RESEARCH PAPER

"Assessment of Radiation Protection Awareness and Practices among Radiology Technologists"

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Abstract
Background: Radiation safety is a fundamental component of diagnostic imaging, particularly for professionals routinely exposed to ionizing radiation. Ionizing Radiation used in modalities such as X-ray, fluoroscopy, and computed tomography poses potential health risks, including deterministic and stochastic effects. Radiology technologists play a critical role in ensuring patient and occupational safety through adherence to radiation protection principles. The concept of ALARA Principle is central to minimizing radiation exposure. However, gaps in awareness and inconsistent safety practices remain a concern, particularly in developing healthcare settings. Assessing the level of knowledge and practical implementation of radiation protection measures is essential for improving safety standards and reducing occupational hazards.
Aim: This study aims to assess the level of radiation protection awareness and evaluate the safety practices among radiology technologists working in diagnostic imaging departments.
Methods: A cross-sectional descriptive study was conducted among 80–120 radiology technologists working in various hospitals and diagnostic centers. Participants were selected using a convenience sampling technique. Data were collected using a structured, pre-validated questionnaire consisting of three sections: demographic details, knowledge of radiation protection principles, and self-reported safety practices. The questionnaire included items related to radiation dose limits, use of personal protective equipment (PPE), awareness of radiation hazards, and adherence to safety protocols. Data collection was carried out through both online and offline modes. The collected data were analyzed using statistical software, and results were expressed as frequencies, percentages, and mean scores. Associations between knowledge and practice were evaluated using appropriate statistical tests such as chi-square and correlation analysis.
Results: The study revealed a moderate level of awareness regarding radiation protection among radiology technologists. A majority of participants demonstrated basic knowledge of radiation hazards and the importance of protective measures; however, significant gaps were identified in specific areas such as dose limits, optimization techniques, and advanced protection strategies. Approximately 60–70% of participants were aware of the ALARA principle, while fewer demonstrated comprehensive understanding of its practical application.
Regarding safety practices, the use of personal protective equipment such as lead aprons and thyroid shields was reported by a majority of technologists; however, consistent use was not universal. The utilization of dosimeters for monitoring occupational exposure was suboptimal, with a notable proportion of participants either not using them regularly or lacking awareness of their importance. Compliance with standard radiation safety protocols, including proper shielding, distance maintenance, and exposure minimization, varied among participants.
The study also identified a significant association between years of experience and level of awareness, with more experienced technologists demonstrating better knowledge and practices. Additionally, participants who had undergone formal training or attended radiation safety workshops exhibited significantly higher awareness levels and better adherence to safety practices.
Conclusion: The study concludes that while radiology technologists possess a basic understanding of radiation protection, there are notable deficiencies in both awareness and consistent implementation of safety practices. These gaps may increase the risk of unnecessary radiation exposure to both patients and healthcare workers.
Recommendations: Regular training programs, continuing medical education (CME), and mandatory radiation safety workshops should be implemented to enhance knowledge and awareness. Strict enforcement of safety protocols, routine monitoring of occupational exposure using dosimeters, and institutional policies promoting adherence to radiation protection guidelines are essential. Incorporating radiation safety education into the curriculum and promoting a culture of safety within radiology departments will significantly improve compliance and reduce radiation-related risks.

Keywords: Radiation Protection, Radiology Technologists, ALARA Principle, Occupational Exposure, Radiation Safety, Awareness and Practices

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Introduction

The use of ionizing radiation in medical imaging has become an indispensable component of modern healthcare, significantly contributing to the diagnosis, treatment, and monitoring of various diseases. Imaging modalities such as X-ray, computed tomography (CT), fluoroscopy, and mammography have revolutionized clinical practice by enabling non-invasive visualization of internal body structures. However, alongside these benefits, the use of ionizing radiation poses potential health risks to both patients and healthcare professionals, particularly radiology technologists who are routinely exposed during imaging procedures. This makes radiation protection a critical aspect of radiological practice (Bushberg et al., 2012; UNSCEAR, 2010) [9,10].

Radiation exposure can lead to harmful biological effects, which are broadly classified as deterministic and stochastic effects. Deterministic effects occur above a certain threshold dose and include conditions such as skin burns, cataracts, and radiation sickness, whereas stochastic effects, such as cancer and genetic mutations, can occur even at low doses without a threshold. Radiology technologists, due to their occupational environment, are at continuous risk of low-dose exposure, especially from scattered radiation during imaging procedures. Over time, cumulative exposure may increase the likelihood of long-term health consequences, emphasizing the importance of effective radiation protection measures (Vano et al., 2008; Ciraj-Bjelac et al., 2010; Rajaraman et al., 2016) [12,13,14].

Radiation protection is based on fundamental principles such as justification, optimization, and dose limitation. The ALARA (As Low As Reasonably Achievable) principle is widely adopted to ensure that radiation exposure is minimized while still achieving the required diagnostic outcome. Key protective strategies include minimizing exposure time, maximizing distance from the radiation source, and using appropriate shielding such as lead aprons, thyroid collars, and protective barriers. Additionally, the use of personal dosimeters allows for monitoring of occupational exposure and ensures compliance with recommended dose limits established by regulatory authorities such as the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) (ICRP, 2007; IAEA, 2014) [7,16].

Radiology technologists play a central role in implementing these radiation safety practices. Their responsibilities extend beyond operating imaging equipment to include patient preparation, selection of appropriate imaging parameters, and ensuring adherence to safety protocols. Their level of knowledge, awareness, and attitude towards radiation protection significantly influences the effectiveness of safety measures in clinical settings. Inadequate awareness or improper practices can lead to unnecessary radiation exposure, posing risks not only to technologists themselves but also to patients and other healthcare workers (Martin, 2007) [18].

Despite the availability of established guidelines and safety protocols, several studies have reported gaps in radiation protection knowledge and practices among radiology personnel. For instance, studies by Yashima et al. (2023) and Alamoudi et al. (2024) have highlighted insufficient awareness levels among technologists regarding radiation hazards and safety measures. Similarly, Maharjan et al. (2020) and Khamtuikrua et al. (2020) reported that a significant proportion of healthcare professionals lack adequate understanding of radiation protection principles, which may result in poor compliance with safety protocols [1–4].

Furthermore, increasing use of advanced imaging technologies, particularly high-dose modalities such as CT and interventional radiology, has raised concerns regarding occupational exposure. Technologists working in such environments are at greater risk due to prolonged exposure times and higher radiation output. This underscores the need for continuous education, training programs, and strict adherence to radiation safety guidelines to ensure a safe working environment (European Commission, 2014; WHO, 2016) [8,11].

In addition, previous research has demonstrated that factors such as lack of formal training, heavy workload, limited availability of protective equipment, and inadequate institutional support contribute to poor radiation safety practices. Sharma et al. (2025) emphasized the importance of structured education and awareness programs in improving radiation protection practices among radiology personnel [5].

Therefore, assessing the level of radiation protection awareness and practices among radiology technologists is of great significance. Such assessment helps in identifying knowledge gaps, evaluating compliance with safety standards, and understanding the challenges faced by technologists in implementing protective measures. The findings can be used to develop targeted interventions, training programs, and policy improvements aimed at enhancing radiation safety culture within healthcare institutions.

In conclusion, while ionizing radiation remains a powerful tool in medical diagnosis and treatment, its safe use depends largely on the awareness and practices of radiology technologists. Strengthening radiation protection knowledge and ensuring strict adherence to safety principles are essential to reduce occupational hazards and safeguard both healthcare workers and patients. This study aims to evaluate the current level of radiation protection awareness and practices among radiology technologists, thereby contributing to improved safety standards and better healthcare outcomes.

The image represents four major diagnostic imaging modalities—X-ray, CT scan, fluoroscopy (C-arm), and mammography—which are widely used in modern radiology and constitute significant sources of occupational radiation exposure for radiology technologists. The X-ray machine, first discovered by Wilhelm Conrad Röntgen in 1895, is the most fundamental imaging device and typically consists of an X-ray tube, high-voltage generator, control panel, patient table, and an image receptor such as film or digital detector. It is extensively used for routine diagnostic procedures including chest radiography, skeletal imaging, and dental examinations due to its simplicity, speed, and cost-effectiveness. Despite its relatively low radiation dose compared to other modalities, the cumulative effect of repeated exposures, especially in high patient-load settings, can increase the risk of stochastic effects among technologists if proper precautions are not followed. In addition, scattered radiation from the patient remains a primary source of occupational exposure in X-ray rooms. This highlights the critical importance of radiation protection awareness, including the consistent use of personal protective equipment such as lead aprons, thyroid shields, and lead gloves, as well as adherence to the principles of time, distance, and shielding. Proper collimation, beam restriction, and positioning techniques further contribute to minimizing unnecessary exposure.

Computed Tomography (CT), introduced in the early 1970s by Sir Godfrey Hounsfield, represents a major advancement in diagnostic imaging technology. The CT scanner comprises a rotating gantry that houses an X-ray tube and multiple detectors, along with a motorized patient table and sophisticated computer systems for image reconstruction. It produces highly detailed cross-sectional and three-dimensional images, making it indispensable in the evaluation of trauma, cancers, neurological disorders, and internal organ pathologies. However, CT imaging is associated with significantly higher radiation doses compared to conventional radiography, thereby increasing both patient and occupational exposure risks. Radiology technologists operating CT systems must possess a high level of awareness regarding dose optimization strategies, including appropriate selection of scanning parameters, use of automatic exposure control systems, and adherence to the ALARA (As Low As Reasonably Achievable) principle. Furthermore, technologists should ensure proper shielding and maintain safe distances during scanning procedures, especially when assisting patients.

Fluoroscopy, particularly in the form of mobile C-arm systems, is widely used for real-time imaging during diagnostic and interventional procedures such as orthopedic surgeries, cardiac catheterization, and gastrointestinal studies. The equipment consists of an X-ray source and an image intensifier or flat-panel detector mounted on a C-shaped arm, allowing flexible positioning around the patient. Unlike conventional X-ray, fluoroscopy involves continuous or pulsed radiation exposure, which significantly increases the risk of radiation exposure to both patients and healthcare workers. Scatter radiation is particularly intense in fluoroscopic procedures, making it one of the highest contributors to occupational dose among radiology staff. Therefore, strong radiation protection practices are essential, including the use of lead barriers, ceiling-suspended shields, lead glasses, and dosimeters for monitoring cumulative exposure. Technologists must also be trained to minimize fluoroscopy time, use pulsed modes, and maintain maximum feasible distance from the radiation source.

Mammography, developed in the mid-20th century and refined over time with digital advancements, is a specialized imaging modality designed specifically for breast examination and early detection of breast cancer. The system includes a dedicated X-ray tube, compression paddle, and high-resolution digital detector optimized for soft tissue imaging. Although mammography uses relatively low doses of radiation, repeated screening procedures, especially in population-based programs, require strict adherence to radiation safety protocols. Proper positioning, compression techniques, and equipment calibration are essential not only for image quality but also for dose reduction. Technologists must be well-trained in these procedures to ensure both patient safety and minimal occupational exposure.

Overall, these imaging modalities are integral to modern healthcare but vary significantly in their radiation dose and associated risks. This directly relates to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it underscores the necessity for continuous education, training, and strict implementation of radiation safety measures. A thorough understanding of equipment operation, exposure risks, and protective strategies is essential for technologists to minimize occupational hazards while maintaining high standards of diagnostic imaging.

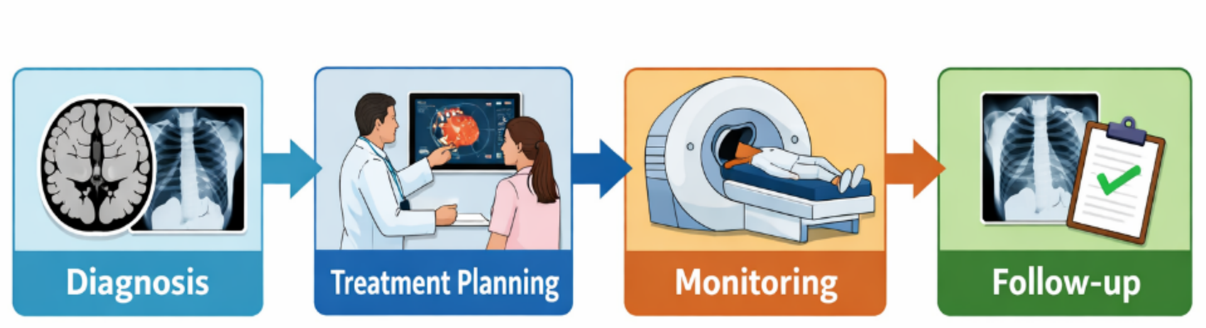


Figure 2: Role of radiological imaging in the continuum of patient care from diagnosis to follow-up

Radiological imaging plays a fundamental role across the entire continuum of patient care, encompassing diagnosis, treatment planning, monitoring, and follow-up. During the diagnostic stage, imaging modalities such as X-ray and CT scans are used to identify diseases, injuries, and abnormalities within the body. Accurate image acquisition at this stage is crucial, as it forms the basis for clinical decisions. Radiology technologists are responsible for operating imaging equipment efficiently while ensuring minimal radiation exposure to patients and themselves. Their awareness of radiation protection principles, including proper shielding, positioning, and exposure control, is essential to prevent unnecessary radiation risks.

In the treatment planning phase, advanced imaging techniques provide detailed anatomical and pathological information that assists clinicians in designing appropriate therapeutic interventions. Imaging helps in determining the exact location, size, and extent of disease, which is particularly important in cases such as cancer management and surgical planning. Radiology technologists contribute significantly by optimizing imaging protocols and ensuring high-quality images while maintaining radiation doses as low as reasonably achievable. Their knowledge of dose optimization techniques and safe equipment handling directly impacts both treatment accuracy and radiation safety.

The monitoring phase involves repeated imaging to evaluate the effectiveness of treatment and detect any progression or complications. Modalities such as CT scans, fluoroscopy, and other imaging systems may be used multiple times, increasing the likelihood of cumulative radiation exposure. This makes it essential for technologists to apply strict radiation protection practices, including minimizing exposure time, maintaining adequate distance from radiation sources, and using protective barriers. Continuous monitoring of radiation dose through personal dosimeters is also an important practice to ensure occupational safety.

During the follow-up stage, imaging is used to assess recovery, detect recurrence of disease, and ensure long-term patient health. Even though imaging at this stage may be less frequent, the cumulative effect of repeated exposures throughout the patient's care pathway remains a concern. Radiology technologists must consistently apply radiation safety measures and adhere to established guidelines to minimize risks.

The integration of radiological imaging throughout these stages highlights the continuous involvement of radiology technologists in patient care. This directly relates to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it emphasizes the importance of maintaining a high level of knowledge, awareness, and compliance with radiation safety protocols. Effective radiation protection practices not only safeguard patients but also protect technologists from occupational hazards, ensuring a safer healthcare environment.

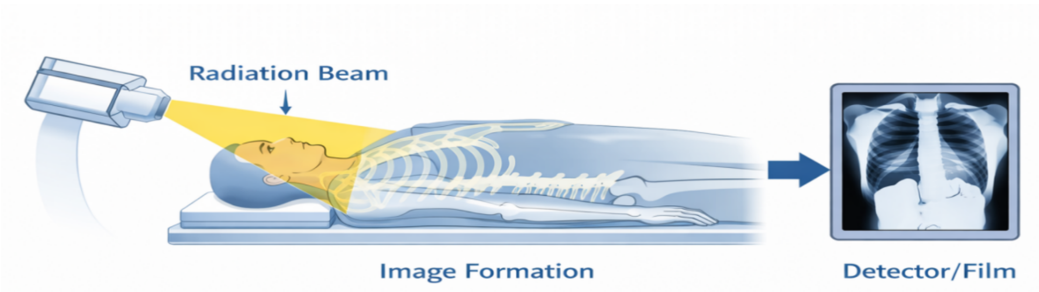


Figure 3: Use of Ionizing Radiation in Medicine

The use of ionizing radiation in medical imaging is fundamental for visualizing internal structures of the human body and plays a crucial role in diagnosis and clinical management. Imaging systems such as X-ray and CT scanners consist of an X-ray tube that emits radiation, a control unit to regulate exposure parameters, and a detector or film that captures the transmitted radiation to form an image. When radiation is directed toward the patient, it passes through the body and is absorbed to varying degrees by different tissues, allowing the formation of contrast between bones, soft tissues, and air spaces. The transmitted radiation is then captured by detectors and converted into a visible image that can be interpreted by clinicians.

The working of these systems involves careful control of exposure factors such as tube voltage (kVp), current (mA), and exposure time to ensure optimal image quality while minimizing radiation dose. Radiology technologists are responsible for selecting appropriate parameters based on the examination and patient characteristics. Their role is critical in balancing diagnostic accuracy with radiation safety. Improper handling or incorrect exposure settings can lead to unnecessary radiation exposure, repeat imaging, and increased risk to both patients and healthcare workers.

In clinical practice, radiation not only interacts with the patient but also produces scattered radiation, which contributes significantly to occupational exposure. Technologists working in close proximity to the patient during imaging procedures are particularly at risk. Therefore, awareness of radiation protection measures is essential, including maintaining safe distance, using shielding devices such as lead aprons and barriers, and minimizing exposure time. The use of personal dosimeters is also important for monitoring cumulative radiation dose and ensuring compliance with safety standards.

The application of ionizing radiation in medicine is directly related to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it highlights the continuous exposure risks associated with imaging procedures. Technologists must have a thorough understanding of how radiation is generated, how it interacts with the body, and how images are formed in order to apply effective protection strategies. Adherence to safety principles and proper training are essential to reduce occupational hazards while maintaining the diagnostic benefits of medical imaging.

Figure 4: Radiology Technologist at Work

Radiology technologists represent a vital component of the healthcare system, functioning at the interface between advanced imaging technology and patient care, while simultaneously being among the most occupationally exposed groups to ionizing radiation. Their routine responsibilities involve the operation of sophisticated imaging modalities such as computed tomography (CT), conventional radiography, and interventional imaging systems, which require a high degree of technical competence and situational awareness. During imaging procedures, technologists are required to perform precise patient positioning, select optimal exposure parameters, and ensure proper alignment of the imaging field to achieve diagnostically adequate images. Inadequate positioning or improper technique not only compromises image quality but also leads to repeat examinations, thereby increasing cumulative radiation exposure for both patients and staff. Consequently, the technologist's expertise directly influences radiation dose optimization and overall imaging efficiency.

Occupational exposure to ionizing radiation remains a significant concern in radiology practice, particularly due to scattered radiation generated during imaging procedures. Technologists working in close proximity to patients, especially in high-dose environments such as CT suites and interventional radiology settings, are at increased risk of chronic low-dose exposure. This cumulative exposure has been associated with potential stochastic effects, including an increased probability of malignancy over time. Therefore, strict adherence to radiation protection principles is essential. The implementation of the ALARA (As Low As Reasonably Achievable) concept forms the cornerstone of radiation safety practices, emphasizing the reduction of exposure time, maximization of distance from the radiation source, and effective use of shielding devices such as lead aprons, thyroid collars, lead glasses, and mobile protective barriers.

In addition to personal protective measures, radiology technologists are responsible for maintaining compliance with established safety standards and regulatory guidelines set by national and international bodies. The use of personal dosimetry devices, such as thermoluminescent dosimeters (TLDs) or electronic personal dosimeters, enables continuous monitoring of occupational exposure and ensures that dose limits are not exceeded. Furthermore, routine quality assurance and equipment calibration are essential to prevent unnecessary radiation output and to maintain optimal performance of imaging systems. Technologists must also demonstrate heightened awareness when dealing with radiosensitive populations, including pediatric and pregnant patients, where even minimal exposure carries greater biological risk. In such cases, justification of imaging procedures and implementation of additional protective strategies become critically important.

Moreover, the role of the radiology technologist extends beyond technical execution to include patient safety advocacy and risk communication. Educating patients about the procedure, ensuring informed cooperation, and minimizing motion artifacts are integral components that indirectly contribute to radiation dose reduction. Continuous professional education and training in radiation protection are indispensable in enhancing knowledge, attitude, and practice among technologists, particularly in rapidly evolving technological environments.

This comprehensive scope of responsibilities directly aligns with the research topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it underscores the dependence of radiation safety on the technologist's level of awareness, adherence to protective protocols, and practical implementation of safety measures. Evaluating these factors is essential for identifying gaps in knowledge and practice, thereby facilitating the development of targeted interventions and training programs aimed at reducing occupational exposure and improving overall radiation safety culture within radiology departments.

Radiation and Its Hazards

Ionizing radiation is a form of energy that has sufficient power to remove tightly bound electrons from atoms, thereby creating ions. In medical imaging, ionizing radiation is widely used to generate diagnostic images of internal body structures. Although it plays a vital role in modern medicine, its interaction with biological tissues can lead to potentially harmful effects, especially when exposure is not adequately controlled.

When ionizing radiation passes through the human body, it can cause damage at the cellular and molecular levels. This damage may affect DNA, proteins, and other critical cellular components, leading to altered cell function or cell death. The severity of these effects depends on several factors, including the dose of radiation, duration of exposure, frequency of exposure, and the sensitivity of the tissues involved.

The biological effects of radiation are broadly classified into deterministic effects and stochastic effects. Deterministic effects occur when the radiation dose exceeds a certain threshold and the severity of the effect increases with the dose. Examples include skin erythema (reddening), hair loss, cataract formation, and radiation burns. These effects are more likely to occur at higher doses and are generally preventable if exposure is kept below threshold levels.

On the other hand, stochastic effects do not have a threshold dose and can occur even at low levels of radiation exposure. The probability of occurrence increases with dose, but the severity is independent of it. The most significant stochastic effects include cancer induction and genetic mutations. Even though the risk from a single diagnostic procedure is small, repeated exposures over time may increase the likelihood of such effects.

Radiology technologists are particularly vulnerable to occupational exposure due to their continuous presence in radiation environments. Even low-dose exposure, when accumulated over long periods, may pose significant health risks. Therefore, understanding radiation hazards is essential for minimizing exposure and ensuring both personal safety and patient protection.

In addition to occupational risks, patients may also be exposed to unnecessary radiation if proper protocols are not followed. Factors such as incorrect exposure settings, repeat examinations, and lack of proper shielding can contribute to increased radiation dose. This highlights the importance of awareness and adherence to radiation protection practices in clinical settings.

Overall, while ionizing radiation remains an indispensable tool in medical imaging, its potential hazards necessitate strict control measures. Proper knowledge, awareness, and safe practices are essential to reduce risks and ensure that the benefits of radiological procedures outweigh their potential harm.

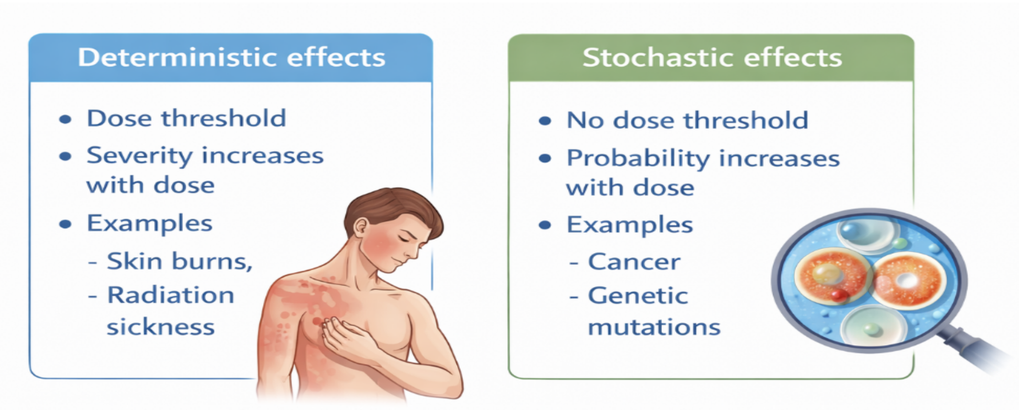


Figure 5: Types of Radiation Effects

Radiation exposure in medical imaging leads to biological effects that are broadly classified into deterministic and stochastic effects, which differ in their mechanism, dose relationship, and clinical significance. Deterministic effects occur only when radiation exposure exceeds a certain threshold dose, and their severity increases with increasing dose. These effects are caused by extensive cell damage and are usually seen at relatively high radiation levels. For example, skin erythema (reddening) may occur at doses around 2 Gy, temporary hair loss (epilation) at approximately 3–5 Gy, and more severe effects such as skin burns or tissue necrosis may occur at doses above 10 Gy. Cataract formation in the lens of the eye has a lower threshold, typically around 0.5 Gy (500 mGy) with repeated exposure. These effects are more relevant in high-dose procedures such as prolonged fluoroscopy or interventional radiology. For radiology technologists, understanding these threshold levels is important to avoid accidental overexposure and to ensure proper use of shielding, exposure control, and procedural limitations.

In contrast, stochastic effects do not have a threshold dose, meaning that even very low levels of radiation exposure can potentially lead to effects, although the probability is small. The risk increases with cumulative dose over time, but the severity of the effect does not depend on the dose. The most important stochastic effects include cancer and genetic mutations, which may develop years or decades after exposure. For example, repeated exposure in the range of 10–100 mSv is associated with a measurable increase in cancer risk, although the exact risk at very low doses remains difficult to quantify. Radiology technologists, who are chronically exposed to low-dose scatter radiation (often in the range of a few mSv per year), are particularly at risk of these cumulative stochastic effects if proper radiation protection practices are not followed.

The distinction between deterministic and stochastic effects highlights the importance of dose monitoring and control in radiological practice. While deterministic effects can be prevented by ensuring that radiation exposure remains below threshold levels, stochastic effects require continuous dose minimization strategies since no safe lower limit exists. This is why the ALARA (As Low As Reasonably Achievable) principle is essential in daily practice. The use of personal dosimeters, adherence to occupational dose limits (such as 20 mSv per year averaged over 5 years for radiation workers), and consistent application of time, distance, and shielding principles are critical for reducing risk.

This understanding is directly relevant to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it emphasizes that technologists must not only be aware of radiation hazards but also understand dose limits and thresholds to effectively prevent both immediate deterministic effects and long-term stochastic risks. Proper knowledge of dose-response relationships enhances safe work practices and contributes significantly to occupational safety in radiology departments.

Table 1 Deterministic vs Stochastic Effects

Feature	Deterministic Effects	Stochastic Effects
Threshold Dose	Present	No threshold
Dose Relationship	Severity ↑ with dose	Probability ↑ with dose
Severity	Dose dependent	Not dose dependent
Cause	Cell death	DNA mutation
Examples	Skin burn, cataract, hair loss	Cancer, genetic mutation
Dose Level	High dose (Gy range)	Low dose (mSv range)
Onset	Early (days–weeks)	Late (years–decades)

Figure 6: Cellular Damage by Radiation

Ionizing radiation interacts with biological tissues at the cellular level, leading to damage that can affect cell structure, function, and survival. When radiation passes through the body, it transfers energy to cells either directly by ionizing DNA molecules or indirectly through the formation of free radicals, particularly from the radiolysis of water. These free radicals are highly reactive and can cause significant damage to cellular components, especially DNA, which is the most critical target.

DNA damage may occur in several forms, including single-strand breaks, double-strand breaks, and base damage, with double-strand breaks being the most severe and difficult to repair. If the damage is mild, cellular repair mechanisms may restore normal function; however, incorrect repair can result in mutations, which are associated with stochastic effects such as cancer. In cases of high radiation dose, the damage may be irreparable, leading to cell death (apoptosis or necrosis), which is associated with deterministic effects.

The extent of cellular damage depends on several factors, including radiation dose, dose rate, type of radiation, and tissue sensitivity. Rapidly dividing cells, such as bone marrow and epithelial tissues, are more radiosensitive compared to stable or slowly dividing cells. At higher doses (in the range of >1 Gy), there is an increased likelihood of significant cellular injury and tissue reactions, while at lower doses (in mSv range), the primary concern is long-term stochastic risk due to DNA mutations.
For radiology technologists, understanding the mechanism of cellular damage is essential for appreciating the biological impact of radiation exposure. Even though occupational exposure is generally low, repeated exposure to scattered radiation can result in cumulative DNA damage over time. This reinforces the importance of strict adherence to radiation protection principles, including dose optimization, use of shielding, and regular monitoring through dosimeters.
This concept is directly relevant to the study "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it emphasizes that awareness of radiation-induced cellular damage forms the scientific basis for safe practices. A strong understanding of these mechanisms enables technologists to recognize the importance of minimizing exposure and adopting protective strategies to reduce both immediate and long-term health risks.

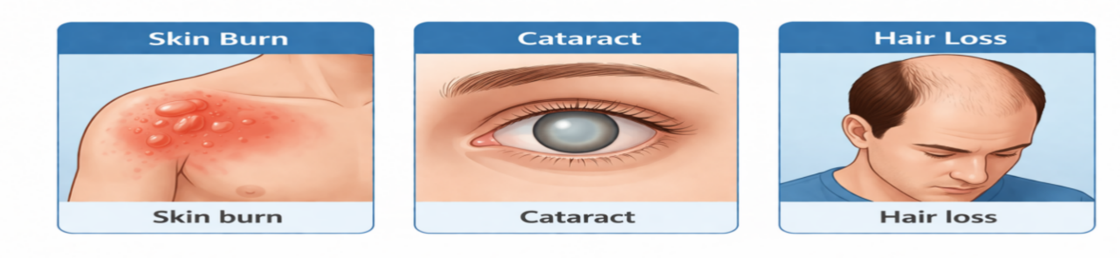


Figure 7: Deterministic Effects Examples

Deterministic effects are radiation-induced health effects that occur only when exposure exceeds a specific threshold dose, and their severity increases with increasing radiation dose. These effects result from significant cellular damage and loss of cell function in affected tissues. Common examples include skin burns, cataract formation, and hair loss, all of which are associated with relatively high radiation exposure levels. For instance, skin erythema may appear at doses around 2 Gy, while temporary or permanent hair loss can occur at approximately 3–5 Gy, and cataract formation in the lens of the eye has a lower threshold of about 0.5 Gy (500 mGy), especially with repeated exposure. These effects are typically observed in high-dose procedures such as prolonged fluoroscopy or interventional radiology, where exposure duration and intensity are considerably higher.
In clinical practice, deterministic effects are of particular concern because they can manifest within a short period, ranging from hours to weeks after exposure, depending on the dose received. Radiology technologists working in environments with high radiation output, such as interventional suites, are at increased risk if protective measures are not strictly followed. Scatter radiation from the patient is a major source of occupational exposure, especially to sensitive organs like the eyes, skin, and hands. Therefore, consistent use of protective equipment such as lead aprons, thyroid shields, lead glasses, and ceiling-suspended barriers is essential to prevent these effects.
The prevention of deterministic effects relies on ensuring that radiation doses remain below established threshold levels. This requires proper control of exposure parameters, minimizing fluoroscopy time, maintaining adequate distance from the radiation source, and using shielding effectively. Awareness of dose limits and thresholds is crucial for radiology technologists to recognize potentially hazardous situations and take appropriate precautions.
This concept is directly relevant to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it emphasizes the importance of understanding dose thresholds and implementing protective strategies to prevent immediate radiation injuries. A high level of awareness and adherence to safety protocols among technologists is essential to avoid deterministic effects and to maintain a safe working environment in radiology departments.

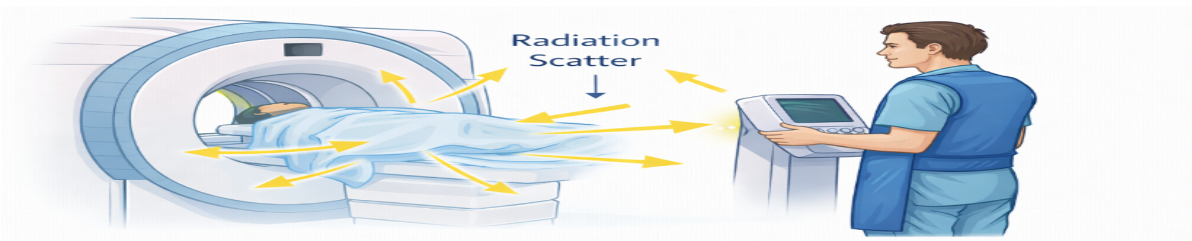


Figure 8: Occupational Exposure in Radiology

Occupational exposure in radiology refers to the radiation dose received by healthcare workers, particularly radiology technologists, during the performance of diagnostic and interventional imaging procedures. Technologists are routinely exposed to scattered radiation, which is generated when the primary X-ray beam interacts with the patient's body. This scattered radiation is the main source of occupational exposure and can affect various parts of the body, especially the hands, eyes, and thyroid, depending on the working position and proximity to the radiation source. Procedures such as fluoroscopy, interventional radiology, and CT imaging are associated with higher levels of occupational exposure due to prolonged exposure time and higher radiation output.
The level of occupational exposure varies depending on several factors, including the type of imaging modality, duration of procedures, workload, and adherence to radiation protection practices. Typically, radiology technologists receive annual radiation doses in the range of 1–5 mSv, although this can be higher in interventional settings if protective measures are not adequately implemented. Regulatory bodies such as the International Commission on Radiological Protection (ICRP) recommend occupational dose limits of 20 mSv per year averaged over 5 years, with no single year exceeding 50 mSv, to minimize health risks associated with long-term exposure.
Chronic low-dose exposure is primarily associated with stochastic effects, particularly an increased risk of cancer over time. Additionally, localized exposure to specific organs, such as the lens of the eye, can lead to deterministic effects like cataract formation, especially if cumulative doses exceed threshold levels (approximately 0.5 Gy for the lens). Therefore, continuous monitoring and dose management are essential in occupational settings.
Radiology technologists must strictly follow radiation protection principles to reduce occupational exposure. This includes minimizing exposure time, maximizing distance from the radiation source, and using appropriate shielding such as lead aprons, thyroid collars, lead glasses, and protective barriers. The use of personal dosimeters, such as thermos-luminescent dosimeters (TLDs), is crucial for tracking cumulative dose and ensuring compliance with safety standards. Additionally, proper training, awareness, and adherence to safety protocols significantly influence the level of occupational exposure.

3. Radiation Protection Principles

Radiation protection principles are fundamental guidelines designed to minimize the harmful effects of ionizing radiation on patients, radiology technologists, and the general public. With the increasing use of diagnostic imaging modalities such as X-ray, CT, and fluoroscopy, the need for effective radiation safety practices has become essential in modern healthcare. These principles ensure that the benefits of medical imaging outweigh the associated risks by controlling and reducing unnecessary radiation exposure.
The core principles of radiation protection are based on justification, optimization, and dose limitation. Justification ensures that every radiological procedure is medically necessary and that no unnecessary exposure is given. Optimization, commonly referred to as the ALARA (As Low As Reasonably Achievable) principle, focuses on reducing radiation dose to the lowest possible level while maintaining adequate image quality. Dose limitation involves adhering to recommended exposure limits for occupational workers and the public to prevent harmful biological effects.
In addition to these principles, practical measures such as time, distance, and shielding play a vital role in reducing radiation exposure in clinical settings. Minimizing exposure time, maximizing distance from the radiation source, and using appropriate protective equipment significantly contribute to radiation safety.
These principles are directly related to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as they form the foundation of safe radiological practice. The level of awareness and proper implementation of these principles by technologists is crucial in minimizing occupational exposure and ensuring a safe healthcare environment.

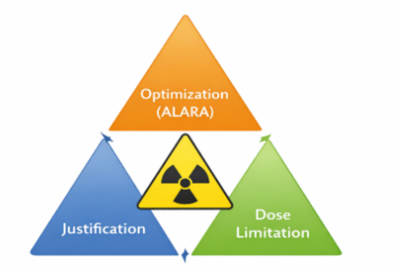


Figure 9: ALARA Principle

The ALARA principle, which stands for "As Low As Reasonably Achievable," is a fundamental concept in radiation protection that emphasizes minimizing radiation exposure while maintaining the required diagnostic image quality. It is based on three key components: justification, optimization, and dose limitation. Justification ensures that any radiological procedure is medically necessary and that the benefits outweigh the potential radiation risks. Optimization involves adjusting imaging parameters and techniques to achieve the best possible image quality with the lowest possible radiation dose. Dose limitation establishes recommended exposure limits for occupational workers and the general public to prevent harmful effects.
In clinical practice, the implementation of ALARA is essential for radiology technologists, as they are directly responsible for controlling exposure during imaging procedures. This includes selecting appropriate technical factors such as tube voltage (kVp), current (mA), and exposure time, as well as using collimation to restrict the beam to the area of interest. Reducing repeat

examinations through proper patient positioning and clear communication is also an important aspect of optimization. Additionally, the use of protective equipment and shielding helps to further reduce unnecessary exposure.

The ALARA principle is particularly important in reducing stochastic effects, as there is no safe threshold dose for such risks. Even low levels of radiation exposure can accumulate over time, increasing the probability of long-term effects such as cancer. Therefore, continuous efforts to minimize exposure are necessary in all radiological procedures, regardless of the dose level.

Radiology technologists must also ensure compliance with regulatory dose limits, such as the occupational exposure limit of 20 mSv per year averaged over 5 years, as recommended by international guidelines. The use of personal dosimeters, adherence to safety protocols, and participation in regular training programs are essential components of effective ALARA implementation.

This principle is directly relevant to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it reflects the level of understanding and application of radiation safety measures in daily practice. A strong awareness of ALARA ensures that technologists consistently adopt safe working habits, minimize occupational exposure, and contribute to maintaining a high standard of radiation protection in healthcare settings.

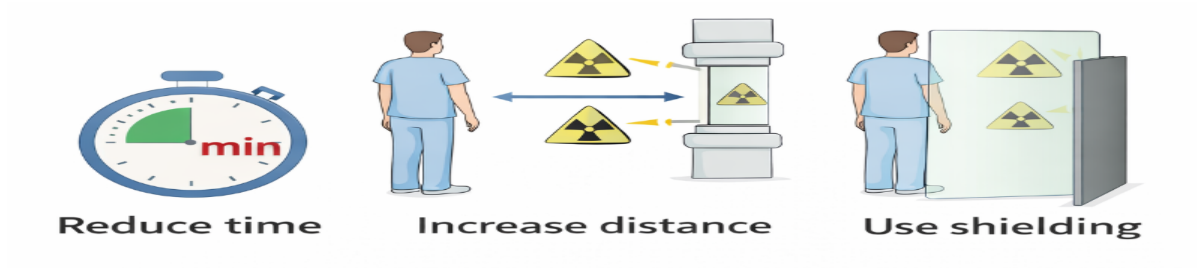


Figure 10: Time, Distance, Shielding

Time, distance, and shielding are the three fundamental principles of radiation protection that form the basis of safe radiological practice. These principles are essential for minimizing occupational radiation exposure among radiology technologists and are widely applied in all imaging environments involving ionizing radiation. The principle of time emphasizes reducing the duration of exposure to radiation sources. Since radiation dose is directly proportional to exposure time, minimizing the time spent near an active radiation source significantly lowers the received dose. Efficient workflow, proper planning of procedures, and avoiding unnecessary delays during imaging are critical strategies to achieve this.

The principle of distance is based on the inverse square law, which states that radiation intensity decreases rapidly as the distance from the source increases. Even a small increase in distance can lead to a substantial reduction in radiation exposure. Radiology technologists are therefore advised to maintain maximum feasible distance from the radiation source and the patient, who acts as a major source of scattered radiation during procedures. This is particularly important in high-exposure settings such as fluoroscopy and interventional radiology, where technologists may need to be present in close proximity to the patient.

Shielding involves the use of protective materials to absorb or block radiation and prevent it from reaching the body. Common shielding devices include lead aprons, thyroid collars, lead gloves, lead glasses, and protective barriers such as lead screens and walls. These materials are designed with high atomic number elements like lead, which effectively attenuate X-rays. Structural shielding in radiology rooms, including lead-lined walls and lead glass windows, also plays a vital role in protecting healthcare workers from radiation exposure.

The combined application of time, distance, and shielding significantly reduces both deterministic and stochastic radiation risks. For radiology technologists, consistent adherence to these principles is crucial in maintaining occupational exposure within recommended limits, such as 20 mSv per year averaged over 5 years. These practices are directly related to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as they reflect the practical implementation of radiation safety knowledge in clinical settings. A strong understanding and routine application of these principles are essential for ensuring a safe working environment and minimizing long-term health risks associated with radiation exposure.

Figure 11: Protective Equipment

Protective equipment plays a crucial role in minimizing occupational radiation exposure among radiology technologists and is an essential component of radiation safety practices. Personal protective equipment (PPE) commonly used in radiology includes lead aprons, thyroid collars, lead gloves, and lead glasses, all of which are designed to attenuate ionizing radiation and protect sensitive organs from exposure. These protective devices are typically made from materials with high atomic numbers, such as lead or lead-equivalent composites, which effectively absorb X-rays and reduce the amount of radiation reaching the body.

Lead aprons are the most commonly used protective devices and are designed to shield vital organs such as the chest, abdomen, and reproductive organs. They typically provide a lead equivalence of 0.5 mm Pb, which can attenuate approximately 90–95% of scattered radiation, depending on the energy of the X-ray beam. Thyroid collars are specifically used to protect the thyroid gland, which is highly radiosensitive and vulnerable to radiation-induced disorders, including cancer. Similarly, lead gloves are used to protect the hands, especially during procedures where technologists may need to work close to the radiation field, such as interventional radiology. Lead glasses provide protection to the lens of the eye, reducing the risk of radiation-induced cataracts, which have a threshold dose of approximately 0.5 Gy.

The proper use, maintenance, and regular inspection of protective equipment are essential to ensure their effectiveness. Damaged or improperly worn protective devices may compromise safety and increase the risk of exposure. Radiology technologists must also ensure that protective equipment is used consistently during all relevant procedures, particularly in high-exposure environments such as fluoroscopy and CT imaging.

The use of protective equipment is directly related to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it reflects the practical application of radiation safety knowledge in clinical settings. A high level of awareness and compliance in using PPE significantly reduces occupational exposure and helps maintain radiation doses within recommended limits, such as 20 mSv per year averaged over 5 years. Therefore, continuous training and strict adherence to protective practices are essential for ensuring the safety of healthcare workers in radiology departments.

Figure 12: Dosimeter (TLD Badge)

Personal dosimeters, particularly Thermoluminescent Dosimeter (TLD) badges, are essential devices used for monitoring occupational radiation exposure among radiology technologists. These badges are worn on the body, typically at chest level outside the lead apron, to measure the amount of ionizing radiation received over a specific period. In certain cases, additional dosimeters may be worn under the apron or on extremities such as the hands or near the eyes, depending on the nature of the work and exposure risk.

TLD badges function by absorbing radiation energy and storing it within the crystal material, commonly lithium fluoride. When the badge is later processed in a laboratory, it is heated, causing the stored energy to be released in the form of light. The intensity of this is proportional to the amount of radiation exposure, allowing accurate measurement of cumulative dose. These devices are highly sensitive and capable of detecting low levels of radiation, making them suitable for long-term occupational monitoring.

The use of dosimeters is critical for ensuring that radiation exposure remains within recommended safety limits. According to international guidelines, such as those from the International Commission on Radiological Protection (ICRP), the occupational dose limit is 20 mSv per year averaged over 5 years, with no single year exceeding 50 mSv. Regular monitoring through TLD badges helps in identifying excessive exposure, evaluating work practices, and implementing corrective measures when necessary.

Radiology technologists must use dosimeters consistently and correctly to obtain accurate readings. Improper use, such as not wearing the badge during procedures or placing it incorrectly, can lead to inaccurate dose assessment. Additionally, periodic evaluation and record-keeping of dosimetry reports are essential for maintaining radiation safety standards and regulatory compliance.

The use of TLD badges is directly relevant to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it reflects the level of awareness and responsibility in monitoring occupational exposure. Proper utilization of dosimeters not only ensures individual safety but also contributes to improving overall radiation protection practices within healthcare institutions. Continuous education and strict adherence to dosimetry protocols are therefore essential for minimizing long-term radiation risks among radiology professionals.

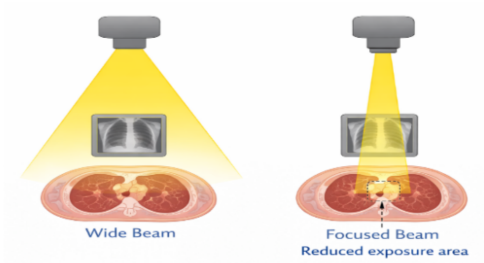


Figure 13: Collimation and Beam Restriction

Collimation and beam restriction are essential techniques in radiology that are used to limit the size and shape of the X-ray beam to the area of clinical interest, thereby reducing unnecessary radiation exposure to surrounding tissues. Modern imaging equipment is equipped with adjustable collimators that allow radiology technologists to control the beam field precisely. By restricting the beam to only the required anatomical region, collimation not only minimizes patient dose but also reduces the amount of scattered radiation produced during imaging procedures.

When a wide, uncollimated beam is used, a larger volume of tissue is exposed, leading to increased radiation dose and higher levels of scatter radiation. This scattered radiation not only degrades image quality by reducing contrast but also contributes significantly to occupational exposure among radiology technologists. In contrast, a well-collimated, focused beam limits exposure to a smaller area, thereby improving image quality and reducing both patient and staff radiation dose. This is particularly important in procedures involving repeated imaging or higher radiation output, such as CT scans and fluoroscopy.

From a radiation protection perspective, effective collimation plays a key role in implementing the ALARA principle by ensuring that radiation exposure is kept as low as reasonably achievable. It directly contributes to dose optimization by avoiding irradiation of non-target tissues and minimizing the need for repeat examinations. Radiology technologists must be trained to adjust collimation accurately for each procedure, considering factors such as patient size, anatomical region, and clinical indication.

This concept is highly relevant to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as proper use of collimation reflects the technologist's practical knowledge and adherence to radiation safety protocols. Consistent application of beam restriction techniques not only enhances diagnostic image quality but also significantly reduces occupational and patient radiation exposure, reinforcing the importance of awareness and training in radiation protection practices.

Figure 14: Shielded Radiology Room

A shielded radiology room is specifically designed to protect healthcare workers and the general public from unnecessary exposure to ionizing radiation through the use of structural shielding. These rooms are constructed with lead-lined walls, doors, and lead glass windows, which effectively absorb and attenuate radiation, preventing it from escaping into adjacent areas. The control room, where the radiology technologist operates the imaging equipment, is typically separated from the examination area by a protective barrier that includes a lead glass viewing window. This setup allows the technologist to monitor the patient and procedure while remaining protected from direct and scattered radiation.

Structural shielding is particularly important in high-radiation environments such as X-ray rooms, CT suites, and fluoroscopy units, where repeated imaging procedures are performed. The design of these rooms follows strict regulatory guidelines to ensure that radiation levels outside the room remain within safe limits for both occupational workers and the public. The thickness of shielding materials, such as lead or concrete, is determined based on factors including workload, type of imaging equipment, and radiation energy levels.

During imaging procedures, the patient becomes a primary source of scattered radiation, which can pose a risk to nearby personnel. By operating from within a shielded control area, radiology technologists significantly reduce their occupational exposure. In addition to structural shielding, warning lights, radiation signs, and controlled access to the imaging room further enhance safety by preventing unnecessary exposure to others.

The use of shielded radiology rooms is directly related to the topic "Assessment of Radiation Protection Awareness and Practices Among Radiology Technologists," as it reflects the implementation of engineering controls in radiation safety. While structural shielding provides a primary level of protection, the effectiveness of these measures depends on the technologist's awareness and adherence to safe working practices, such as remaining behind protective barriers during exposure and ensuring that safety protocols are followed at all times. Proper understanding and utilization of shielded environments are therefore essential for minimizing occupational radiation exposure and maintaining a safe radiology workplace.

Role of Radiology Technologists + Awareness & Practices

Radiology technologists are key professionals in the healthcare system who play a vital role in the safe and effective use of ionizing radiation. They are directly involved in performing diagnostic imaging procedures, including X-rays, computed tomography (CT), fluoroscopy, and other radiological examinations. Their responsibilities include patient positioning, selection of exposure parameters, operation of imaging equipment, and ensuring optimal image quality while minimizing radiation exposure.

Due to their continuous involvement in radiological procedures, radiology technologists are at a higher risk of occupational radiation exposure. Therefore, their knowledge and understanding of radiation safety principles are crucial in preventing unnecessary exposure to both patients and themselves. Proper implementation of radiation protection measures depends largely on the awareness and competency of these professionals.

Awareness refers to the level of knowledge and understanding that radiology technologists have regarding radiation hazards, safety principles, and protective measures. This includes knowledge about dose limits, biological effects of radiation, use of protective equipment, and adherence to safety guidelines such as the ALARA principle. Adequate awareness ensures that technologists recognize the risks associated with radiation and take appropriate precautions during imaging procedures.

However, awareness alone is not sufficient to ensure radiation safety. The actual practices followed in the clinical setting are equally important. Practices refer to the real-life application of radiation protection measures during routine work. These include the consistent use of personal protective equipment such as lead aprons and thyroid shields, proper use of collimation, maintaining appropriate distance from the radiation source, minimizing exposure time, and wearing personal dosimeters regularly.

In many cases, a gap exists between knowledge and practice. Radiology technologists may have adequate theoretical knowledge but may fail to consistently apply safety measures due to factors such as heavy workload, time constraints, lack of supervision, insufficient training, or unavailability of protective equipment. This discrepancy can lead to increased radiation exposure and compromise both patient and occupational safety.

Furthermore, the level of awareness and adherence to radiation protection practices may vary depending on factors such as educational background, years of experience, type of healthcare institution, and access to continuing education programs. Inadequate training or lack of regular updates on radiation safety guidelines can further contribute to poor compliance with safety protocols.

Radiology technologists also have an ethical and professional responsibility to ensure patient safety. They must justify each procedure, avoid unnecessary repeat exposures, and provide appropriate shielding to patients and attendants when required. Proper communication with patients, especially in cases involving pregnant women or pediatric patients, is also essential to minimize radiation risks.

Therefore, assessing both the awareness and practices of radiology technologists is essential to identify gaps, improve training programs, and enhance radiation safety standards in healthcare settings. Understanding these aspects can help in developing targeted interventions that promote a culture of safety and ensure compliance with established radiation protection guidelines.

5. Need of Study

Despite the widespread use of radiation protection guidelines and safety standards in radiology departments, there is growing concern regarding their proper implementation in clinical practice. Although international and national regulatory bodies have established clear recommendations for radiation safety, adherence to these guidelines is not always consistent among healthcare professionals, particularly radiology technologists.

One of the major challenges in radiological practice is the potential gap between theoretical knowledge and practical application of radiation protection measures. While radiology technologists may possess basic awareness of radiation hazards and safety principles, this knowledge is not always translated into routine clinical practice. Factors such as heavy workload, lack of continuous training, inadequate supervision, limited availability of protective equipment, and negligence can contribute to poor compliance with radiation safety protocols.

In addition, variations in educational background, level of experience, and type of healthcare institution may influence the level of awareness and adherence to radiation protection practices. In some settings, especially in resource-limited environments, insufficient infrastructure and lack of updated training programs may further compromise radiation safety. These issues not only increase the risk of occupational exposure among technologists but also affect patient safety by potentially leading to unnecessary radiation exposure.

Furthermore, repeated exposure to ionizing radiation, even at low doses, can have cumulative effects over time. This highlights the importance of regular monitoring, strict adherence to safety protocols, and continuous evaluation of radiation protection practices among healthcare workers. Ensuring a high level of awareness and proper implementation of safety measures is essential to reduce long-term health risks and improve the overall quality of radiological services.

Given these concerns, it becomes necessary to assess the current level of awareness and the extent to which radiation protection practices are being followed by radiology technologists. Such an assessment can help identify existing gaps, evaluate compliance with safety standards, and provide valuable insights for improving training programs and institutional policies.

Therefore, the present study is undertaken to evaluate the awareness and practices related to radiation protection among radiology technologists. By identifying deficiencies and areas requiring improvement, this study aims to contribute to the enhancement of radiation safety culture and promote better protection for both patients and healthcare profession.

Methodology

This study is designed as a **descriptive cross-sectional survey** conducted among radiology technologists working in a diagnostic imaging center. A cross-sectional study design is appropriate for assessing the level of awareness and current practices related to radiation protection at a single point in time. This approach allows for the identification of existing knowledge levels, behavioral patterns, and gaps in radiation safety practices among technologists.

Study Area

The study will be carried out in a diagnostic imaging center, where various radiological procedures such as X-ray, CT, fluoroscopy, and MRI are routinely performed.

Study Population

The study population will include radiology technologists working in diagnostic imaging departments, who are directly involved in performing imaging procedures and handling radiation-emitting equipment.

Inclusion Criteria

- Radiology technologists working in modalities such as X-ray, CT, fluoroscopy, MRI, etc.
- Technologists with at least 6 months of work experience
- Individuals who are willing to participate in the study

Exclusion Criteria

- Students and trainees
- Technologists not willing to participate
- Non-technical staff (administrative personnel)

Study Design Rationale

A cross-sectional approach enables the simultaneous assessment of both knowledge (awareness) and self-reported practices related to radiation protection. Previous studies have demonstrated discrepancies between knowledge and actual behavior, particularly in areas such as dosimeter usage and adherence to safety guidelines. Therefore, this design is suitable for identifying such gaps and evaluating real-world practices.

Sample Size and Sampling Technique

A total sample size of 30 radiology technologists will be selected using a convenience sampling technique. Although the sample size is relatively small, it is appropriate for an exploratory study conducted within a single center. The findings will help identify local gaps in radiation protection awareness and practices and provide a basis for future large-scale studies.

Study Instrument

Data will be collected using a structured, self-administered questionnaire, consisting of the following sections:

1. **Demographic and Occupational Information**
Includes age, gender, qualification, years of experience, working modality, and prior radiation safety training.
2. **Knowledge of Radiation Hazards**
Assesses understanding of ionizing and non-ionizing radiation, deterministic and stochastic effects, and basic radiation dose concepts.
3. **Awareness of Radiation Protection Guidelines**
Evaluates knowledge of ALARA principle, time-distance-shielding, institutional protocols, and regulatory requirements.
4. **Practices Related to PPE Use**
Assesses the frequency and correctness of using protective equipment such as lead aprons, thyroid shields, and protective barriers.
5. **Practices Related to Dosimetry**
Evaluates the use of personal dosimeters, consistency in wearing them, and awareness of dose monitoring reports.
6. **Perceived Barriers and Gaps**
Identifies factors such as lack of training, workload, availability of PPE, and institutional support affecting radiation safety practices.

Validity and Reliability

The questionnaire will be reviewed by subject experts such as a radiologist and medical physicist to ensure content validity. Reliability will be assessed using internal consistency measures (Cronbach's alpha) and, if feasible, pilot testing with a small group to ensure clarity and consistency of responses.

Data Collection Procedure

After obtaining institutional permission and ethical approval, eligible participants will be informed about the study objectives and provided with a consent form. Data will be collected using either paper-based or electronic questionnaires, ensuring confidentiality and voluntary participation.

Ethical Considerations

The study involves minimal risk as it is survey-based. Ethical principles such as informed consent, confidentiality, anonymity, and the right to withdraw will be strictly followed. Since the study relates to workplace safety, responses will not be linked to individual identities to avoid bias and ensure honest reporting.

DATA Analysis

- Each correct response in the awareness section will be scored as **1**, and incorrect/unknown as **0**
- Practice-related responses will be scored based on frequency (Always, Sometimes, Never)
- Total scores will be categorized as:
  - **Good** (≥75%)
  - **Moderate** (50–74%)
  - **Poor** (<50%)

Outcome Measures

The study will evaluate:

- Level of radiation protection awareness among technologists
- Degree of compliance with radiation safety practices
- Association between awareness and actual practices
- Identification of gaps in knowledge and implementation

Limitations of the Study

- Use of convenience sampling may limit generalizability
- Self-reported data may introduce response bias
- Study limited to selected institutions

Table 1: Demographic Characteristics of Participants

Variable	Category	Frequency (n)	Percentage (%)

Age	20–30 years	18	60%
	31–40 years	9	30%
	>40 years	3	10%
Gender	Male	19	63.3%
	Female	11	36.7%
Qualification	Diploma	14	46.7%
	Degree	16	53.3%
Experience	<2 years	10	33.3%
	2–5 years	12	40%
	>5 years	8	26.7%

Table 2: Knowledge of Radiation Hazards

Knowledge Parameter	Correct Response (%)
Awareness of ionizing radiation	90%
Knowledge of deterministic effects	70%
Knowledge of stochastic effects	66.7%
Awareness of dose limits	53.3%
MRI is non-ionizing	73.3%

Table 3: Knowledge Level Distribution

Category	Frequency (n)	Percentage (%)
Good	12	40%
Moderate	13	43.3%
Poor	5	16.7%

Table 4: Awareness of Radiation Protection Guidelines

Parameter	Yes (%)
Awareness of ALARA principle	80%
Knowledge of time-distance-shielding	86.7%
Awareness of institutional protocols	60%
Awareness of regulatory dose limits	56.7%

Table 5: Use of Personal Protective Equipment (PPE)

PPE Usage	Always (%)	Sometimes (%)	Never (%)
Lead apron	70%	23.3%	6.7%
Thyroid collar	56.7%	30%	13.3%
Lead gloves	33.3%	40%	26.7%
Lead glasses	20%	36.7%	43.3%

Table 6: Use of Dosimeters

Parameter	Response (%)
Dosimeter provided	83.3%
Always wear dosimeter	60%
Sometimes wear	26.7%
Never wear	13.3%
Receive dose reports	46.7%

Table 7: Association Between Experience and Knowledge

Experience	*Good Knowledge (%)*
<2 years	20%
2–5 years	41.7%
>5 years	62.5%

Table 8: Identified Gaps in Radiation Protection Practices

Barrier	Percentage (%)
Lack of training	40%
Heavy workload	36.7%
Lack of supervision	30%
Unavailability of PPE	23.3%

Results

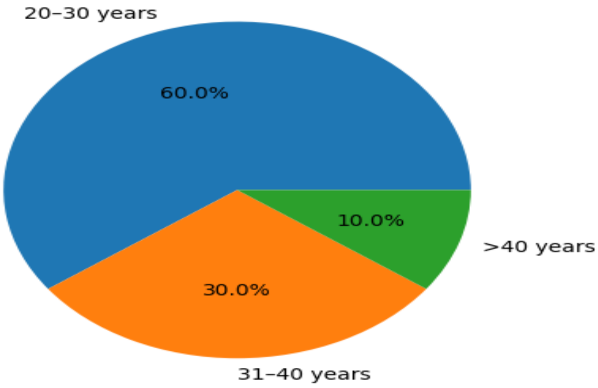
A total of 30 radiology technologists participated in the study.

Demographic Characteristics

A total of 30 radiology technologists participated in the study. The majority of participants were in the age group of 20–30 years (60%), followed by 31–40 years (30%), and only 10% were above 40 years. Male participants constituted 63.3%, while females accounted for 36.7%. Regarding educational qualification, 53.3% were degree holders, while 46.7% had diploma-level education. In terms of work experience, 40% had 2–5 years of experience, followed by 33.3% with less than 2 years, and 26.7% with more than 5 years of experience.

Majority participants were young (20–30 years) and had 2–5 years of experience.

Fig. Age Distribution



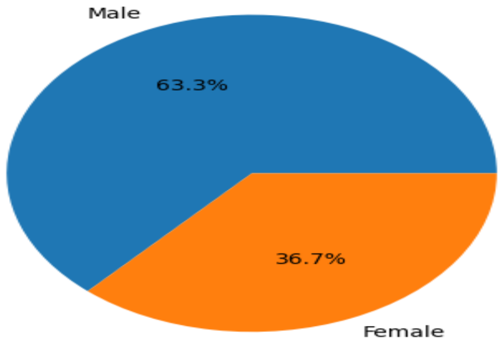


Fig. Gender Distribution

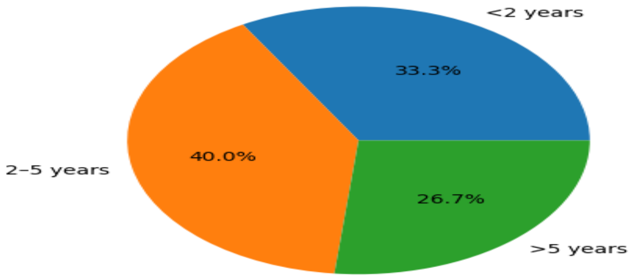


Fig. Experience Distribution

Knowledge of Radiation Hazards

Most participants demonstrated awareness of basic radiation concepts. About 90% correctly identified ionizing radiation, while 70% were aware of deterministic effects and 66.7% understood stochastic effects. However, only 53.3% were aware of radiation dose limits, indicating a gap in advanced knowledge.

Overall knowledge assessment showed that 40% of participants had good knowledge, 43.3% had moderate knowledge, and 16.7% had poor knowledge. This indicates that while basic awareness is present, there is room for improvement in deeper understanding of radiation safety.

Most participants had moderate knowledge, with gaps in dose limits awareness.

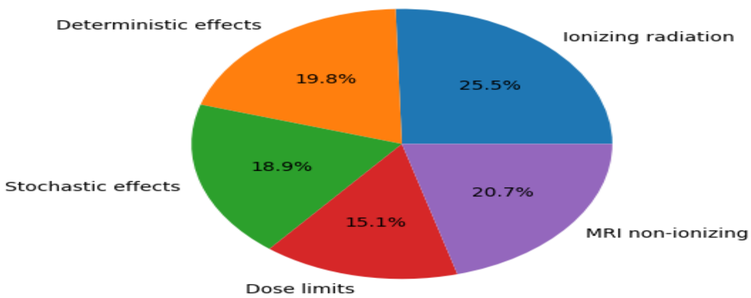


Fig: Knowledge Distribution

Awareness of Radiation Protection Guidelines

Awareness of radiation protection principles was relatively high. About 80% of participants were aware of the ALARA principle, and 86.7% understood the concepts of time, distance, and shielding. However, only 60% were aware of institutional safety protocols, and 56.7% had knowledge of regulatory dose limits, indicating incomplete awareness of formal guidelines.

While basic principles are well known, awareness of formal guidelines is limited.

Use of Personal Protective Equipment (PPE)

The use of PPE varied among participants. Lead apron usage was high, with 70% always using it, while 23.3% used it sometimes. However, the use of other protective devices was less consistent. Only 56.7% always used thyroid collars, and 33.3% regularly used lead gloves.

The use of lead glasses was particularly low, with only 20% always using them, while 43.3% never used them. This indicates inadequate protection of sensitive organs such as the eyes.Lead apron use is high, but eye and hand protection is poor.

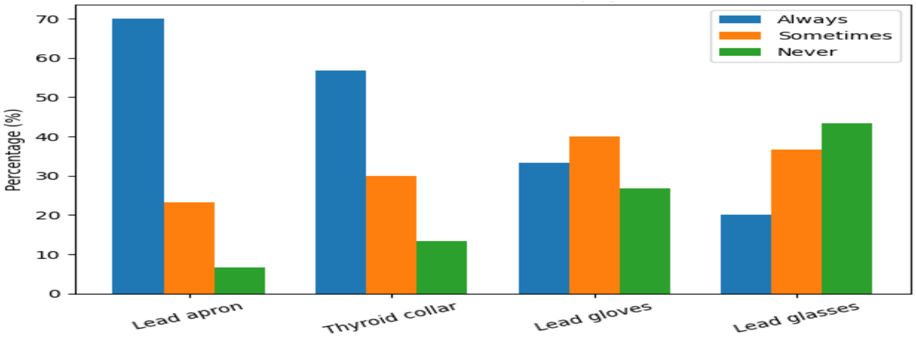


Fig: Use of personal Equipment (PPE)

Use of Dosimeters

A majority (83.3%) of participants reported that dosimeters were available in their workplace. However, only 60% reported always wearing them, while 26.7% used them occasionally, and 13.3% did not use them at all.

Additionally, only 46.7% of participants reported receiving regular dose reports, suggesting gaps in Availability is good, but consistent use is lacking.

Association Between Experience and Knowledge

An increase in knowledge level was observed with increasing work experience. Among technologists with more than 5 years of experience, 62.5% demonstrated good knowledge, compared to only 20% among those with less than 2 years of experience.Statistical analysis using the Chi-square test showed a significant association ($p < 0.05$) between experience and knowledge level.Chi-square test showed **$p < 0.05$**, statistically significant

Identified Gaps in Radiation Protection Practices

Several barriers affecting radiation protection practices were identified. The most common issue was lack of training (40%), followed by heavy workload (36.7%), lack of supervision (30%), and unavailability of PPE (23.3%).

Major issues: training and workload pressure

DISCUSSION

The present study aimed to assess the awareness and practices related to radiation protection among radiology technologists. The findings of this study revealed that while participants demonstrated moderate knowledge of radiation hazards and protection principles, there were significant gaps in practical implementation and adherence to safety measures.

The demographic findings showed that the majority of participants were young technologists (20–30 years) with relatively limited experience, which may influence both knowledge and practical skills in radiation protection. Similar findings have been reported in previous studies, where younger or less experienced technologists exhibited lower levels of awareness compared to more experienced professionals.

In terms of knowledge, most participants were aware of basic radiation concepts, such as ionizing radiation and radiation effects. However, awareness of radiation dose limits was relatively low (53.3%), indicating insufficient understanding of advanced safety parameters. This finding is consistent with studies by Maharjan et al. and Alamoudi et al., which reported that although basic knowledge is present, there is a lack of deeper understanding of radiation safety concepts and dose limits.

Awareness of radiation protection guidelines, including the ALARA principle and time-distance-shielding, was relatively high among participants. However, awareness of institutional protocols and regulatory dose limits was comparatively lower. This suggests that while general principles are known, formal safety guidelines are not adequately emphasized or implemented in clinical practice. Similar observations have been reported in previous literature, where gaps exist between theoretical knowledge and practical application of radiation protection measures.

The study also revealed variability in the use of personal protective equipment (PPE). While lead apron usage was high, the use of thyroid collars, lead gloves, and especially lead glasses was inconsistent. The low usage of lead glasses (only 20% always using them) is particularly concerning, given the sensitivity of the eye lens to radiation exposure and the risk of cataract formation. These findings are in agreement with previous studies that reported inconsistent PPE usage due to factors such as discomfort, lack of availability, or negligence.

Regarding dosimeter usage, although most participants reported availability of dosimeters, consistent usage was not observed. Only 60% of technologists reported always wearing dosimeters, and less than half received regular dose reports. This indicates gaps in both compliance and monitoring practices. Previous studies have similarly highlighted that although dosimeters are available, they are not consistently used, reducing their effectiveness in monitoring occupational exposure.

The association between experience and knowledge showed that technologists with more years of experience had better knowledge levels. This finding suggests that practical exposure and experience contribute significantly to improved awareness and adherence to safety practices. However, reliance solely on experience without structured training may not be sufficient to ensure optimal radiation protection.

The study also identified key barriers affecting radiation safety practices, including lack of training, heavy workload, lack of supervision, and unavailability of PPE. These findings highlight that both individual and organizational factors influence radiation protection practices. Similar barriers have been reported in previous research, emphasizing the need for institutional support and continuous training programs.

Overall, the findings of this study indicate a gap between knowledge and practice among radiology technologists. While awareness of basic concepts exists, consistent application of radiation protection measures is lacking, which may increase occupational exposure risks.

CONCLUSION

The study concludes that radiology technologists possess moderate awareness of radiation protection principles; however, there are significant gaps in the consistent implementation of safe practices. Although most participants were aware of basic concepts such as ionizing radiation and ALARA, knowledge of dose limits and regulatory guidelines was limited.

The use of personal protective equipment was inconsistent, with adequate use of lead aprons but poor compliance in using thyroid shields, lead gloves, and lead glasses. Similarly, although dosimeters were available, their consistent use and monitoring were inadequate.

Experience was found to be positively associated with knowledge levels, indicating that practical exposure plays an important role in improving awareness. However, reliance on experience alone is insufficient without proper training and supervision.

The study also identified key barriers, including lack of training, workload pressure, and inadequate supervision, which contribute to poor radiation safety practices. These findings highlight the need for continuous education, strict implementation of safety protocols, and improved institutional support.

Overall, there is a clear need to strengthen radiation protection awareness and practices among radiology technologists to ensure both occupational safety and patient protection.

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