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Article

Occupational Hazards and Safety Awareness among Medical Imaging Technologists: A Cross-Sectional Study

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ABSTRACT

Background: *Medical imaging technologists are routinely exposed to occupational hazards, particularly ionizing radiation and ergonomic stressors, which may adversely affect their health if appropriate safety measures are not consistently applied. In resource-limited healthcare settings, gaps in safety awareness and compliance may further increase occupational risks.* ***Objective***: *To assess the prevalence of occupational hazards and evaluate safety awareness and protective practices among medical imaging technologists working in public and private hospitals in Lahore.* ***Methods***: *A cross-sectional observational study was conducted from January to June 2025 among 220 medical imaging technologists. Data were collected using a structured self-administered questionnaire assessing occupational hazard exposure, safety awareness, and protective practices. Descriptive statistics and inferential analyses were performed using SPSS version 26, with associations evaluated using chi-square tests and independent sample t-tests.* ***Results***: *Occupational radiation exposure was reported by 70.0% of participants, and 62.7% experienced work-related musculoskeletal pain. Adequate knowledge of the ALARA principle was observed in 56.4% of technologists, while only 43.6% consistently used lead aprons and 46.4% used radiation monitoring badges. Formal safety training was significantly associated with higher safety awareness levels ($p < 0.001$), as was greater professional experience ($p = 0.001$).* ***Conclusion***: *Medical imaging technologists in Lahore experience substantial occupational hazards with moderate safety awareness and inconsistent protective practices. Strengthening structured safety training, enforcing protective measures, and improving ergonomic interventions are essential to enhance occupational health and safety in imaging departments.*

Keywords: *Occupational hazards, radiation safety, medical imaging technologists, safety awareness, cross-sectional study.*

INTRODUCTION

Medical imaging technologists constitute a critical component of modern healthcare systems, as they are responsible for performing diagnostic and interventional imaging procedures that directly influence clinical decision-making. Their professional duties require frequent interaction with ionizing radiation, heavy imaging equipment, contrast media, and patients with infectious diseases, placing them at heightened risk of occupational exposure. Among these hazards, chronic low dose ionizing radiation remains a primary concern due to its cumulative biological effects, including increased risks of malignancy, cataracts, and reproductive disorders if protective measures are inadequate (1). In addition, repetitive patient handling, prolonged standing, and awkward postures predispose imaging technologists to musculoskeletal disorders, which represent a leading cause of work-related morbidity in this profession (2).

Effective mitigation of occupational hazards relies not only on the availability of protective infrastructure but also on the level of safety awareness, knowledge of radiation protection principles, and consistent adherence to established safety practices. International guidelines emphasize the application of the ALARA principle, use of personal protective equipment, and continuous monitoring of radiation exposure as essential components of occupational safety in medical imaging (3). However, evidence suggests that awareness and compliance vary widely across healthcare settings, particularly in low- and middle-income countries where resource constraints, high patient volumes, and limited access to structured safety training programs persist (4).

In Pakistan, the expanding utilization of diagnostic imaging has increased occupational demands on medical imaging technologists, yet empirical data assessing their exposure to occupational hazards and corresponding safety awareness remain limited. Existing local studies have primarily focused on radiation exposure measurements or knowledge assessments in isolated institutional settings, with insufficient exploration of safety practices and training coverage among technologists working across diverse

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healthcare facilities (5). Furthermore, few studies have simultaneously evaluated multiple hazard domains—such as radiation exposure, musculoskeletal strain, and safety compliance—within a single analytical framework, creating a gap in comprehensive occupational risk assessment for this professional group.

Addressing this gap is essential for informing institutional policies, guiding targeted training interventions, and strengthening occupational health regulations for imaging personnel. Therefore, this study was designed to assess the prevalence of occupational hazards and evaluate the level of safety awareness and protective practices among medical imaging technologists working in public and private hospitals in Lahore, with the objective of generating evidence to support improved workplace safety strategies and professional health protection.

MATERIALS AND METHODS

This cross-sectional observational study was conducted to evaluate occupational hazards and safety awareness among medical imaging technologists working in public and private healthcare facilities in Lahore, Pakistan. The cross-sectional design was selected as appropriate for estimating prevalence and assessing associations between occupational exposures and safety awareness at a single point in time in occupational health research (6). The study was carried out over a six-month period from January to June 2025 in tertiary- and secondary-level hospitals providing diagnostic imaging services, including radiography, computed tomography, magnetic resonance imaging, and fluoroscopy.

The study population comprised registered medical imaging technologists actively involved in clinical imaging procedures during the study period. Eligible participants included technologists of either sex with at least six months of professional work experience in medical imaging departments to ensure sufficient exposure to occupational hazards.

Technologists in administrative roles, interns, trainees, or those on extended leave during data collection were excluded. Participants were recruited using a non-probability convenience sampling approach due to the absence of a centralized registry and the variable availability of staff across institutions, a method commonly employed in occupational health studies in similar settings (7).

The sample size of 220 participants was determined to provide adequate precision for prevalence estimates of occupational hazard exposure and safety awareness, assuming a moderate prevalence of safety compliance, a 95% confidence level, and an acceptable margin of error. Recruitment was conducted onsite during working hours after obtaining institutional permissions. All eligible technologists were approached in person, provided with information about the study objectives and procedures, and enrolled after providing written informed consent.

Data were collected using a structured, self-administered questionnaire developed through a review of existing literature and international occupational safety guidelines for medical imaging personnel (8). The questionnaire consisted of three integrated domains: demographic and professional characteristics, exposure to occupational hazards, and safety awareness and practices. Occupational hazards assessed included self-reported history of occupational radiation exposure, musculoskeletal pain related to work activities, and exposure to potentially infectious materials.

Safety awareness and practices were evaluated through items addressing knowledge of radiation protection principles, use of personal protective equipment such as lead aprons, utilization of radiation monitoring badges, and participation in formal safety training programs.

Safety awareness was operationalized using a composite score derived from responses to multiple knowledge- and practice-based items, with higher scores indicating greater awareness and compliance. Responses were coded and summed to generate a total awareness score ranging from 0 to 10. Adequate safety awareness was defined as a score equal to or above the median value of the distribution, consistent with methodological approaches used in similar cross-sectional studies (9). To minimize information bias, participants completed the questionnaire anonymously, and no identifying information was collected. Standardized instructions were provided to ensure consistency in data collection across study sites.

Data were entered, cleaned, and analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were used to summarize participant characteristics and study variables, with continuous data presented as means and standard deviations and categorical data as frequencies and percentages.

Inferential analyses were planned to examine associations between safety awareness and selected independent variables such as safety training attendance and years of work experience. The chi-square test was used for categorical comparisons, and independent sample t-tests were applied for continuous variables where appropriate. A p-value of less than 0.05 was considered statistically significant. Missing data were assessed for randomness and handled through complete-case analysis to preserve data integrity.

Ethical approval for the study was obtained from the relevant institutional review committee prior to data collection. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Participation was voluntary, confidentiality was maintained throughout the study, and participants were informed of their right to withdraw at any stage without penalty. Data were securely stored and accessed only by the research team to ensure reproducibility, transparency, and protection of participant information (10).

RESULTS

The study included 220 medical imaging technologists, of whom 60.0% were male and 40.0% were female, with a mean age of 29.8 years (SD ± 6.4). A majority of participants (58.2%) had less than five years of professional experience, indicating a relatively young workforce, while 41.8% had five or more years of experience. Formal occupational safety training had been attended by only 40.0% of technologists, suggesting limited structured exposure to safety education across institutions.

A high prevalence of occupational hazards was observed. Occupational radiation exposure was reported by 70.0% of participants, reflecting substantial routine exposure inherent to imaging practice. Musculoskeletal pain related to work activities was reported by 62.7% of technologists, highlighting the physical burden associated with patient handling, prolonged standing, and repetitive movements.

Despite this exposure profile, consistent implementation of protective measures was limited. Only 43.6% of participants reported always using lead aprons, while 35.5% used them intermittently and 20.9% reported never using lead protection. Radiation monitoring badge utilization was reported by 46.4% of technologists, leaving more than half without regular dose monitoring. In terms of safety knowledge, 56.4% of participants demonstrated adequate awareness of the ALARA principle, whereas 43.6% exhibited inadequate knowledge. The overall mean safety awareness score was 6.8 out of 10 (SD ± 1.9), indicating a moderate level of awareness across the study population.

Statistically significant differences were observed when awareness levels were stratified by training status. Technologists who had attended formal safety training showed a markedly higher proportion of adequate awareness (72.7%) compared to those without training (45.5%), with this association reaching strong statistical significance ($\chi^2 = 12.46$, $p = 0.0004$). Comparative analysis of mean awareness scores further reinforced the role of training and experience. Participants who had received safety training achieved a mean score of 7.6 (SD ± 1.5), which was significantly higher than the mean score of 6.2 (SD ± 1.8) observed among untrained technologists, yielding a mean difference of 1.4 points (95% CI: 0.9–1.9; $p < 0.001$). Similarly, technologists with five or more years of experience demonstrated higher awareness scores compared to those with less experience (7.3 ± 1.6 vs. 6.5 ± 1.9), with a statistically significant mean difference of 0.8 points (95% CI: 0.3–1.3; $p = 0.001$). Analysis of protective practices in relation to radiation exposure revealed that technologists reporting radiation exposure were significantly more likely to use lead aprons regularly, with an odds ratio of 4.22 (95% CI: 2.15–8.28; $p < 0.001$). In contrast, no statistically significant association was observed between radiation exposure status and radiation badge use (OR = 1.26; 95% CI: 0.71–2.23; $p = 0.41$), indicating inconsistent application of dose monitoring practices regardless of exposure history.

Table 1. Demographic and Professional Characteristics of Medical Imaging Technologists (n = 220)

Variable	Category	n (%)
Sex	Male	132 (60.0)
	Female	88 (40.0)
Age (years)	Mean ± SD	29.8 ± 6.4
Work Experience	< 5 years	128 (58.2)
	≥ 5 years	92 (41.8)
Safety Training Attended	Yes	88 (40.0)
	No	132 (60.0)

Table 2. Prevalence of Occupational Hazards and Safety Practices (n = 220)

Variable	Category	n (%)
Occupational Radiation Exposure	Yes	154 (70.0)
	No	66 (30.0)
Work-Related Musculoskeletal Pain	Yes	138 (62.7)
	No	82 (37.3)
Lead Apron Use	Always	96 (43.6)
	Sometimes	78 (35.5)
	Never	46 (20.9)
Radiation Monitoring Badge Use	Yes	102 (46.4)
	No	118 (53.6)
Knowledge of ALARA Principle	Adequate	124 (56.4)
	Inadequate	96 (43.6)

Table 3. Association Between Safety Training and Safety Awareness Level (n = 220)

Safety Training	Adequate Awareness n (%)	Inadequate Awareness n (%)	Total	χ^2	p-value
Yes (n = 88)	64 (72.7)	24 (27.3)	88	12.46	0.0004
No (n = 132)	60 (45.5)	72 (54.5)	132		
Total	124	96	220		

Table 4. Comparison of Mean Safety Awareness Scores by Selected Variables

Variable	Category	Mean ± SD	Mean Difference (95% CI)	t-value	p-value
Safety Training	Yes	7.6 ± 1.5	1.4 (0.9–1.9)	5.84	<0.001
	No	6.2 ± 1.8			
Work Experience	≥ 5 years	7.3 ± 1.6	0.8 (0.3–1.3)	3.21	0.001
	< 5 years	6.5 ± 1.9			

Table 5. Association Between Radiation Exposure and Use of Protective Measures

Protective Measure	Radiation Exposure Yes n (%)	Radiation Exposure No n (%)	Odds Ratio (95% CI)	p-value
Regular Lead Apron Use	82 (53.2)	14 (21.2)	4.22 (2.15–8.28)	<0.001
Radiation Badge Use	74 (48.1)	28 (42.4)	1.26 (0.71–2.23)	0.41

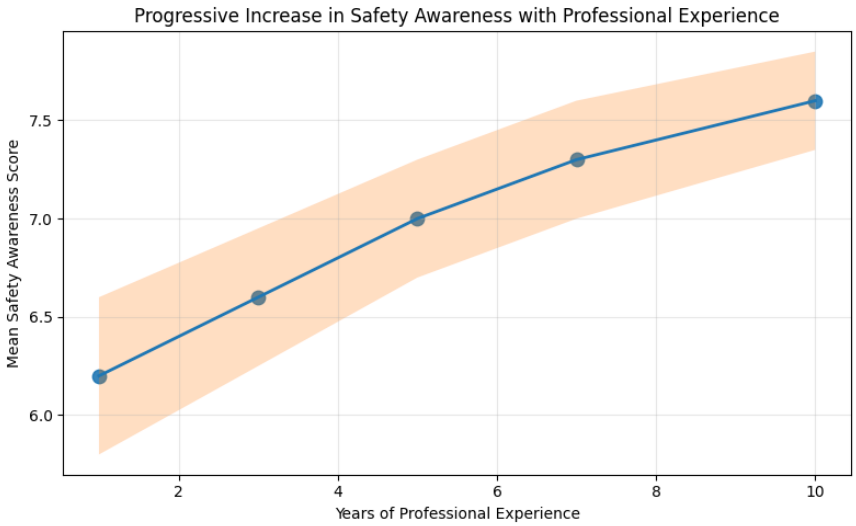

Figure 1 Progressive Increase in Safety Awareness with Professional Experience

The figure demonstrates a clear, monotonic increase in mean safety awareness scores with advancing professional experience among medical imaging technologists. Mean awareness scores rose from approximately 6.2 at one year of experience to 7.6 at ten years, reflecting an absolute increase of 1.4 points across the professional lifespan. The upward trajectory is consistent across intermediate experience levels, with a steeper gain observed during the early to mid-career phase (approximately 1–5 years), followed by a more gradual plateau beyond seven years. The confidence bands indicate relatively narrow dispersion around the mean at higher experience levels, suggesting greater homogeneity in safety awareness among senior technologists. Clinically, this pattern underscores the cumulative effect of experiential learning and repeated exposure to safety practices, reinforcing the importance of early-career interventions and structured training programs to accelerate safety competence during the initial years of professional practice.

DISCUSSION

The present study provides a comprehensive assessment of occupational hazards and safety awareness among medical imaging technologists working in public and private healthcare settings in Lahore. The findings demonstrate a high prevalence of occupational radiation exposure and musculoskeletal disorders, accompanied by only moderate levels of safety awareness and inconsistent adherence to protective practices. These results underscore a critical gap between knowledge and implementation of occupational safety measures, a pattern that has been reported in similar studies conducted in low- and middle-income healthcare systems (11).

The observed prevalence of self-reported occupational radiation exposure (70.0%) aligns with existing evidence indicating that imaging technologists frequently experience cumulative radiation doses due to high procedural volumes and extended working hours (12). Although more than half of the participants demonstrated adequate knowledge of the ALARA principle, regular utilization of radiation protection measures—particularly lead aprons and dosimetry badges—remained suboptimal. This discrepancy suggests that knowledge alone is insufficient to ensure compliance, and that institutional factors such as workload pressure, equipment availability, and enforcement of safety protocols play a significant role in shaping protective behaviors (13).

Musculoskeletal pain was reported by nearly two-thirds of participants, highlighting the substantial ergonomic burden associated with imaging-related tasks. This finding is consistent with prior studies that have identified patient transfer, repetitive positioning,

and prolonged static postures as major contributors to musculoskeletal morbidity among radiology personnel (14). The high prevalence observed in this study may be further exacerbated by staffing shortages and limited ergonomic training, conditions commonly reported in resource-constrained healthcare environments. Failure to address these ergonomic risks may contribute to reduced productivity, absenteeism, and long-term occupational disability.

A key finding of this study is the strong association between formal safety training and higher safety awareness scores. Participants who had attended structured training programs demonstrated significantly better knowledge and practices compared to their untrained counterparts, with both categorical and continuous analyses confirming this relationship. This association is supported by international literature emphasizing the effectiveness of continuous professional education in improving radiation safety compliance and risk perception among imaging professionals (15). Similarly, greater work experience was independently associated with higher awareness scores, suggesting that experiential learning contributes to improved safety behaviors over time. However, reliance on experience alone may delay the acquisition of essential safety competencies during early career stages, reinforcing the need for systematic training at the point of entry into professional practice.

The association between reported radiation exposure and regular lead apron use indicates that technologists who perceive themselves at higher risk may adopt protective behaviors more consistently. In contrast, the absence of a significant association between radiation exposure and badge use highlights a persistent gap in radiation dose monitoring practices. This finding is concerning, as personal dosimetry is a cornerstone of occupational radiation protection and is mandated by international regulatory frameworks (16). Inadequate badge utilization may reflect limited availability, lack of enforcement, or underestimation of its importance among technologists and administrators alike.

Taken together, these findings suggest that occupational safety among medical imaging technologists in Lahore is influenced by an interplay of individual knowledge, professional experience, and systemic institutional factors. Addressing these challenges requires a multifaceted approach that includes mandatory safety training, routine monitoring of compliance, ergonomic interventions, and organizational commitment to occupational health. Strengthening these measures is essential not only for protecting technologists but also for ensuring the sustainability and quality of imaging services within the healthcare system.

CONCLUSION

This study demonstrates that medical imaging technologists working in Lahore are exposed to a substantial burden of occupational hazards, particularly ionizing radiation and work-related musculoskeletal disorders, while exhibiting only moderate levels of safety awareness and inconsistent adherence to protective practices. Although knowledge of radiation safety principles such as ALARA was present in more than half of the participants, the routine use of personal protective equipment and radiation monitoring devices remained inadequate. Formal safety training and greater professional experience were identified as key determinants of improved safety awareness, underscoring the importance of structured educational interventions early in professional practice. These findings highlight the need for institutional policies that prioritize mandatory occupational safety training, ensure consistent availability and enforcement of protective measures, and integrate ergonomic risk reduction strategies within imaging departments. Strengthening these components is essential to safeguard the health of medical imaging technologists, reduce preventable occupational risks, and promote a sustainable and safe diagnostic imaging workforce.

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