



Original Article

Compliance with Radiation Safety Protocols in Libyan Hospital Imaging Departments: A Cross-Sectional Assessment

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Abstract

Background: Radiation safety is a fundamental pillar of healthcare quality; however, compliance challenges vary across different regulatory environments. This multicenter cross-sectional study investigates the status of adherence to radiation safety protocols within medical imaging departments in Libyan hospitals and evaluates the subsequent impact on occupational safety. **Method:** Targeting a purposive sample of 68 radiology technicians across six major public hospitals in Zawia, Sorman, Sabratha, and Tripoli, data were collected using a structured and validated questionnaire covering training, administrative supervision, technical equipment status, and patient protection measures. **Result:** The findings reveal critical systemic gaps in the radiation protection framework. Statistical analysis indicates that 89.7% of X-ray units operate without periodic calibration, while 82.4% of departments lack regular quality control programs. Regarding professional competence, 70.6% of personnel had not received specialized periodic training, and a significant deficiency in patient protection was observed, with 64.7% of respondents reporting the absence of shielding for sensitive areas during exposure. These results correlate with a lack of administrative oversight, as 69.2% of departments operate without direct supervision from a radiation protection officer. **Conclusion:** The study concludes that the current state of radiation safety in the surveyed Libyan hospitals necessitates an urgent national regulatory strategy. Key recommendations center on mandatory equipment calibration, continuous professional education, and the empowerment of Radiation Protection Officers to ensure a safe environment for both healthcare workers and patients.

Keywords: Radiation safety; healthcare quality; compliance challenges; Libya

Introduction

The discovery of X-rays by Wilhelm Conrad Röntgen over a century ago marked a pivotal turning point in medical history, laying the foundation for modern diagnostic radiology [1]. Since then, the continuous innovation process in medical imaging has revolutionized the way clinicians diagnose and manage diseases [2]. However, this rapid technological expansion has led to a significant overall increase in radiation exposure from medical imaging, serving as a global "wake-up call" to re-evaluate radiation safety and protection measures [3].

A central debate in radiological protection concerns the biological risks associated with low-dose radiation. While the Linear No-Threshold (LNT) theory has traditionally been the standard for safety protocols, some researchers argue it is time to move beyond this model for low-dose protection [4], citing historical and methodological concerns regarding its adoption [5]. Conversely, others

maintain that separating fact from fantasy in radiation risks is essential, as even low doses of ionizing radiation are attributable to measurable cancer risks [6, 7]. For many experts, despite the complexities, linearity remains the most practical and prudent approach for safety guidelines [8]. Effective patient dose management requires a shift toward practical actions and a robust safety culture [9]. Joint initiatives by international bodies, such as the European Society of Radiology (ESR) and the European Federation of Radiographer Societies (EFRS), emphasize that patient safety is a collective responsibility involving both technological and administrative strategies [10]. Central to this is the principle of justification, ensuring that each radiographic examination is necessary and provides a net benefit to the patient [11, 12]. However, studies indicate a persistent gap in patient awareness regarding radiation exposure, which underscores the need for better communication and education [13]. This lack of awareness is not limited to patients; variations in radiation awareness





have also been documented among dentists, radiographers, and students [14]. To address these challenges, international organizations have established rigorous frameworks for safety. The International Commission on Radiological Protection (ICRP) Publication 103 provides the fundamental recommendations for justification, optimization, and dose limitation [15], which are further operationalized by the International Atomic Energy Agency (IAEA) in its Basic Safety Standards [16]. Empirical studies in developing regions, such as Ghana, have highlighted that while knowledge may be high, practical adherence—such as the consistent use of dosimeters—often remains unsatisfactory [17]. Regionally, surveys in countries like Syria have emphasized the importance of establishing diagnostic reference levels to manage and monitor patient doses effectively [18]. Furthermore, advanced safety codes, such as Canada's recently updated Safety Code 35 (2024), provide detailed procedures for equipment installation and control to ensure a safe clinical environment [19].

In the context of the Libyan healthcare system, identifying gaps in the implementation of these international standards is crucial. This study aims to provide a comprehensive assessment of radiation protection practices and administrative compliance in selected Libyan hospitals, offering evidence-based insights to enhance radiological safety for both patients and healthcare providers.

Theoretical Background and Literature Review

General Principles of Radiation Safety

The clinical application of ionizing radiation is governed by fundamental physical laws and protective protocols designed to minimize occupational and public exposure.

- **Distance and the Inverse Square Law:** Increasing the distance from the radiation source is one of the most effective methods for dose reduction. According to the inverse square law, the intensity of radiation exposure is inversely proportional to the square of the distance from the source. Consequently, doubling the distance reduces the exposure to one-quarter of its original value. In practice, operators should remain inside a protective control booth behind a leaded screen or maintain a minimum distance of 6 feet from the source during exposure [1, 15].
- **Use of Protective Barriers:** Structural and personal shielding are essential to attenuate scattered radiation. Personal protective equipment (PPE), such as lead aprons, must have a minimum lead equivalence of 0.25 mm. For specialized protection, lead gloves and goggles with at least 0.33 mm lead equivalence are recommended [1, 19]. Furthermore, radiology rooms must be lined with appropriate lead shielding to prevent radiation leakage to adjacent areas.

- **Radiation Monitoring Devices:** Systematic monitoring of occupational exposure is mandatory. Radiation workers must wear personal dosimeters, such as film badges or TLDs, positioned at the waist and neckline to assess whole-body and head/neck exposure, respectively [16, 19].
- **Personnel Considerations:** Due to heightened biological sensitivity, specific administrative exclusions apply. Individuals under 18 years of age and pregnant personnel are generally excluded from radiographic duties to mitigate potential developmental or teratogenic risks [15, 16].

Literature Review

Global literature underscores significant regional variations in adherence to radiation safety mandates. In Egypt, studies reveal a complex picture of moderate compliance but critical gaps. For instance, one assessment in a radiology department found overall compliance at 57.4%, with environmental protection practices (75.1%) and patient protection (60.4%) being higher than self-protection (45.7%) [20]. More concerning, a study at Cairo University Hospitals reported that only 5.6% of radiographers consistently used personal dosimeters, and just 6.7% wore intact lead aprons, indicating a serious disconnect between knowledge and practice [21].

In Palestine, research highlights significant deficiencies in both knowledge and implementation. A recent evaluation found that radiographers had a low mean knowledge score of only 7.20 out of 17, with 40.5% reporting they rarely received any radiation safety training and 27% having never received any training at all [22]. Another study focusing on intensive care unit staff during portable radiography revealed an average knowledge level of just 56%. Furthermore, dangerous practices were common: 56.3% admitted to leaving the department during exposures, up to 73.9% never used basic personal protective equipment, and 72.5% had never attended a radiation protection course [23].

In Nepal, while awareness appears moderate, practical application remains limited. A survey of radiographers and technologists found that only 46.7% had attended any radiation safety classes or seminars, and a mere 8.7% reported using dosimeters [24]. Another medical college-based study reported an average knowledge level of 68.57% among professionals, which dropped to 55.42% among diploma graduates. The study strongly recommended the establishment of national radiation protection laws and regulations, which are currently lacking [25]. In contrast, advanced healthcare systems in Europe, the United States, and Australia have emphasized the role of standardized, mandatory training programs and regular audits in maintaining high safety standards [10, 12]. Recent updates, such as the 2024 Canadian Safety Code 35, reinforce that technical maintenance and administrative



supervision are inseparable from professional practice in achieving optimal protection [19]. These international findings provide a benchmark for assessing the current state of radiation safety in Libya, where local systemic challenges may influence the effectiveness of these universal principles. Similar to findings from Ghana [17], a persistent gap between theoretical knowledge and practical adherence appears to be a common challenge across many developing nations.

Material and Method

Study Design

A descriptive, cross-sectional study was employed to evaluate the level of adherence to radiation protection protocols among radiology professionals. This design was selected for its efficacy in quantifying compliance levels and identifying professional practices within a specific timeframe across multiple clinical settings.

Study Settings and Participants

The study was conducted across a network of six healthcare institutions situated in four major cities in Libya: Zawia (Zawia Hospital), Sorman (Sorman Hospital), Sabratha (Sabratha Hospital), and Tripoli (Trauma Aboslim Hospital, Tripoli Central Hospital, and Tripoli Medical Central Hospital). The study population specifically targeted radiology technicians, as they represent the primary personnel responsible for implementing safety measures during diagnostic imaging. Participants provided informed consent, and the study was conducted in accordance with institutional ethical guidelines.

Data Collection Instrument and Procedures

The data collection phase was executed over a one-month duration, spanning from July 1, 2022, to August 1, 2022. The primary research instrument was a structured questionnaire, meticulously designed to assess the multifaceted aspects of adherence to radiation protection practices. This instrument facilitated the systematic gathering of data regarding professional conduct and safety compliance among the participants.

Sample Characteristics

A total of 68 radiology technicians successfully completed the questionnaire. This sample represents the active workforce involved in radiological procedures within the selected hospitals during the study period, providing a foundation for the subsequent analysis of safety adherence in these facilities.

Results

Communication and Training

The assessment of institutional support and professional development revealed significant gaps in specialized training. As illustrated in Figure 1, only 29.4% of the surveyed radiology technicians reported receiving both initial and periodic training in radiation protection, while the vast majority (70.6%) indicated a lack of such essential training. Regarding the technical oversight, 50% of respondents perceived the Radiation Protection Officer (RPO) as having sufficient knowledge of radiological safety concepts, suggesting a balanced but improvable level of expert supervision within the facilities.

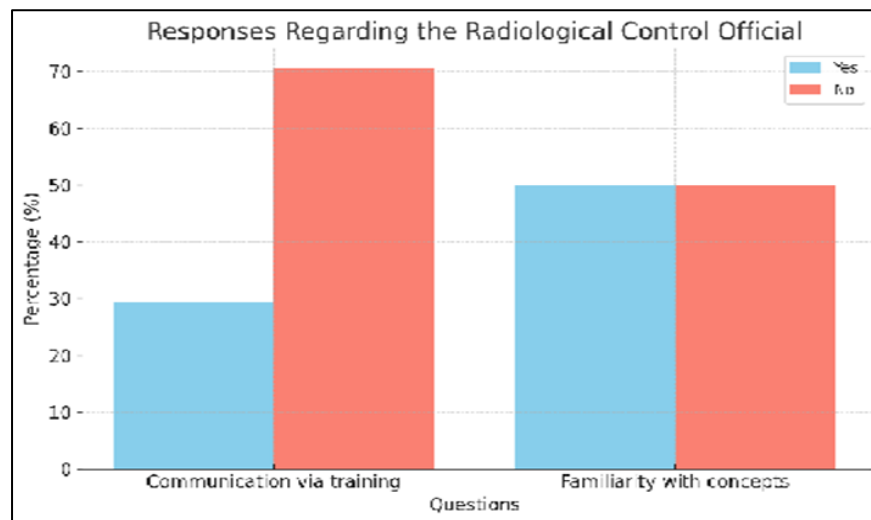


Figure 1: Staff Training Status versus Perceived Competence of the Radiological Control Official.



Warning Signs and Risk Communication

The presence of visual safety cues and risk communication tools was evaluated to determine the level of environmental safety. According to Figure 2, only 33.8% of respondents confirmed the presence of radiation warning signs in clear and prominent locations, whereas

66.2% reported their absence. Furthermore, the availability of specialized warning signs specifically targeting vulnerable groups, such as pregnant women and children, was reported by 48.5% of the participants, leaving more than half of the departments (51.5%) without these critical safety notices.

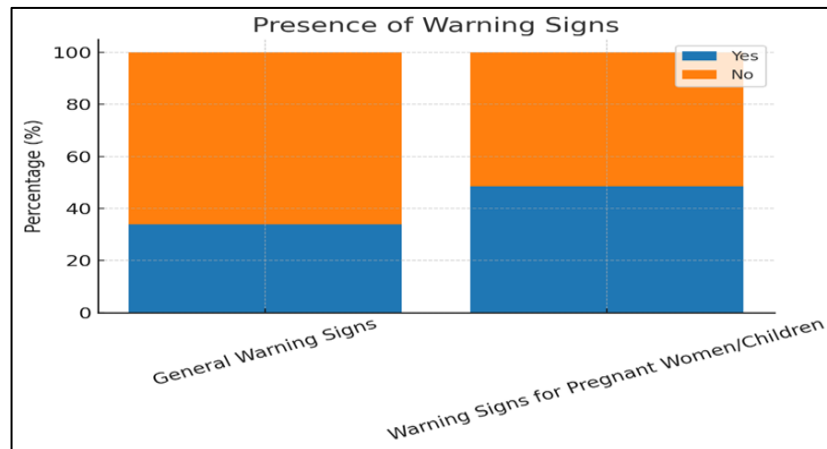


Figure 2: Assessment of General and Specialized Radiation Warning

Local Rules and Administrative Supervision

The results regarding regulatory adherence and administrative oversight are presented in Figure 3. Administrative supervision from both the facility management and the prevention officer was reported by only 30.8% of the staff, indicating that 69.2% operate with

minimal direct safety oversight. While 50% of the respondents noted that local radiation protection rules were documented in an understandable language, only 23.5% reported active supervision specifically aimed at ensuring strict adherence to these established procedures.

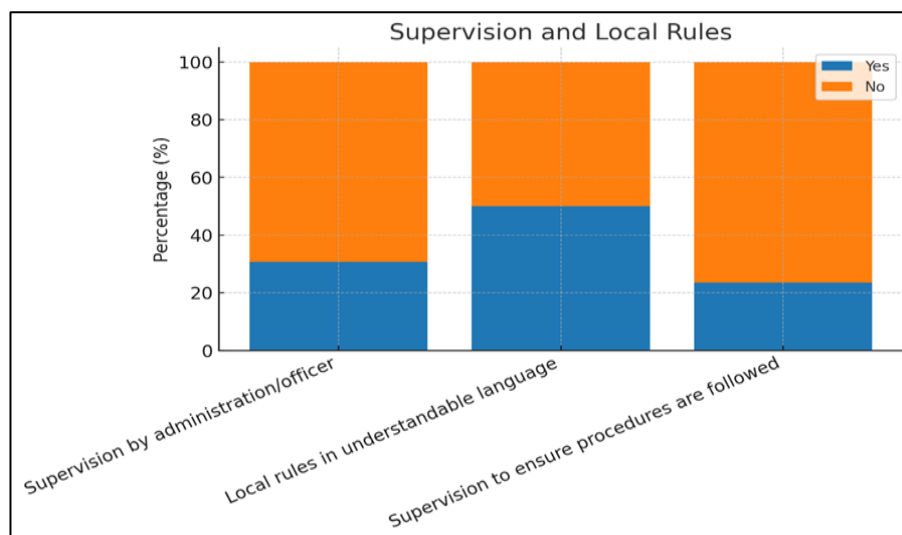


Figure 3: Implementation of Local Safety Rules and Level of Administrative



Equipment Calibration and Quality Control (QC)

A critical finding of this study pertains to the technical maintenance of radiological equipment. As shown in Figure 4, an overwhelming 89.7% of the respondents indicated that X-ray devices were not subjected to periodic

calibration. Consistent with this lack of maintenance, 82.4% of the technicians reported the absence of a systematic periodic quality control (QC) program, which is a fundamental requirement for ensuring dose optimization and diagnostic accuracy.

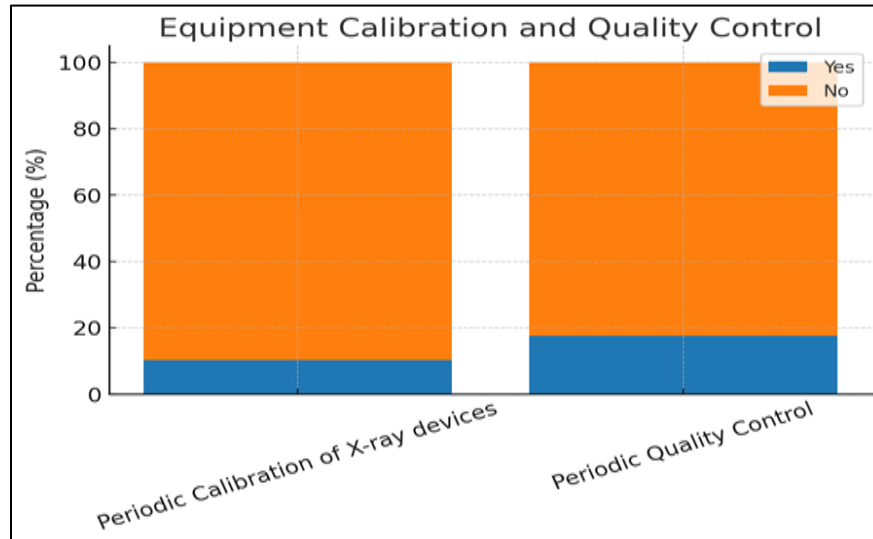


Figure 4: Technical Compliance Status Regarding Equipment Calibration and Quality Control.

Medical Exposure Practices

Professional practices during medical exposure were documented in Figure 5. The findings show that 61.8% of radiographic procedures were conducted upon the explicit request of a specialized practicing physician. Concerning the clinical environment, 66.2% of respondents noted the

presence of unauthorized or unnecessary employees during medical exposures. On a positive note, 85.3% of the technicians reported that the radiation field was strictly limited to the specific examination area. However, a significant safety deficit was identified in patient protection, with 64.7% of the participants reporting a total absence of radiation shields for protecting sensitive organs in patients.

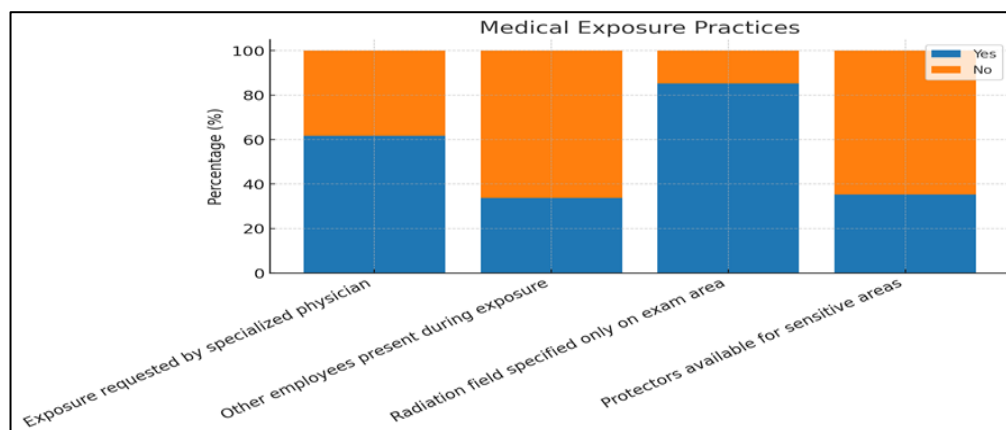


Figure 5: Evaluation of Clinical Practices and Safety Measures during Medical Exposure.



Statistical Analysis of Adherence Levels

To provide a comprehensive overview of the safety landscape across the surveyed hospitals, descriptive statistics were employed to quantify the levels of adherence to various radiation protection practices. Table 1 summarizes the respondents' reports, categorized by key safety variables.

The data highlights a critical disparity between procedural knowledge and technical execution. While clinical justification—represented by exposure at the request of a specialized physician (61.8%) and field collimation (85.3%)—showed relatively higher adherence, technical maintenance variables such as periodic calibration and quality control exhibited the lowest compliance rates at 10.3% and 17.6%, respectively.

Table 1: Descriptive Statistics of Respondents' Adherence to Radiation Protection Practices (N = 68).

Training & Knowledge		
Initial and Periodic Training	29.4	70.6
Knowledge of Radiation Protection Concepts	50.0	50.0
Environmental Safety		
Presence of Warning Signs	33.8	66.2
Specific Warning Signs (Pregnant Women & Children)	48.5	51.5
Administrative Oversight		
Supervision from Administration & Prevention Officer	30.8	69.2
Understandable Local Rules	50.0	50.0
Supervision to Ensure Adherence to Procedures	23.5	76.5
Technical Maintenance		
Periodic Calibration of X-ray Devices	10.3	89.7
Periodic Quality Control	17.6	82.4
Clinical Practices		
Exposure at Request of Specialized Physician	61.8	38.2
Presence of Other Employees During Medical Exposure	33.8	66.2
Specification of Radioactive Field	85.3	14.7
Availability of Radiation Shields for Sensitive Areas	35.3	64.7
Note: For the variable "Presence of Other Employees," the table reflects the adherence to safety (i.e., 33.8% reported proper practice/absence of others, while 66.2% reported the presence of unauthorized personnel).		

Inferential Statistics

To further evaluate the significance of the observed frequencies and identify critical areas of non-compliance, Chi-square tests were conducted. The inferential analysis aimed to determine whether the disparities in adherence levels across the surveyed hospitals were statistically significant.

The results of the Chi-square analysis revealed significant gaps in several key domains of radiation protection:

- Professional Development: A statistically significant lack of initial and periodic training among the technical staff.
- Hazard Communication: Significant deficiencies in the placement of mandatory warning signage and specialized notices for vulnerable populations.
- Regulatory Oversight: A significant disconnect between the existence of local rules and the actual administrative supervision required to ensure procedural adherence.

- Technical Compliance: The most critical significant gap was identified in equipment maintenance, specifically regarding the lack of periodic calibration and systematic quality control programs.

These inferential findings confirm that the observed low levels of adherence are not random but represent systemic failures in the radiological safety frameworks within the targeted healthcare facilities.

Discussion

The findings of this study identify critical systemic gaps in radiation protection practices within the surveyed Libyan hospitals. A primary concern is the significant deficiency in professional development; with only 29.4% of respondents receiving periodic training, a clear risk of technical obsolescence and safety non-compliance emerges. This is consistent with findings in Palestine [22]



and Nepal [24], where limited access to specialized training was cited as a major barrier to safety adherence. The disconnect between knowledge and practice is further exemplified by the fact that while 50% of respondents recognized the expertise of the Radiation Protection Officer (RPO), actual administrative supervision to ensure procedural adherence was reported at only 23.5%. This lack of oversight correlates with the high presence of unauthorized personnel during exposures (66.2%), a practice that directly contradicts international safety standards established by the IAEA [16] and the ICRP [15]. Similar disconnects have been documented in Egypt [21] and Ghana [17], where theoretical awareness often fails to translate into clinical practice due to inadequate supervision.

Furthermore, the study highlights a severe deficit in technical maintenance and environmental safety. The overwhelming lack of periodic equipment calibration (89.7%) and quality control programs (82.4%) represents a critical failure in dose optimization. Without regular calibration, as emphasized in Canada's Safety Code 35 [19], the risk of unnecessary radiation dose to both patients and staff increases significantly. This technical negligence, coupled with the absence of specialized warning signs for vulnerable groups (51.5%) and the lack of sensitive organ shielding (64.7%), underscores an urgent need for a robust national regulatory framework and institutional safety culture.

Conclusion

This study provides a comprehensive assessment of the radiation protection landscape within several key Libyan hospitals, revealing a critical state of adherence that warrants immediate attention. The findings indicate that radiation safety practices are currently hindered by a significant systemic disconnect; while there is a foundational awareness of some clinical protocols—such as physician-led justification (61.8%) and radioactive field specification (85.3%)—the core pillars of a robust safety culture are largely absent.

The evidence suggests that the primary drivers of this non-compliance are twofold: administrative and technical. Administratively, the acute deficiency in periodic training (70.6%) and the lack of active supervision (76.5%) to ensure procedural adherence create an environment where unsafe practices, such as the unauthorized presence of personnel during exposures, become prevalent.

References

1. Panchbhai AS. Wilhelm Conrad Röntgen and the discovery of X-rays: revisited after centennial. *J Indian Acad Oral Med Radiol.* 2015;27(3):390–

Technically, the near-total absence of periodic equipment calibration (89.7%) and quality control measures (82.4%) poses a direct threat to the principle of optimization, potentially leading to inconsistent diagnostic quality and unnecessary radiation doses.

Furthermore, the environmental safety of these facilities is compromised by the lack of adequate risk communication tools, specifically the absence of prominent warning signs and specialized notices for vulnerable populations like pregnant women and children. In summary, the significant gaps identified in this research highlight that radiation protection in the surveyed hospitals is currently reactive rather than proactive. To ensure the long-term safety and well-being of both the healthcare workforce and the patient population, it is imperative to transition toward a structured safety framework that integrates continuous professional education with rigorous technical maintenance and administrative oversight.

Recommendations

To enhance radiation protection practices in Libyan hospitals and align them with international standards, the following measures are recommended:

- Institutional Awareness: Implement comprehensive programs to increase awareness of radiation protection among all hospital personnel, particularly those in high-traffic diagnostic areas.
- Mandatory Training: Establish mandatory, periodic training sessions for radiology technicians to ensure they remain updated on the latest safety protocols and biological risk mitigation strategies.
- Strengthening Supervision: Empower Radiation Protection Officers (RPOs) and hospital administrations to conduct regular, active supervision to ensure strict adherence to local and international safety procedures.
- Technical Quality Assurance: Implement rigorous schedules for the regular maintenance, periodic calibration, and quality control of all X-ray equipment to ensure diagnostic accuracy and dose optimization.
- Establishing a centralized national radiation metrology laboratory to facilitate periodic calibration services for public hospitals.

Conflict of Interest

The authors declare no conflict of interest.

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395.<https://doi.org/10.4103/0972-1363.167119>

2. Laal J. Innovation process in medical imaging. *Procedia Soc Behav Sci.* 2013;81:60–64.



- <https://doi.org/10.1016/j.sbspro.2013.06.388>
3. Al-Lamki L. Radiation exposure from medical imaging: a wake-up call for oman!. Sultan Qaboos University Medical Journal. 2011 Feb 12;11(1):1.
4. Cardarelli JJ, Ulsh BA. It Is Time to Move Beyond the Linear No-Threshold Theory for Low-Dose Radiation Protection. *Dose-Response*. 2018;16(3).<https://doi.org/10.1177/1559325818779651>
5. Calabrese EJ. The Mistaken Birth and Adoption of LNT: An Abridged Version. *Dose-Response*. 2017;15(4).<https://doi.org/10.1177/1559325817735478>
6. Hendee WR, O'Connor MK. Radiation risks of medical imaging: separating fact from fantasy. *Radiology*. 2012;264(2):312–321.<https://doi.org/10.1148/radiol.12112678>
7. Brenner DJ, Doll R, Goodhead DT, et al. Cancer risks attributable to low doses of ionizing radiation: assessing what we really know. *Proc Natl Acad Sci U S A*. 2003;100(24):13761–13766.
<https://doi.org/10.1073/pnas.2235592100>
8. Little MP, Wakeford R, Tawn EJ, Bouffler SD, de Gonzalez AB. Risks associated with low doses and low dose rates of ionizing radiation: why linearity may be (almost) the best we can do. *Radiology*. 2009;251(1):6–12.<https://doi.org/10.1148/radiol.2511081686>
9. Park MY, Jung SE. Patient dose management: focus on practical actions. *J Korean Med Sci*. 2016;31(Suppl 1):S45–S54.<https://doi.org/10.3346/jkms.2016.31.S1.S45>
10. European Society of Radiology, European Federation of Radiographer Societies (EFRS). Patient safety in medical imaging: a joint paper of the European Society of Radiology (ESR) and the European Federation of Radiographer Societies (EFRS). *Insights Imaging*. 2019;10(1):45.<https://doi.org/10.1186/s13244-019-0721-y>
11. Malone J, Guleria R, Craven C, et al. Justification of diagnostic medical exposures: some practical issues. Report of an International Atomic Energy Agency consultation. *Br J Radiol*. 2012;85(1013):523–538.<https://doi.org/10.1259/bjr/42893576>
12. Vom J, Williams I. Justification of radiographic examinations: what are the key issues? *J Med Radiat Sci*. 2017;64(3):212–219. <https://doi.org/10.1002/jmrs.211>
13. Ribeiro A, Husson O, Drey N, et al. Ionising radiation exposure from medical imaging – a review of patients' (un)awareness. *Radiography*. 2020;26(2):E25–E30.
<https://doi.org/10.1016/j.radi.2019.10.002>
14. Furmaniak KZ, Kołodziejska MA, Szopiński KT. Radiation awareness among dentists, radiographers and students. *Dentomaxillofac Radiol*. 2016;45(8):20160097.
<https://doi.org/10.1259/dmfr.20160097>
15. International Commission on Radiological Protection (ICRP). The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. 2007.<https://www.icrp.org/publication.asp?id=ICRP%20Publication%20103>
16. International Atomic Energy Agency (IAEA). Radiation protection and safety of radiation sources: international basic safety standards. GSR Part 3. Vienna: IAEA; 2014.
<https://www.iaea.org/publications/8930/radiation-protection-and-safety-of-radiation-sources-international-basic-safety-standards>
17. Fiagbedzi E, Gorleku PN, Nyarko S, Asare A, Ndede GA. Assessment of radiation protection knowledge and practices among radiographers in the central region of Ghana. *J Radiat Res Appl Sci*. 2022;15(4):396–402.
<https://doi.org/10.1016/j.radmp.2022.06.001>
18. Kharita MH, Khedr MS, Wannus KM. Survey of patient doses from conventional diagnostic radiographic examinations in Syria. *Radiat Prot Dosimetry*. 2010;140(2):163–165. <https://doi.org/10.1093/rpd/ncq106>
19. Health Canada. Safety procedures for the installation, use and control of X-ray equipment in large medical facilities. Safety Code 35. 2024 Jul.
<https://www.canada.ca/en/health-canada/services/publications/health-system-administration/safety-code-35.html>
20. Abuzaid MM, Elshami W, Shawki M, Salama D. Assessment of compliance to radiation safety and protection at the radiology department. *Int J Radiat Res*. 2019;17(3):439–446.
<https://doi.org/10.18869/acadpub.ijrr.17.3.439>
21. Mohammed RH, Abdou NM, Farahat SA, Seif EM. Ionizing radiation hazards and protection practices among radiographers at Cairo University Hospitals. Cairo: Cairo University; 2017.
22. Khalilia WM. Evaluation of radiographers knowledge about radiation safety and cancer risks of ionizing radiation exposure. *Am J Med Sci Pharm Res*. 2025;7(1):6–14.
<https://doi.org/10.37547/tajmspr/Volume07Issue01-02>
23. Juha EIE. Assessment of knowledge and practices of intensive care unit staff of radiation protection during portable radiography in the city of Bethlehem and East Jerusalem, Palestine [master's thesis]. Jerusalem: Al-Quds University; 2023.
24. Sharma BR, Singh S, Mandal S, Poudel N. Knowledge of radiation exposure and its risk among radiographers and radio technologists. *J Gandaki Med Coll Nepal*. 2019;12:17–22.<https://doi.org/10.3126/jgmcn.v12i2.27152>
25. Maharjan S, Parajuli K, Sah S, Poudel U. Knowledge of radiation protection among radiology professionals and students: a medical college-based study. *Eur J Radiol Open*. 2020;7:100287.<https://doi.org/10.1016/j.ejro.2020.100287>