comes from space and continuously reaches the Earth's surface. Exposure levels increase with altitude, so pilots and flight attendants receive higher radiation doses.

Terrestrial (ground) radiation: Caused by the presence of naturally radioactive elements in the Earth's crust, such as uranium, thorium, and radon, which are found in soil, rocks, and water.

Internal radiation: Associated with naturally occurring radioisotopes in the human body, such as potassium-40 and carbon-14, which participate in metabolic processes.

b) Artificial sources

Medical procedures: X-rays, computed tomography (CT), and radiotherapy are the main sources of artificial exposure for the population. Despite strict control, these procedures contribute significantly to the effective radiation dose.

Nuclear power plants: Although their operation is strictly regulated, small releases of radionuclides into the environment are possible during normal operation or in the event of accidents.

Nuclear tests and accidents: Historical events, such as the Chernobyl disaster (1986) and the Fukushima Daiichi nuclear accident (2011), led to large-scale radioactive contamination and long-term environmental consequences.

Industrial and research applications: Radiation is widely used in sterilization of medical instruments, food preservation, scientific experiments, and quality control of materials.

3. Effects of Radiation on the Human Body

The biological impact of radiation depends on the type of radiation, the dose received, exposure duration, and the affected area of the body. The primary mechanism of radiation damage involves DNA strand breaks, disruption of normal cellular functions, and impairment of cell division and repair processes.

a) Acute exposure (short-term irradiation)

High doses of ionizing radiation over a short period can lead to acute radiation syndrome (ARS), characterized by a complex set of clinical symptoms:

Nausea, vomiting, general weakness, and rapid fatigue;

Skin burns and hair loss (alopecia);

Bone marrow suppression, leading to immunodeficiency and increased susceptibility to infections;

Internal bleeding, liver, kidney, and other organ damage;

In severe cases, multi-organ failure and death.

A classic example is the victims of the atomic bombings of Hiroshima and Nagasaki (1945), who exhibited severe burns, bone marrow damage, and high mortality due to massive radiation exposure.

b) Chronic exposure (long-term low-level irradiation)

Prolonged exposure to low doses of radiation does not cause immediate symptoms but can result in long-term effects that may appear months or years later:

Oncological diseases: Particularly leukemia, thyroid, lung, and breast cancers;

Genetic mutations: DNA damage in germ cells can be inherited, causing congenital malformations;

Cataracts: Long-term radiation exposure can lead to lens opacity;

Reproductive dysfunction: Infertility or anomalies in offspring;

Immunodeficiency: Weakening of the immune system, increasing susceptibility to infections.

These effects are especially significant for nuclear industry workers, medical personnel, and residents of regions with elevated radiation levels.

c) Cellular Mechanisms of Damage

At the molecular level, ionizing radiation induces the formation of free radicals—unstable molecules that interact with DNA, proteins, and cell membranes. These reactions cause oxidative stress, leading to mutations, apoptosis (cell death), or uncontrolled cell division, which underlies carcinogenesis.

If damaged DNA is not efficiently repaired, the genetic stability of the cell is disrupted, increasing the risk of malignant tumors and heritable mutations.

4. Measurement of Radiation Exposure

Radiation dose is measured in sieverts (Sv), a unit reflecting the biological equivalent of ionizing radiation exposure on body tissues. One sievert corresponds to the amount of energy absorbed by tissues, taking into account the radiation weighting factor, which depends on the type of radiation (alpha, beta, gamma, etc.) and the sensitivity of the organs.

Derivative units are also commonly used:

Millisievert (mSv) — one thousandth of a sievert

Microsievert (μSv) — one millionth of a sievert

Dosimetric instruments are used to monitor and assess radiation doses, recording both external and internal exposure. A fundamental principle remains adherence to the ALARA (As Low As Reasonably Achievable) standard, aimed at minimizing radiation risks while maintaining the effectiveness of technologies.

Dose (Sievert, Sv)	Degree of Exposure	Description
0.001 – 0.01 Sv	Minimal	Level of natural background radiation; does not cause harmful biological effects.
0.1 Sv	Low	Slight increase in the probability of developing cancer with prolonged exposure
1 – 2 Sv	Moderate	Symptoms of radiation sickness: nausea, weakness, fatigue; temporary disorders of blood functions may occur.
3 – 5 Sv	Severe	Serious damage to bone marrow and internal organs; approximately 50% of cases are fatal without treatment.
5 Sv	Lethal	Critical dose: leads to death within several weeks due to multiple organ failure.

Volume 4, Issue 2, February 2026 ISSN (E): 2938-3765

5. Methods of Radiation Protection

To minimize the harmful effects of radiation, three fundamental principles of radiation safety are applied: time, distance, and shielding. These principles form the basis of all international standards established by the International Atomic Energy Agency (IAEA) and other regulatory organizations.

a) Time

The duration of exposure near radiation sources should be minimized. The shorter the exposure, the lower the absorbed dose.

b) Distance

The distance between a person and the radiation source should be increased. Radiation intensity decreases inversely with the square of the distance: doubling the distance reduces exposure by a factor of four.

c) Shielding

Protective materials are used to absorb or attenuate radiation:

Lead — effective against X-rays and gamma radiation;

Concrete — used at nuclear power plants and laboratories to protect against high-energy particles;

Plastic or aluminum — used to shield against beta particles.

d) Personal Protective Equipment (PPE)

Workers in high-radiation areas use lead aprons, gloves, protective eyewear, and personal dosimeters that record radiation levels.

e) Radioprotective Agents

Certain chemical compounds can reduce radiation damage to the body:

Potassium iodide (KI) prevents the accumulation of radioactive iodine in the thyroid gland;

Antioxidants (vitamins C and E) reduce cell damage caused by free radicals.

f) Monitoring and Regulation

National and international authorities, including the IAEA, establish radiation safety standards, monitor radiation levels, and ensure that exposure doses remain within permissible limits.

6. Examples and Real Cases

Chernobyl Disaster (1986)

As a result of the explosion at the Chernobyl Nuclear Power Plant (Ukraine), massive amounts of radioactive substances were released into the atmosphere. This led to widespread radioactive contamination, an increase in cancer incidence (particularly thyroid cancer), and genetic consequences that are still observed today.

Fukushima Daiichi Nuclear Accident (2011)

Following a destructive tsunami in Japan, the reactor core melted, causing the release of radioactive materials. Thousands of residents were evacuated, and environmental contamination required large-scale decontamination efforts.

Medical Exposure

Modern imaging techniques, such as CT scans and X-rays, are indispensable for disease diagnosis. However, excessive or unjustified use can increase the lifetime risk of cancer. Therefore, physicians adhere to the ALARA principle (As Low As Reasonably Achievable) to minimize radiation exposure.

Volume 4, Issue 2, February 2026 ISSN (E): 2938-3765

7. Positive Applications of Radiation

Despite its potential hazards, when used responsibly, radiation provides significant benefits to humanity:

Medical diagnostics: X-rays, CT scans, and positron emission tomography (PET) enable detailed imaging of internal organs.

Cancer treatment: Radiotherapy targets and destroys cancer cells while minimizing damage to healthy tissues.

Sterilization: Gamma radiation is used to disinfect medical instruments and food products.

Agriculture: Radiation assists in developing new plant varieties that are resistant to diseases and adverse environmental conditions.

Thus, radiation is a "double-edged tool": it can be dangerous if mishandled, yet it serves as a vital means for scientific and medical progress when used according to safety measures.

Conclusion

Radiation is a powerful force of nature and technology that demands respect and careful handling. While it provides significant benefits in medicine, energy, and science, uncontrolled exposure to radiation poses a serious threat to human health and the environment. Understanding the nature of radiation, its biological effects, and safety measures is essential for anyone working with radiation sources or living near them.

In conclusion, human health can only be preserved through education, strict safety regulations, continuous monitoring, and responsible use of radiological technologies. Radiation is not an invisible enemy but a powerful tool that must be used wisely for the benefit of humanity.

References

1. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). (2020). Sources, Effects and Risks of Ionizing Radiation. United Nations Publication, New York.
2. International Atomic Energy Agency (IAEA). (2018). Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. IAEA Safety Standards Series No. GSR Part 3. Vienna: IAEA.
3. Hall, E. J., & Giaccia, A. J. (2019). Radiobiology for the Radiologist (8th ed.). Philadelphia: Wolters Kluwer.
4. World Health Organization (WHO). (2016). Ionizing Radiation: Health Effects and Protective Measures. Geneva: WHO.
5. National Council on Radiation Protection and Measurements (NCRP). (2019). Management of Radiation Dose in Fluoroscopically Guided Interventional Medical Procedures. NCRP Report No. 168. Bethesda, Maryland.
6. Brenner, D. J., & Hall, E. J. (2007). Computed Tomography — An Increasing Source of Radiation Exposure. New England Journal of Medicine, 357(22), 2277–2284.
7. Mettler, F. A., & Upton, A. C. (2018). Medical Effects of Ionizing Radiation (4th ed.). Philadelphia: Elsevier.