International Journal of Science, Strategic Management and Technology
Volume **02** Issue **05** May-**2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

Hidden Radiation Exposure: Daily Life vs Medical Imaging

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https://doi.org/10.55041/ijsmt.v2i5.597

Cite this Article: Diksha, , Aanshi, , Ishika, & Kunal, (2026). Hidden Radiation Exposure: Daily Life vs Medical Imaging. International Journal of Science, Strategic Management and Technology, *02*(05). https://doi.org/10.55041/ijsmt.v2i5.597

Abstract—

Radiation is a natural and unavoidable part of human life, present in the environment as well as in medical imaging procedures. While many people fear radiation from diagnostic imaging such as X-rays and CT scans, they are often unaware of the hidden radiation exposure received from natural background sources like radon gas, sunlight, and soil. This study aimed to evaluate public awareness regarding hidden radiation exposure in daily life compared with medical imaging radiation. A cross-sectional survey was conducted among 120 participants of different age groups using a structured questionnaire. The study assessed awareness about radiation sources, ionizing and non-ionizing radiation, natural background radiation, and imaging modalities involving radiation exposure. The results showed that the majority of participants belonged to the 15–25 years age group, with females representing a higher proportion of respondents. Most participants had heard about radiation exposure (94.2%) and believed that radiation exists in daily life (90.8%). A large proportion correctly identified multiple radiation sources and recognized radon gas as the major source of natural background radiation. Most respondents also understood that X-rays and CT scans use ionizing radiation, whereas MRI does not. Additionally, 82.5% of participants were aware that CT scans deliver higher radiation doses than conventional X-rays. Despite the overall good level of awareness, some misconceptions regarding non-ionizing radiation and natural radiation exposure were still observed. The study concludes that although awareness regarding medical imaging radiation is relatively high, hidden daily-life radiation exposure remains less clearly understood among some individuals. Public education programs are essential to improve understanding of radiation sources, reduce unnecessary fear regarding medical imaging, and promote informed healthcare decisions

Index Terms— Ionizing Radiation, X-Rays, Background Radiation, Radiation Protection
should be between 150 and 250 words and must reflect the core contribution of the paper. Please avoid citations in the abstract.

Keywords— List 4–6 relevant keywords separated by semicolons.

I. INTRODUCTION

The word "radiation" originally designated to the emission or transmission of energy in the form of waves or particles. It is derived from the Latin verb "radiare," meaning "to radiate, emit rays."This verb is in turn derived from the Indo-European root h_1reh_1*-/*, which means "to shine." The same root also gives rise to other words related to light and brightness, such as "ray," "radius," and "rainbow."

Radiation can be outlined as energy or particles from a source that travel through space or other mediums. Light, heat, and the microwaves and radio waves used for wireless communications are all forms of radiation. Radiationn covers particles and electromagnetic waves that are emitted by some materials and carry energy.[1]

History of the Discovery and Study of X-Rays: In 1895, German physicist Wilhelm Conrad Röntgen discovered X-rays while experimenting with cathode rays and a Crookes tube. He noticed that an unknown invisible radiation passed through solid objects and caused a fluorescent screen to glow. Röntgen published his findings in a paper titled "On a New Kind of Rays", naming them X-rays to denote their unknown nature.His discovery transformed physics and medicine. Within months, X-rays were being used to image broken bones. Röntgen won the first Nobel Prize in Physics in 1901 for his groundbreaking work. Later, pioneers like Marie Curie, William Coolidge, and Max von Laue expanded the field, developing better X-ray tubes and discovering X-ray diffraction, which disclosed the atomic structure of crystals.

Timeline of X-Ray Milestones:

1895 – Discovery of X-Rays: Wilhelm Conrad Röntgen discovers a new type of invisible radiation while experimenting with cathode rays. He labels them X-rays and captures the first X-ray image (his wife's hand).

1896 – First Medical Use of X-Rays: X-rays are quickly adopted for detect bone fractures, locating foreign objects, and studying internal anatomy.

1896 – Early Radiation Injuries Reported :Scientists and technicians begin experiencing burns and tissue damage, leading to early awareness of radiation hazards.

1901 – First Nobel Prize in Physics: Röntgen is awarded the first Nobel Prize in Physics for the discovery of X-rays.

1913 – Development of the Coolidge Tube: William D. Coolidge invents the hot cathode X-ray tube, making X-ray production more reliable and controllable.

1914–1918 – World War I: X-rays are widely used in battlefield medicine for locating bullets and bone fractures.

1915 – X-Ray Crystallography Begins: William Henry Bragg and William Lawrence Bragg pioneer X-ray diffraction, allowing scientists to study atomic and molecular structures of crystals.

1927 – First Radiobiology Experiments: Studies begin expressing that X-rays can damage DNA and cause mutations.

1953 – DNA Structure Revealed by X-Ray Crystallography: Rosalind Franklin's X-ray diffraction images of DNA (Photo 51) contribute to Watson and Crick's model of the DNA double helix.

1960s – Image Intensifiers Introduced: X-ray fluoroscopy systems with image intensifiers enable real-time imaging with lower doses.

1972 – First CT Scanner Developed: Sir Godfrey Hounsfield and Allan Cormack develop the computed tomography (CT) scanner, revolutionizing medical imaging. They share the 1979 Nobel Prize in Physiology or Medicine.

1990s – Digital Radiography Becomes Common: Digital X-ray detectors replace film in many applications, improving image quality, speed, and archiving.

1999 – Launch of the Chandra X-ray Observatory: NASA's Chandra X-ray Observatory begins studying high-energy cosmic phenomena like black holes and supernovae.

2000s–Present – Advanced X-Ray Applications: Widespread use of cone-beam CT, dual-energy imaging, portable digital X-ray units, and AI-assisted diagnostics.

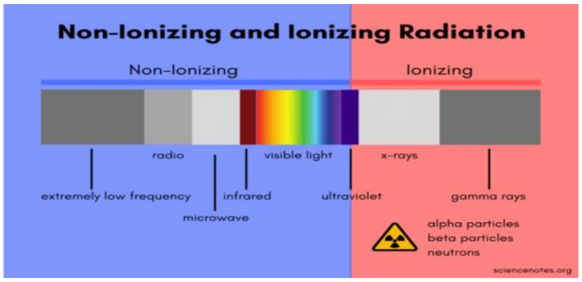
2020s – Synchrotron and Free Electron Lasers: Ultra-bright X-ray sources like XFELs (X-ray Free Electron Lasers) enable femtosecond imaging of molecular dynamics in real time.[2]

What Are X-Rays? X-rays are a type of ionizing electromagnetic radiation with very short wavelengths and high frequencies. They are generated when high-energy electrons decelerate rapidly (as in a bremsstrahlung process) or when inner-shell electrons are displaced and replaced (as in characteristic X-rays).Wavelength range: 0.01 to 10 nanometers (nm).Frequency range: ~3×10^{16} to 3×10^{19} Hz.Energy range: ~100 electronvolts (eV) to ~100 kiloelectronvolts (keV).[3]

Ionizing and non-ionizing radiation are the two wide categories of radiation. Ionizing radiation includes subatomic particles and the high energy, short-wavelength portion of the electromagnetic spectrum. Non-ionizing radiation include the visible spectrum and the low energy, long-wavelength part of the spectrum beyond visible light. Here is a intent look at the dissimilarity between ionizing and non-ionizing radiation and the health risks they pose.[4]

Ionizing vs Non-Ionizing Radiation

Feature	Ionizing Radiation	Non-Ionizing Radiation
Energy	High	Low to moderate
Ability to ionize atoms	Yes	No
Typical wavelength	Short	Long
Examples	X-rays, gamma rays, alpha particles	Radio waves, microwaves, visible light
Main biological effect	DNA damage, ionization	Heating, excitation
Risk level	Higher (with exposure)	Lower (typical exposure)



Ionizing Radiation: Ionizing radiation has adequate energy to ionize atoms. Generally, this means it can remove electrons from atoms, although some types of radiation cause nuclear reactions involving protons and neutrons. The higher-energy part of the ultraviolet region of spectrum is ionizing radiation, while the lower-energy part is non-ionizing radiation. The dividing line is not clear-cut because ionization occurs at different energies for different molecules. Photons or particles with energies greater than 10-33 electron volts (EV) are ionizing. The threshold depends on the material.

Types of Ionizing Radiation

Here is a list of the types of ionizing radiation:

High-energy ultraviolet light
X-rays
Gamma rays
Alpha particles
Beta particles
Neutrons
High-energy protons
Charged atomic nuclei from cosmic rays and the Sun
Positrons and other antimatter
Background radiation

Ionizing Radiation Health Effects: Ionizing radiation is what most people think of as "radiation." Because it has adequate energy to ionize atoms and break chemical bonds, it can damage or kill cells and change DNA and other molecules. Alpha, gamma, and neutron radiation can induce radioactivity in previously non-radioactive materials and even transmute one element into another. Ionization liberates charged particles, so it has electrical effects. Electrical discharge can harm people and other animals and damage equipment.[5]

Non-Ionizing Radiation: By definition, non-ionizing radiation is radiation with insufficient energy to ionize atoms or molecules. However, it does have enough energy for excitation, which raises electrons to higher energy states.

Types of Non-Ionizing Radiation

Here is a list of the types of non-ionizing radiation:

Near-ultraviolet light
Visible light
Infrared radiation
Microwaves
Radio waves
Very low frequency (VLF) radiation
Extremely low frequency (ELF) radiation
Thermal radiation
Black-body radiation

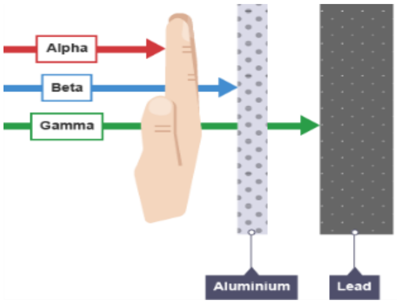
Non-Ionizing Radiation Health Effects: Heating is the most frequent effect of non-ionizing radiation. Extreme heating causes tissue damage, but low exposure to non-ionizing radiation typically doesn't cause a problem. For example, the human body releases harmless thermal energy, while a microwave oven generates enough non-ionizing radiation to cook food. The long-wavelength portion of the spectrum (radio, VLF, ELF) hardly ever causes heating, but it can cause an accumulation of electric charge on the body. In extreme cases, low-frequency radiation disturbs muscle and nerve responses. Even though infrared, visible, and ultraviolet light don't ionize atoms, they still provide enough energy to initiate chemical reactions. Strong light can causes hyperpigmentation of skin, photoaging, and cataracts.

Properties of radiation: Substances in its path can absorb radiation. For example, alpha radiation travels only a few centimetres in air, beta radiation travels tens of centimetres in air, and gamma radiation travels very large distances. All types of radiation become less extreme as they travel further away from the radioactive material – this is because the particles or rays become more spread out. The thicker the substance, the more the radiation is absorbed. The three types of radiation penetrate materials in different ways.

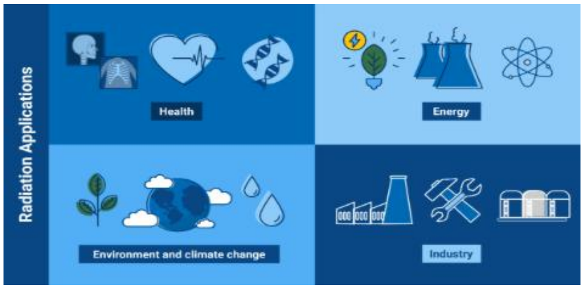
Alpha radiation: Alpha radiation is the least penetrating. It can be stopped (or absorbed) by a human hand.

Beta radiation: Beta radiation can penetrate air and paper. It can be stopped by a thin sheet of aluminium.[6]

Gamma radiation: Gamma radiation is the most penetrating. Even small levels can penetrate air, paper or thin metal. Higher levels can only be stopped by many centimetres of lead or many metres of concrete.



Uses of Radiation: Although scientists have only known about radiation since the 1890s, they have developed a broad variety of uses for this natural force. Today, to benefit humankind, radiation is used in medicine, academics, and industry, as well as for generating electricity. In addition, radiation has useful applications in such areas as agriculture, archaeology (carbon dating), space exploration, law enforcement, geology (including mining), and many others.[7]



Units of Radiation Measureement:

1. Gray (Gy) — The Absorbed Dose: The gray measures the physical amount of radiation energy absorbed by a material, such as your tissues. 1 Gy = 1 joule of radiation energy per kilogram of matter. Example: If your body absorbs 1 Gy of X-rays, each kilogram of your tissue has soaked up 1 joule of energy. (Historical note: the old unit "rad" was used before. 100 rad = 1 Gy.)
2. Sievert (Sv) — The Biological Effect: Not all radiation causes the same biological damage, even if the energy absorbed is identical. The sievert accounts for both the type of radiation and the sensitivity of the tissues exposed, giving a measure of biological risk. Alpha particles are far more damaging inside the body than gamma rays, so they're given a higher weighting. 1 Sv of any type of radiation is considered to have the same estimated biological effect. In practice, sieverts are large, so we usually talk in millisieverts (mSv) or microsieverts (μSv):

1 mSv = one-thousandth of a sievert
1 μSv = one-millionth of a sievert

If a medical report mentions your X-ray gave you 0.1 mSv (100 µSv), that's an effective dose in sievert terms — it already factors in both the type of radiation and which body parts were exposed.

3. Becquerel (Bq) — The Activity: While sieverts and grays talk about dose, the becquerel measures radioactivity itself — how fast atoms are decaying. 1 Bq = one atomic decay per second. A smoke detector might contain thousands of becquerels of Americium, yet your dose from it is fundamentally zero. (For history buffs: the older unit is the Curie (Ci), where 1 Ci = 3.7×10^{10} decays per second — a massive amount.) Think of becquerels as measuring how "radioactive" something is, not how much it affects you.

4. Rem — The Old-School Unit: In the U.S., radiation doses were once commonly reported in rem ("roentgen equivalent man"). It's basically the vintage version of the sievert: 100 rem = 1 Sv. Today you'll still see mrem (millirem) on older safety documents or public notices. To convert: 1 mSv = 100 mrem. Easy math, no slide rule required.[16]

Putting It All Together:

Grays (Gy): How much energy your body absorbs

Sieverts (Sv): How much biological risk that energy represents

Becquerels (Bq): How radioactive the material is

Rem: The retro version of sieverts

For pregnant radiation workers, after announcement of pregnancy 1 mSv on the embryo/fetus should not exceed.

Background Natural Radiation: Background radiation, i.e., ionizing radiation existing in the environment may be from natural origin or artificial/man-made sources. Natural background radiation sources are cosmic rays and terrestrial sources, natural radioactive material such as radon from ground, building walls and floors, and traces of naturally crop up radioactive material in food and drinks. Artificial or man-made origin includes radioactive fallout from nuclear weapons test and major nuclear accidents, medical diagnostic and therapeutic use of ionizing radiation, X-ray machines, particle accelerators, consumer products and transport of radioactive materials. Worldwide average of effective dose from background natural radiation is about 2.4 mSv/year (2400 µSv/year). In Kerala coast this is about 12.5 mSv/year. In northern Iran, this value is about 260 mSv/year.[17]

AIM& OBJECTIVES

AIM:

Hidden Radiation Exposure in Daily Life vs Medical Imaging.

Objectives:

To quantify and compare radiation dose received from: Natural Background Radiation.

To assess the lack of public awareness regarding hidden sources of radiation in daily life compared to fear of medical imaging.

LITERATURE REVIEW

3.1 The study was conducted by D'Auria, S. (2018). "Introduction to Radiation" https://doi.org/10.1007/978-3-319-93855-4_1.This study mentioned that This book is about radiation, radioactive decays and some elements of nuclear and particle physics. Einstein's theory of special relativity is needed for a correct description of some of these phenomena. The word "special" is used to distinguish this part from the theory of general relativity that deals with non-inertial reference frames and with gravity. Some textbooks follow a rather historical, or history-driven, approach to radiation. While this approach would be quite educational, giving a view of how ideas developed almost exactly one hundred years ago, it is probably not the fastest way to explain the fundamental concepts.[18]

3.2 The study was conducted by Berger, M., Yang, Q., Maier, A. (2018). X-ray Imaging. In: Maier, A., Steidl, S., Christlein, V., Hornegger, J. (eds) Medical Imaging Systems. Lecture Notes in Computer Science(), vol 11111. Springer, Cham "X-ray Imaging" https://doi.org/10.1007/978-3-319-96520-8_7 In this chapter, the physical principles of X-rays are introduced. We start with a general definition of X-rays compared to other well known rays, e. g., the visible light. In Sec. 7.2, we will learn how X-rays can be generated and how they can be characterized with respect to their energy. The most relevant concept to understand how X-ray imaging works is the behavior of X-rays when they interact with matter.[19]

3.3 The study was conducted by Myles-Worsley, M., Johnston, W. A., & Simons, M. A. (1988). The influence of expertise on X-ray image processing. Journal of Experimental Psychology: Learning, Memory, and Cognition, 14(3), 553–557. "The influence of expertise on X-ray image processing" https://doi.org/10.1037/0278-7393.14.3.553 Observers with four different levels of radiological experience performed a recognition memory task on slides of faces and chest X-ray films. Half of the X-ray films revealed clinically significant abnormalities and half did not. Recognition memory for faces was uniformly high across all levels of radiological experience. Memory for abnormal X-ray films increased with radiological experience and, for the most experienced radiologists, was equivalent to memory for faces. Suprisingly, recognition memory for normal films actually decreased with radiological experience from above chance to a chance level. These results indicate that radiological expertise is associated with selective processing of clinically relevant abnormalities in X-ray images. Expert radiologists appear to process X-ray images the way that we all process faces, by quickly detecting and devoting processing resources to features that distinguish one stimulus from another. However, the selective processing of X-ray films appears to be restricted to clinically relevant abnormalities. As they develop the ability to detect these abnormalities, radiologists appear to lose the ability to detect variations in normal features.[20]

3.4 The study was conducted by Pasveer, B. (1989), "Knowledge of shadows: the introduction of X-ray images in medicine". Sociology of Health & Illness, 11: 360-381. https://doi.org/10.1111/1467-9566.ep11373066 Abstract Ever since the discovery of X-rays in 1895, X-ray imaging has played a large role in the cognitive and practical organization of medicine. This article analyses the way X-ray images were introduced and made sense of in medical thinking and acting around the turn of the century. The implicit assumption in many histories of radiology is that the specific (diagnostic) message of the X-ray images resided inside them from the beginning, and that it is obscured either by technological or epistemological problems. These being solved, it would then be no problem to see directly what information the image contains. In this article this assumption is contested. It is argued that the specific content of the images was shaped by the activities of X-ray workers within the context of medical developments of the time. This shaping, as it is historically reconstructed here, consisted of four methods. X-ray workers (be they physicians, technicians or scientists) experimented with the technology, the images, the photographic materials and the objects that were X-rayed. They used X-ray images of dead bodies to compare them with radiographs of living patients. Radiologists tried to'translate'diagnostic information acquired with other methods into the shadows of the X-ray images. And finally they compared images with images.

The process of shaping the content and use of X-ray images, of making them represent reality, took place within specific institutions, and it took a different form in different countries, but also for different parts of the body. Developments of institutionalisation and professionalisation of radiology in England and the Netherlands are presented to provide a small part of the background of this shaping of knowledge of shadows.[21]

3.5 The study was conducted by Dartnell LR. Ionizing Radiation and Life. Astrobiology. 2011;11(6):551-582. "Ionizing Radiation and Life" https://doi.org/10.1089/ast.2010.0528 Ionizing radiation is a ubiquitous feature of the Cosmos, from exogenous cosmic rays (CR) to the intrinsic mineral radioactivity of a habitable world, and its influences on the emergence and persistence of life are wide-ranging and profound. Much attention has already been focused on the deleterious effects of ionizing radiation on organisms and the complex molecules of life, but ionizing radiation also performs many crucial functions in the generation of habitable planetary environments and the origins of life. This review surveys the role of CR and mineral radioactivity in star formation, generation of biogenic elements, and the synthesis of organic molecules and driving of prebiotic chemistry. Another major theme is the multiple layers of shielding of planetary surfaces from the flux of cosmic radiation and the various effects on a biosphere of violent but rare astrophysical events such as supernovae and gamma-ray bursts. The influences of CR can also be duplicitous, such as limiting the survival of surface life on Mars while potentially supporting a subsurface biosphere in the ocean of Europa. This review highlights the common thread that ionizing radiation forms between the disparate component disciplines of astrobiology. Key Words: Cosmic rays—Solar energetic particles—Radioactivity—Ultraviolet—Supernova—Gamma-ray burst—Magnetosphere—Panspermia—Biosignature. Astrobiology 11, 551–582.[22]

3.6 The study was conducted by Goodhead, D. T. (1989). The Initial Physical Damage Produced by Ionizing Radiations. International Journal of Radiation Biology, 56(5), 623–634 https://doi.org/10.1080/09553008914551841 Biophysical studies of different ionizing radiations and their differences in biological effect can provide useful information and constraints on the nature of the initial biologically relevant damage and hence the subsequent biochemistry and repair processes. It is clear that the nature of the predominant critical component produced by densely ionizing (high-LET) radiations is qualitatively, as well as quantitatively, different from that which predominates for low-LET radiations. Comparisons of radiation track structure with observed biological effects of the radiations allow hypotheses to be developed as to the nature of these different types of damage. That associated with low-LET radiations seems consistent with what is known about DNA double-strand breaks (dsb). It is produced predominantly by a localized cluster of ionizations within a single electron 'track end' either by direct action on the DNA or in conjunction with closely-associated molecules. The characteristic high-LET damage is somewhat larger in number of ionizations and spatial extent and therefore presumably also in molecular complexity. It is suggested that the total spectrum of initial damage be categorized into four classes; in addition to the above two this would include on the one extreme sparse isolated ionizations, which may lead to very simple products that are of limited biological relevance, and on the other extreme very large and relatively rare events which are uniquely achievable by some high-LET radiations, such as alpha-particles, but not at all by low-LET radiations. These biophysical considerations pose a challenge to radiation chemistry studies to consider the chemical consequences of highly localized clusters of initial ionizations and excitations in or very near to DNA, and to biochemistry to consider classes of damage involving DNA (and perhaps associated molecules) of greater complexity than the simplest dsb.[23]

3.7 The study was conducted by International Commission on Non-Ionizing Radiation Protection (ICNIRP). Principles for Non-Ionizing Radiation Protection. Health Phys. 2020 May;118(5):477-482. DOI: 10.1097/HP.0000000000001252 In this statement, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) presents its principles for protection against adverse health effects from exposure to non-ionizing radiation. These are based upon the principles for protection against ionizing radiation of the International Commission for Radiological Protection (ICRP) in order to come to a comprehensive and consistent system of protection throughout the entire electromagnetic spectrum. The statement further contains information about ICNIRP and the processes it uses in setting exposure guidelines.[24]

3.8 The study was conducted by Schwan, H.P. Biological effects of non-ionizing radiations: Cellular properties and interactions. Ann Biomed Eng 16, 245–263 (1988). https://doi.org/10.1007/BF02368002 The Lauriston Taylor lectures honor the founder of the National Committee on Radiation Protection and Measurement soon to be followed by the corresponding international organization. These standard setting bodies had a vast influence on proper recognition of radiation hazards. The 10th Taylor lecture is the first to deal with nonionizing radiations and may be, therefore, of particular interest to the bioengineer. During early history biophysics and bioengineering were primarily concerned with ionizing radiation bioeffects and electrophysiology. The nonionizing part of the radiation field and electrophysiology are closely related. Biomedical observation, biophysical and bioengineering efforts in the nonionizing radiation field are defined and complement each other. Topics concentrate on the relevant biophysical and bioengineering efforts of the author and his colleagues. They include: electrical properties of biological systems; established electrical field interactions (excitation, macromolecular responses and cellular responses); problems of dosimetry (macroscopic and microscopic considerations); conclusions about relative merits of various research approaches.[25]

3.9 The study was conducted by Ken K. Karipidis, Geza Benke, Malcolm R. Sim, Timo Kauppinen, Graham Giles, Occupational exposure to ionizing and non-ionizing radiation and risk of glioma, Occupational Medicine, Volume 57, Issue 7, October 2007, Pages 518–524 https://doi.org/10.1093/occmed/kqm078 The study population consisted of 416 cases of glioma and 422 controls. The risk estimates given by FINJEM for ELF, RF and ionizing radiation were close to or below unity. Gender-specific analysis for UV showed odds ratios of 1.60 [95% confidence interval (CI) 0.95–2.69] and 0.54 (95% CI 0.27–1.07) for the highest exposed group of men and women, respectively (corresponding *P* value for trend was 0.03 and 0.04).[26]

3.10 The study was conducted by Makino, T. Present research on thermal radiation properties and characteristics of materials. Int J Thermophys 11, 339–352 (1990). https://doi.org/10.1007/BF01133566 This paper reviews the recent advances in our spectroscopic research on radiation properties and characteristics of solid and liquid materials, from thermal engineering point of view. The topics discussed are optical constants of metallic materials, radiation characteristics of the real surfaces in actual industrial environments, those of semi-transparent scattering-absorbing media, and those of human body and environmental surfaces of human living space. The review also includes the algorithm for radiation pyrometry and the demand for radiation data of new materials and for new engineering techniques. It is concluded that the development of engineering models is important for the systematic research of the complicated radiation phenomena and that generation and compilation of pertinent data are necessary.[27]

3.11 The study was conducted by Cothern, C.R. (1987). Properties. In: Cothern, C.R., Smith, J.E. (eds) Environmental Radon. Environmental Science Research, vol 35. Springer, Boston, MA. https://doi.org/10.1007/978-1-4899-0473-7_1 Radon is a naturally occurring, colorless, odorless, almost chemically inert, and radioactive gas. Some of its properties are shown in Table 1.1. Compared to the other noble gases, radon is the heaviest and has the highest melting point, boiling point, critical temperature, and critical pressure. It is soluble in cold water, and its solubility decreases with increasing temperature as shown in Figure 1.1. This characteristic of radon causes it to be released during water-related activities in the home, such as washing clothes and dishes, taking showers or baths, flushing toilets, and general cleaning. Radon is not perfectly inert and is less so than lighter noble gases.[28]

3.12 The study was conducted by Currey, J.D., Foreman, J., Laketić, I., Mitchell, J., Pegg, D.E. and Reilly, G.C. (1997), Effects of ionizing radiation on the mechanical properties of human bone. J. Orthop. Res., 15: 111-117. https://doi.org/10.1002/jor.1100150116 Allogeneic bone grafts are frequently sterilized by means of ionizing radiation. We investigated the effects of ionizing radiation on both quasistatic and impact mechanical properties of human bone. Specimens from four paired femora of four donors received doses of 29.5 kGy ("Standard" frequently used by tissue bandks), 94.7 kGy ("high") or 17 kGy ("low") of ionizing radiation. Young's modulus was unchanged by any level of radiation. Radiation significantly reduced bending strength, work to fracture, and impact energy absorption; in each case, the severity of the effect increased from low to standard to high doses of radiation. Work to fracture was particularly severely degraded; specimens irradiated with the high dose absorbed only 5% of the energy of the controls. Radiation. even at relatively low doses, makes the bone more brittle and thereby reduces its energy-absorbing capacity. We suggest that because the level of radiation required to produce an acceptable level of viral inactivation (90 kGy) produces an unacceptable reduction in the mechanical integrity of the bone. low levels of radiation, sufficient to produce bacterial safety, should be used in conjunction with biological tests to ensure viral safety.[29]

3.13 This study was conducted by Cuttler JM. Application of Low Doses of Ionizing Radiation in Medical Therapies. Dose-Response. 2020;18(1). doi:10.1177/1559325819895739 The discovery of X-rays and radioactivity in 1895/1896 triggered a flood of studies and applications of radiation in medicine that continues to this day. They started with imaging fractures/organs and progressed to treating diseases by exposing areas to radiation from external and internal sources. By definition, low-dose treatments stimulate damage control (or adaptive protection) systems that remedy diseases. Publications are identified on low-dose ionizing radiation (LDIR) therapies for different cancers, infections, inflammations, and autoimmune and neurodegenerative diseases. The high rate of endogenous DNA damage, due to leakage of oxygen from aerobic metabolism, and the damage control systems that deal with this are discussed. Their stimulation and inhibition by radiation are described. The radium dial painter studies revealed the radium ingestion threshold for malignancy and the dose threshold for bone sarcoma. The radiation scare that misled the medical profession and the public is a barrier to LDIR therapies. Many studies on nasal radium irradiation demonstrated that children are not unduly radiation sensitive. Omissions in the medical textbooks misinform physicians about the effects of LDIR therapy, which blocks clinical trials to determine optimal doses, efficacy, and thresholds for onset of harm. Information from many recent case reports on LDIR therapies, including successes with radon therapy, is provided.[30]

3.14 This study was conducted by Leith, J.T., Miller, R.C., Gerner, E.W. and Boone, M.L.M. (1977), Hyperthermic potentiation. Biological aspects and applications to radiation therapy. Cancer, 39: 766-779 https://doi.org/10.1002/1097-0142(197702)39:2+<766::AID-CNCR2820390711>3.0.CO;2-5 Experimental studies have provided evidence that hyperthermia may be an effective agent, either alone or in combination with ionizing radiation, in the treatment of cancer. Results have shown that temperatures in the range of 42° to 45°C: 1) are cytotoxic, with cell lethality showing little or no dependence on levels of oxygenation; 2) inhibit the recovery of cells from sub-lethal and potentially lethal radiation damage while enhancing the levels of lethal damage; and 3) may be combined with x-irradiation in a manner to improve therapeutic ratios. The observed interaction between hyperthermia and x-rays may in part be due to differences in the Age Response Functions and reassortment of cycling cells to these two agents. Hyperthermia may also greatly change repopulation and re-oxygenation parameters in irradiated tumor and normal tissue volumes. An overall consideration of these and other factors is essential in the design of optimal schedules of combined hyperthermia and x-irradiation treatments in the management of malignant disease.[31]

3.15 This study was conducted by Goyal, Shikha, Kataria, Tejinder, Image Guidance in Radiation Therapy: Techniques and Applications, Radiology Research and Practice, 2014, 705604, 10 pages, 2014 https://doi.org/10.1155/2014/705604 In modern day radiotherapy, the emphasis on reduction on volume exposed to high radiotherapy doses, improving treatment precision as well as reducing radiation-related normal tissue toxicity has increased, and thus there is greater importance given to accurate position verification and correction before delivering radiotherapy. At present, several techniques that accomplish these goals impeccably have been developed, though all of them have their limitations. There is no single method available that eliminates treatment-related uncertainties without considerably adding to the cost. However, delivering "high precision radiotherapy" without periodic image guidance would do more harm than treating large volumes to compensate for setup errors. In the present review, we discuss the concept of image guidance in radiotherapy, the current techniques available, and their expected benefits and pitfalls.[32]

3.16 This study was conducted by Littlefield, T.A., Thorley, N. (1979). The Electromagnetic Spectrum. In: Atomic and Nuclear Physics. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-1470-7_5 Light travels from the sun to the earth, a distance of about 145 000 000 km, through space containing very little material. When absorbed by a surface it is converted into heat, a form of energy. Energy must therefore have arrived from the sun across this immense distance. In fact almost all the energy known to man has been derived from the sun either now or in past ages. Thus the sun's energy, which millions of years ago was responsible for the growth of luxurious vegetation, is now available to us in the form of coal. To account for this transfer of energy over such a large distance we must know something of the nature of light. Energy can pass from one place to another in two ways.

The kinetic energy of a moving body which obeys the laws of mechanics is the essential feature of the corpuscular theory as advocated by Newton at the close of the seventeenth century on the basis of the experimental evidence known to him at that time. On the other hand, energy can also pass from one place to another by a wave motion. This was the basis of the wave theory of light supported by Hooke and Huygens. Sound was then known to be a wave motion and the fact that one could hear but was unable to see around corners proved to be a serious obstacle to the acceptance of the wave theory of light for over a hundred years even though it was known that light deviated very slightly from its straight line path on passing close to the edge of an obstacle.[33]

3.17 This study was conducted by Nobuyuki Hamada, Yuki Fujimichi, Classification of radiation effects for dose limitation purposes: history, current situation and future prospects, Journal of Radiation Research, Volume 55, Issue 4, July 2014, Pages 629–640, https://doi.org/10.1093/jrr/rru019 Radiation exposure causes cancer and non-cancer health effects, each of which differs greatly in the shape of the dose–response curve, latency, persistency, recurrence, curability, fatality and impact on quality of life. In recent decades, for dose limitation purposes, the International Commission on Radiological Protection has divided such diverse effects into tissue reactions (formerly termed non-stochastic and deterministic effects) and stochastic effects. On the one hand, effective dose limits aim to reduce the risks of stochastic effects (cancer/heritable effects) and are based on the detriment-adjusted nominal risk coefficients, assuming a linear-non-threshold dose response and a dose and dose rate effectiveness factor of 2. On the other hand, equivalent dose limits aim to avoid tissue reactions (vision-impairing cataracts and cosmetically unacceptable non-cancer skin changes) and are based on a threshold dose. However, the boundary between these two categories is becoming vague. Thus, we review the changes in radiation effect classification, dose limitation concepts, and the definition of detriment and threshold. Then, the current situation is overviewed focusing on (i) stochastic effects with a threshold, (ii) tissue reactions without a threshold, (iii) target organs/tissues for circulatory disease, (iv) dose levels for limitation of cancer risks vs prevention of non-life-threatening tissue reactions vs prevention of life-threatening tissue reactions, (v) mortality or incidence of thyroid cancer, and (vi) the detriment for tissue reactions. For future discussion, one approach is suggested that classifies radiation effects according to whether effects are life threatening, and radiobiological research needs are also briefly discussed.[34]

3.18 This study was conducted by G. Dietze, H.-G. Menzel, Dose quantities in radiation protection and their limitations, Radiation Protection Dosimetry, Volume 112, Issue 4, 15 December 2004, Pages 457–463, https://doi.org/10.1093/rpd/nch097 For more than 50 years the quantity absorbed dose has been the basic physical quantity in the medical applications of ionising radiation as well as radiological protection against harm from ionising radiation. In radiotherapy relatively high doses are applied (to a part of the human body) within a short period and the absorbed dose is mainly correlated with deterministic effects such as cell killing and tissue damage. In contrast, in radiological protection one is dealing with low doses and low dose rates and long-term stochastic effects in tissue such as cancer induction. The dose quantity (absorbed dose) is considered to be correlated with the probability of cancer incidence and thus risk induced by exposure.

ICRP has developed specific *dosimetric quantities* for radiological protection that allow the extent of exposure to ionising radiation from whole and partial body external radiation as well as from intakes of radionuclides to be taken into account by one quantity. Moreover, radiological protection quantities are designed to provide a correlation with risk of radiation induced cancer. In addition, operational dose quantities have been defined for use in measurements of external radiation exposure and practical applications.

The paper describes the concept and considerations underlying the actual system of dose quantities, and discusses the advantage as well as the limitations of applicability of such a system. For example, absorbed dose is a non-stochastic quantity defined at any point in matter. All dose quantities in use are based on an averaging procedure. Stochastic effects and microscopic biological and energy deposition structures are not considered in the definition. Absorbed dose is correlated to the initial very short phase of the radiation interaction with tissue while the radiation induced biological reactions of the tissue may last for minutes or hours or even longer. There are many parameters other than absorbed dose that influence the process of cancer induction, which may influence the consideration of cells and/or tissues at risk which are most important for radiological protection.[35]

3.19 This study was conducted by Dobrzyński L, Fornalski KW, Feinendegen LE. Cancer Mortality Among People Living in Areas With Various Levels of Natural Background Radiation. Dose-Response. 2015;13(3). doi:10.1177/1559325815592391 There are many places on the earth, where natural background radiation exposures are elevated significantly above about 2.5 mSv/year. The studies of health effects on populations living in such places are crucially important for understanding the impact of low doses of ionizing radiation. This article critically reviews some recent representative literature that addresses the likelihood of radiation-induced cancer and early childhood death in regions with high natural background radiation. The comparative and Bayesian analysis of the published data shows that the linear no-threshold hypothesis does not likely explain the results of these recent studies, whereas they favor the model of threshold or hormesis. Neither cancers nor early childhood deaths positively correlate with dose rates in regions with elevated natural background radiation.[36]

3.20 This study was conducted by J. P. Mc Laughlin, Some characteristics and effects of natural radiation, Radiation Protection Dosimetry, Volume 167, Issue 1-3, November 2015, Pages 2–7, https://doi.org/10.1093/rpd/ncv206 Since life first appeared on the Earth, it has, in all its subsequent evolved forms including human, been exposed to natural radiation in the environment both from terrestrial and extra-terrestrial sources. Being an environmental mutagen, ionising natural radiation may have played a role of some significance in the evolution of early life forms on Earth. It has been estimated by United Nations Scientific Committee on the Effects of Atomic Radiation that at the present time, exposure to natural radiation globally results in an annual average individual effective dose of about 2.4 mSv. This represents about 80 % of the total dose from all sources. The three most important components of natural radiation exposure are cosmic radiation, terrestrial radioactivity and indoor radon. Each of these components exhibits both geographical and temporal variabilities with indoor radon exposure being the most variable and also the largest contributor to dose for most people. In this account, an overview is given of the characteristics of the main components of the natural radiation environment and some of their effects on humans. In the case of cosmic radiation, these range from radiation doses to aircrew and astronauts to the controversial topic of its possible effect on climate change. In the case of terrestrial natural radiation, accounts are given of a number of human exposure scenarios.[37]

3.21 This study was conducted by F. Steinhäusler, The Natural Radiation Environment: Future Perspective, Radiation Protection Dosimetry, Volume 45, Issue 1-4, 1 December 1992, Pages 19–23, https://doi.org/10.1093/rpd/45.1-4.19 The need to control the exposure of man to the natural radiation environment (NRE) is increasingly recognised. The main NRE sources and exposure situations warranting intensified efforts in the future are: exposure to radiation in space (astronaut: ≤ 1 $\mathrm{mSv.d^{-1}}$), technologically enhanced natural radiation (TENR; global impact: 400,000 $\mathrm{man.Sv.y^{-1}}$) and populations living in high background radiation areas (resident: ≤ 360 $\mathrm{mGy.y^{-1}}$). Data on NRE-TENR-induced biological effects are scarce and inconclusive, such as increased frequency of chromosome aberrations and mental retardation from environmental gamma radiation, but there are contradictory results for thorium and radon exposure induced lung cancer risk. Four coordinated actions are proposed, i.e. international standardisation of methods, coordination of multidisciplinary health effect studies, development of principles for NRE/TENR control, and establishment of an international clearing house for all NRE-related topics.[38]

3.22 This study was conducted by S.M.J. Mortazavi, M. Ghiassi-Nejad, P.A. Karam, T. Ikushima, A. Niroomand-Rad and J.R. Cameron Published Online:October 3, 2005pp 20-27 Cancer incidence in areas with elevated levels of natural radiation" https://doi.org/10.1504/IJLR.2006.007892 It has been reported that on reaching a certain level of cell damage the production of repair enzymes is triggered which decreases the chromosome aberrations. If this happens, prolonged exposure to high levels of natural radiation in areas with elevated levels of background radiation could decrease the frequency of chromosome aberrations. Recent epidemiological studies indicated that there is an increased risk of cancer in healthy individuals with high levels of chromosomal aberrations. Studies performed in Nordic countries as well as Italy, showed that increased levels of chromosome aberrations in lymphocytes can be used to predict cancer risk in humans. One may conclude that a dose of ionising radiation sufficient to produce a certain level of cell damage increases production of antioxidants and repair enzymes that decrease either the frequency of chromosome aberrations or the cancer risk. People in some areas of Ramsar, a city in northern Iran, receive an annual radiation dose from background radiation that is more than five times higher than the 20 mSv. Yr^{-1} that is permitted for radiation workers. Inhabitants of Ramsar have lived for many generations in these high background areas. If an annual radiation dose of a few hundred mSv is detrimental to health, causing genetic abnormalities or an increased risk of cancer, it should be evident in these people. The absorbed dose rate in some high background radiation areas of Ramsar is approximately 55-200 times higher than that of the average global dose rate. It has been reported that 3–8% of all cancers are caused by current levels of ionising radiation. If this estimation were true, all the inhabitants of such an area with extraordinary elevated levels of natural radiation would have died of cancer. Our cytogenetic studies show no significant differences between people in the high background area compared to people in normal background areas. As there was no increased level of chromosome aberrations, it may be predicted that the cancer incidence is not higher than in the neighbouring areas with a normal background radiation level. Although there is not yet solid epidemiological information, most local physicians in Ramsar report anecdotally that there is no increase in the incidence rates of cancer or leukemia in their area. There are no data to indicate a significant increase of cancer incidence in other high background radiation areas (HBRAs). Furthermore, several studies show a significant decrease of cancer death rates in areas with high backgrounds. It can be concluded that prolonged exposure to high levels of natural radiation possibly triggers processes such as the production of antioxidants and repair enzymes, which decreases the frequency of chromosome aberrations and the cancer incidence rate.[39]

3.23 This study was conducted by John E. Pattison, Richard P. Hugtenburg, Stuart Green; Enhancement of natural background gamma-radiation dose around uranium microparticles in the human body. J R Soc Interface 6 April 2010; 7 (45): 603–611. https://doi.org/10.1098/rsif.2009.0300 . This study mentioned that Ongoing controversy surrounds the adverse health effects of the use of depleted uranium (DU) munitions. The biological effects of gamma-radiation arise from the direct or indirect interaction between secondary electrons and the DNA of living cells. The probability of the absorption of X-rays and gamma-rays with energies below about 200 keV by particles of high atomic number is proportional to the third to fourth power of the atomic number. In such a case, the more heavily ionizing low-energy recoil electrons are preferentially produced; these cause dose enhancement in the immediate vicinity of the particles. It has been claimed that upon exposure to naturally occurring background gamma-radiation, particles of DU in the human body would produce dose enhancement by a factor of 500–1000, thereby contributing a significant radiation dose in addition to the dose received from the inherent radioactivity of the DU. In this study, we used the Monte Carlo code EGSnrc to accurately estimate the likely maximum dose enhancement arising from the presence of micrometre-sized uranium particles in the body. We found that although the dose enhancement is significant, of the order of 1–10, it is considerably smaller than that suggested previously.[40]

3.24 This study was conducted by Borzoueisileh, S., Shabestani Monfared, A., Comby, B., Khosravifarsani, M., Roshan Shomal, P., Saeid Ramezani, M., & Ramezani, L. (2014). The highest background radiation school in the world and the health status of its students and their offspring. *Isotopes in Environmental and Health Studies*, *50*(1), 114–119.https://doi.org/10.1080/10256016.2013.821986 . This study mentioned that Although the average effective human dose from natural background radiation is about 2.4 mSv per year, the students of the Saeid Nafisi school in Ramsar received effective doses of about 250 mSv while studying there for over 5 years. The goal of this project was a retrospective study of the health status of former students of this school and their offspring. The list of the students of the Saeid Nafisi school (high background radiation) and Taleghani and Kashani schools (ordinary background radiation) was provided by the Department of Education. After matching sex, age and socioeconomic level and obtaining their consent, part 1 of the specifically designed questionnaire was filled out by interview, and clinical examinations were recorded in part 2 of the questionnaire by a physician. The data were analysed using Statistical Package for the Social Sciences 16. Our study shows that 88.1 % of general examinations of high background radiation school students were normal as compared with 85.7 % for control group. There were no significant differences. This study is interesting and unique. It reveals that there is no health emergency related to these high radiation doses. We recommend continuing the health supervision of this population in the future.[41]

3.25 This study was conducted by Lampe N, Breton V, Sarramia D, Sime-Ngando T, Biron DG. Understanding low radiation background biology through controlled evolution experiments. Evol Appl. 2017;10:658–666. https://doi.org/10.1111/eva.12491 . The study mentioned that Biological experiments conducted in underground laboratories over the last decade have shown that life can respond to relatively small changes in the radiation background in unconventional ways. Rapid changes in cell growth, indicative of hormetic behaviour and long-term inheritable changes in antioxidant regulation have been observed in response to changes in the radiation background that should be almost undetectable to cells. Here, we summarize the recent body of underground experiments conducted to date, and outline potential mechanisms (such as cell signalling, DNA repair and antioxidant regulation) that could mediate the response of cells to low radiation backgrounds. We highlight how multigenerational studies drawing on methods well established in studying evolutionary biology are well suited for elucidating these mechanisms, especially given these changes may be mediated by epigenetic pathways. Controlled evolution experiments with model organisms, conducted in underground laboratories, can highlight the short- and long-term differences in how extremely low-dose radiation environments affect living systems, shining light on the extent to which epimutations caused by the radiation background propagate through the population. Such studies can provide a baseline for understanding the evolutionary responses of microorganisms to ionizing radiation, and provide clues for understanding the higher radiation environments around uranium mines and nuclear disaster zones, as well as those inside nuclear reactors.[42]

RESULT

Table 01: AGE Distribution

AGE	No. Of Population
15-20	**48**
21-25	**52**
26-30	**10**
31-35	**1**
36-40	**1**
41-45	**5**
46-50	**2**
51-55	**0**
56-60	**1**
Total	**120**

MEAN AGE: 22.92 Years
Median: 21 years
Mode: 22 years

EXPLANATION : The survey shows that most people belong to the younger age group, especially between 15 to 25 years. The highest number of participants are in the 21–25 age group, followed closely by the 15–20 group, which means the data is mainly focused on youth.

Very few people are from age above 30, and almost no participation is seen in the higher age groups like 50+, showing low representation of older individuals.

The average age (mean ≈ 23 years) also supports that most respondents are young. The median (21 years) and mode (22 years) further indicate that most people are in their early twenties.

TABLE 02: GENDER DISTRIBUTION

AGE	MALE	FEMALE
15-20	18	30
21-25	16	36
26-30	6	3
31-35	1	0
36-40	1	1
41-45	2	3
46-50	2	0
51-55	0	0
56-60	0	1
TOTAL	46	74

MEAN : Male 24.0 years, Female 22.46 years
MEDIANS: Male 22.56 years, Female 21.97 years
MODE: Male 19.5 years Female 21.77 years

EXPLANATION: This survey includes a total of 120 people, out of which 46 are males and 74 are females, showing that female participation is higher than male participation. When we look at the age distribution, most people belong to the 15–25 years age group. The highest number of participants is in the 21–25 age group, followed by the 15–20 group. As the age increases beyond 30 years, the number of participants decreases sharply, and very few people are present in higher age groups like 40 and above. From the statistical values, the mean age is around 23 years, the median is around 21–22 years, and the mode lies in the 21–25 age group. This clearly shows that most participants are in their early twenties. When gender is considered, females are more in number and slightly older on average, while males are more concentrated in the younger age group (15–20 years). Females are mainly concentrated in the 21–25 age group, which is the most dominant group in the survey.

Table 3: Awareness of Radiation Exposure Among Population (n = 120)

Response Category	Percentage (%)	Number of Population
Yes	94.2%	113
No	4.2%	5
Not sure	1.6%	2

Mean = 40% Median = 4.2% Mode = Yes (94.2%)

This table shows that almost all participants (113 out of 120) have heard about radiation exposure. Only a very small number of people are either unaware or unsure. This clearly indicates a *high level of general awareness* among the population.

Table 4: Perception of Radiation Presence in Daily Life (n = 120)

Response Category	Percentage (%)	Number of Population
Yes	90.8	109
No	6.7	8
Not sure	2.5	3

Mean = 33.3%
Median = 6.7%
Mode = Yes (90.8%)

EXPLANATION: Most participants (109 out of 120) believe that radiation exists in daily life. Only a small number of people think otherwise or are unsure. This shows that people are aware that radiation is not just in hospitals but also present in everyday surroundings.

Table 5: Knowledge of Sources of Radiation Among Participants (n = 120)

Response Category	Percentage (%)	Number of Population
Sunlight	11.7	14
X-Ray	15.8	19
Soil/ Earth	0	00
All The Above	72.5	87

Mean = 25%
Median = 13.75%
Mode = All the above (72.5%)

EXPLANATION: Most participants (87 out of 120) correctly chose "All of the above," which shows good knowledge of different radiation sources. Some participants selected only Sunlight or X-rays, and no one picked Soil/Earth alone. This indicates strong overall awareness, but a few people still have partial understanding.

Table 6: Awareness of Main Source of Natural Background Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
Radon Gas	**68.3**	**82**
Mobile phones	**15.8**	**19**
WiFi	**0.8**	**01**
Not Sure	**15.0**	**18**

Mean = 25%
Median = 15.4%
Mode = Radon gas (68.3%

EXPLANATION: Most participants (82 out of 120) correctly identified radon gas as the main source of natural background radiation. However, some people still chose incorrect options like mobile phones or were unsure. This shows that awareness is generally good, but a few misconceptions still exist among participants.

Table 7 : Perception of Unavoidability of Natural Radiation Exposure (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
Yes	**65**	**78**
No	**23.3**	**28**
Not Sure	**11.7**	**14**

MEAN: 33.3., MEDAIN 23.3, MODE: 65.0

EXPLANATION: Most participants (78 out of 120) believe that natural radiation exposure is unavoidable, which is scientifically correct because we are constantly exposed to background radiation from the environment. However, a noticeable number of people either think it can be avoided or are unsure, showing partial understanding and some confusion among participants.

Table 8: History of Undergoing Medical Imaging Tests (X-ray/CT) (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
Yes	**79.2**	**95**
No	**20.8**	**25**

MEAN = 50%. MEDIAN = 50% MODE = 79.2%

EXPLANATION : A large majority of participants (95 out of 120) have undergone medical imaging tests like X-rays or CT scans. This shows that medical radiation exposure is very common in daily life, supporting your research idea that people are frequently exposed to radiation through medical procedures.

Table 9: Awareness of Imaging Methods that Use Ionizing Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
X-ray	**14.2**	**17**
CT Scan	**3.3**	**4**
MRI	**3.3**	**4**
Both X-Ray and CT scan	**79.2**	**95**

MEAN = 25% MEDIAN = 8.75% MODE = Both X-ray and CT scans) 79.3

EXPLANATION : Most participants (95 out of 120) correctly identified that both X-rays and CT scans use ionizing radiation. However, a small number of participants selected incorrect options like MRI, which does not use ionizing radiation. This indicates good overall knowledge but some misconceptions still exist.

Table 10: Awareness of Imaging Methods that Do NOT Use Ionizing Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
X-ray	**6.7**	**8**
CT Scan	**6.7**	**8**
MRI	**75.8**	**91**
PET Scan	**10.8**	**13**

MEAN = 25% MEDIAN = 8.75% MODE = MRI Scan (75.8%)

EXPLANATION: Most participants (91 out of 120) correctly chose MRI as the imaging method that does not use ionizing radiation. However, some participants incorrectly selected X-ray, CT, or PET scans, which involve radiation. This shows strong awareness but still some confusion among a small group.

Table 11 : Awareness that CT Scans Deliver Higher Radiation than X-rays (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
YES	**82.5**	**99**
NO	**6.7**	**08**
NOT SURE	**10.8**	**13**

MEAN =33.3% MEDIAN= 10.8% MODE= 82.5%

EXPLANATION: Most participants (99 out of 120) correctly believe that CT scans give higher radiation than X-rays. This shows good awareness about radiation dose differences in medical imaging. However, a small group is still unaware or unsure, indicating minor knowledge gaps.

Table 12: Awareness of Radiation Risks Before Undergoing Imaging (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
YES	**55.8**	**67**
NO	**22.5**	**27**
NOT APPLICABLE	**21.7**	**26**

MEAN= 33.3% MEDIAN = 22.5% MODE= 55.8%

EXPLANATION: Only about half of the participants (67 people) were informed about radiation risks before imaging. A significant number were either not informed or said it was not applicable. This highlights an important issue in patient communication and awareness, suggesting that better education is needed before imaging procedures.

Table 13: Knowledge of Average Annual Natural Radiation Exposure (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
1–3 mSv	**51.7**	**62**
5–10 mSv	**10.0**	**12**
>20 mSv	**6.7**	**08**
Not sure	**31.7**	**38**

MEAN = 25% MEDIAN =20.8% MODE=51.7%

EXPLANATION: More than half of the participants (62 people) correctly identified the average natural radiation exposure range (1–3 mSv). However, a large number (38 people) were unsure, showing that technical knowledge about radiation levels is still limited among the general population.

Table 14: Knowledge of Equivalent Dose of a Chest X-ray (n = 120)

Response Category	**Percentage (%)**	**Number of Population**
1 day of natural radiation	**11.7**	**14**
1 month of natural radiation	**7.5**	**9**
	4.2	**5**
1 week of natural radiation	**45.8**	**55**
Not sure	**30.8**	**37**

Mean = 20% Median = 11.7% Mode = 1 week of natural radiation (45.8%)

EXPLANATION: Most participants (55 people) selected "1 week of natural radiation," which is close to the correct concept. However, a large number (37 people) were unsure, and some chose incorrect options. This shows that understanding of radiation dose equivalence is moderate but not very strong.

Table 15: Knowledge of Equivalent Dose of a CT scan (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Few days of natural radiation	**16.7%**	**20**
Few months of natural radiation	**30.0%**	**36**
Several years of natural radiation	**25.8%**	**31**
Not sure	**27.5%**	**33**

Mean = 25% Median = 26.65% Mode = Few months of natural radiation (30.0%)

EXPLANATION: Most participants selected "few months of natural radiation," but many also chose incorrect options like "few days" or "several years," and a large number were unsure. This shows that understanding of CT scan dose equivalence is quite mixed and not very clear among participants.

Table 16: Perception of Radiation Contribution Over a Lifetime (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Natural background radiation	**44.2%**	**53**
Medical imaging	**19.2%**	**23**
Both equal	**25.8%**	**31**
Not sure	**10.8%**	**13**

Mean = 25% Median = 22.5% Mode = Natural background radiation (44.2%)

EXPLANATION:

Most participants (53 people) correctly believe that natural background radiation contributes more over a lifetime. However, many think both are equal or are unsure. This indicates moderate awareness but still confusion about long-term radiation exposure sources.

Table 17: Awareness that Small Radiation Exposures Accumulate Over Time (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Yes	**70.8%**	**85**
No	**12.5%**	**15**
Not sure	**16.7%**	**20**

Mean = 33.3% Median = 16.7% Mode = Yes (70.8%)

EXPLANATION: A large majority (85 participants) understand that small radiation exposures can accumulate over time, which is scientifically correct. However, some participants either disagree or are unsure, showing minor gaps in understanding long-term radiation effects.

Table 18: Awareness of Activities that Increase Radiation Exposure (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Air travel	**57.5%**	**69**
Watching TV	**16.7%**	**20**
Sleeping	**5.8%**	**7**
Not sure	**20.0%**	**24**

Mean = 25% Median = 18.35% Mode = Air travel (57.5%)

EXPLANATION: Most participants (69 people) correctly identified air travel as an activity that increases radiation exposure. However, some selected incorrect options like watching TV or sleeping, and many were unsure. This shows good awareness overall but presence of misconceptions in some participants.

Table 19: Awareness that Radiation Exposure Increases at Higher Altitude (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
True	**76.7%**	**92**
False	**6.7%**	**8**
Not sure	**16.7%**	**20**

Mean = 33.3% Median = 16.7% Mode = True (76.7%)

EXPLANATION

Most participants (92 out of 120) correctly know that radiation exposure increases at higher altitudes due to reduced atmospheric protection. However, some participants are unsure or incorrect, indicating good awareness but not complete understanding.

Table 20: Knowledge of Materials that Emit Natural Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Granite	**25.8%**	**31**
Concrete	**5.0%**	**6**
Bricks	**3.3%**	**4**
All of the above	**65.8%**	**79**

Mean = 25% Median = 15.4% Mode = All of the above (65.8%)

EXPLANATION : Most participants (79 people) correctly chose "All of the above," showing good knowledge that building materials like granite, concrete, and bricks can emit natural radiation. However, a few participants selected individual options, showing partial understanding in some cases.

Table 21: Perception of Danger of Medical Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Yes	**28.3%**	**34**
No	**4.2%**	**5**
Only at high doses	**63.3%**	**76**
Not sure	**4.2%**	**5**

Mean = 25% Median = 16.25% Mode = Only at high doses (63.3%)

EXPLANATION: Most participants (76 people) believe that medical radiation is dangerous only at high doses, which is scientifically correct. Very few think it is always dangerous or completely safe. This shows good awareness about risk levels of medical radiation.

Table 22: Behaviour of Avoiding Medical Imaging Due to Fear of Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Yes	**19.2%**	**23**
No	**58.3%**	**70**
Sometimes	**22.5%**	**27**

Mean = 33.3% Median = 22.5% Mode = No (58.3%)

Explanation: Most participants (70 people) do not avoid medical imaging due to fear of radiation, which is a positive sign. However, some participants either avoid it or do so sometimes, indicating that fear and misconceptions about radiation still exist among a portion of the population.

Table 23: Perception that Benefits of Medical Imaging Outweigh Risks (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Yes	**69.2%**	**83**
No	**10.0%**	**12**
Not sure	**20.8%**	**25**

Mean = 33.3% Median = 20.8% Mode = Yes (69.2%)

EXPLANATION: Most participants (83 out of 120) believe that the benefits of medical imaging outweigh the risks, which reflects a positive and informed attitude toward healthcare procedures. However, some are unsure or disagree, indicating remaining doubts among a smaller group.

Table 24: Awareness of Which Radiation is More Controlled and Monitored (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Medical imaging	**66.7%**	**80**
Natural radiation	**8.3%**	**10**
Both	**16.7%**	**20**
Not sure	**8.3%**	**10**

Mean = 25% Median = 12.5% Mode = Medical imaging (66.7%)

EXPLANATION: Most participants (80 people) correctly identified that medical radiation is more controlled and monitored compared to natural radiation. This shows good awareness of safety regulations in medical imaging, although some participants are still confused or unsure.

Table: 25 Perception that People Fear Medical Radiation More than Natural Radiation (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Yes	**80.0%**	**96**
No	**10.0%**	**12**
Not sure	**10.0%**	**12**

Mean = 33.3% Median = 10.0% Mode = Yes (80.0%)

EXPLANATION: A large majority (96 participants) believe that people fear medical radiation more than natural radiation. This supports your research idea that medical radiation is often overestimated, while natural radiation is underestimated.

Table 26: Perception that Natural Radiation Exposure is Underestimated (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Yes	**70.0%**	**84**
No	**13.3%**	**16**
Not sure	**16.7%**	**20**

Mean = 33.3% Median = 16.7% Mode = Yes (70.0%)
EXPLANATION: Most participants (84 people) believe that natural radiation exposure is underestimated. This strongly supports your research objective that people are less aware of natural radiation risks compared to medical radiation, even though it contributes more over time.

Table 27: Perception of Major Source Contributing to Yearly Radiation Exposure (n = 120)

Response Category	**Percentage (%)**	**Number of Participants**
Natural sources	**52.5%**	**63**
Medical imaging	**16.7%**	**20**
Both equal	**21.7%**	**26**
Not sure	**9.2%**	**11**

Mean = 25% Median = 19.2% Mode = Natural sources (52.5%)

EXPLANATION: More than half of the participants (63 out of 120) believe that natural sources contribute more to yearly radiation exposure. This is scientifically correct, which shows that a good number of people have the right understanding.

CHAPTER VI

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