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Original Article

Adherence to Radiation Safety Measures and Its Impact on Self-Reported Occupational Health Problems among Radiology Staff

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ABSTRACT

Background: Radiology personnel may experience occupational radiation exposure alongside ergonomic and psychosocial health risks. Adherence to established safety practices is essential, but its relationship with self-reported occupational health problems remains insufficiently understood. Objective: To assess radiation-safety adherence, self-reported occupational health problems, and the association between these outcomes among radiology staff. Methods: This descriptive analytical cross-sectional study included 96 radiology personnel selected through convenience sampling from public and private hospitals. Participants completed a self-administered questionnaire covering professional characteristics, radiation-safety adherence, and occupational health problems. Descriptive statistics, Cronbach's alpha, independent-samples t-tests, and Pearson and Spearman correlations were calculated using IBM SPSS Statistics version 27.0. Results: Most participants were female (91.7%) and worked in general diagnostic imaging (76.0%). The mean radiation-safety adherence score was 16.97 ± 4.82, and the scale demonstrated acceptable internal consistency ($\alpha = 0.757$). The mean occupational health-problem score was 19.34 ± 4.51, although its internal consistency was weak ($\alpha = 0.573$). Neither radiation-safety adherence ($p = 0.987$) nor occupational health-problem scores ($p = 0.583$) differed significantly by sex. Radiation-safety adherence was moderately and positively correlated with occupational health-problem scores using Pearson analysis ($r = 0.480$, 95% CI: 0.309–0.621; $p < 0.001$) and Spearman analysis ($\rho = 0.501$, 95% CI: 0.334–0.637; $p < 0.001$). Conclusion: Greater reported safety adherence was associated with greater reporting of occupational health problems; however, the cross-sectional design prevents causal interpretation. Keywords: Radiation Safety; Occupational Exposure; Radiology Personnel; Occupational Health; Safety Adherence.

INTRODUCTION

Radiological imaging is an essential component of contemporary healthcare, supporting the diagnosis, treatment planning, and monitoring of a wide range of clinical conditions. Personnel working in radiology departments may be repeatedly exposed to ionising radiation, particularly during general radiography, computed tomography, fluoroscopy, and image-guided interventional procedures. Although occupational exposure is generally maintained within regulated dose limits, repeated exposure remains an important safety concern because ionising radiation can produce cellular and molecular damage, with the probability of stochastic effects increasing as cumulative exposure rises (1,2). Radiology personnel must therefore consistently apply established radiation-protection principles, including justification, optimisation, dose limitation, appropriate distancing, exposure-time reduction, shielding, and personal dose monitoring (2,3).

International radiation-protection standards recommend the routine use of personal protective equipment, individual dosimeters, thyroid shields, lead barriers, and other exposure-control measures where appropriate (2,3). Nevertheless, adherence to these measures varies considerably across healthcare institutions. Studies have shown that radiology personnel may demonstrate satisfactory knowledge of radiation-protection principles while inconsistently applying them during routine clinical practice (4,5). This knowledge–practice gap may be influenced by limited access to protective equipment, insufficient monitoring, weak enforcement of safety policies, inadequate training, high patient volume, staffing shortages, and pressure to complete imaging procedures quickly (4–6).

Professional experience and workplace safety culture may also influence radiation-protection behaviour. Personnel with greater clinical experience may be more familiar with occupational hazards and established safety procedures, whereas less experienced workers may require closer supervision and repeated reinforcement of radiation-protection practices (7,8). However, experience alone may not ensure adherence when organisational systems do not provide adequate equipment, training, monitoring, or accountability. High workloads and time pressure may further encourage personnel to prioritise workflow efficiency over complete compliance with recommended safety procedures (6,9).

Radiology personnel are also exposed to occupational health problems that are not necessarily caused directly by ionising radiation. Prolonged standing, repetitive patient positioning, manual handling, awkward working postures, shift work, screen exposure, and demanding workloads may contribute to musculoskeletal pain, fatigue, headaches, visual discomfort, psychological stress, and burnout (10–13). Concern about cumulative radiation exposure may additionally increase anxiety among workers, even when recorded exposure remains within permissible limits (14). These physical and psychological problems may coexist with radiation-safety concerns and may affect both employee well-being and clinical performance.

Previous research has commonly examined radiation-safety knowledge, protective practices, or occupational health problems separately. Comparatively limited evidence has evaluated adherence to radiation-safety measures and self-reported occupational health problems within the same analytical framework, particularly among heterogeneous radiology personnel working in public and private healthcare institutions. Understanding this relationship is important because a positive or negative association may reflect not only the potential protective role of safety practices but also differences in workload, exposure intensity, professional awareness, symptom recognition, institutional support, and occupational risk perception. Therefore, this study aimed to assess adherence to radiation-safety measures, describe self-reported occupational health problems, and examine the association between radiation-safety adherence and occupational health-problem scores among radiology staff working in public and private hospitals.

MATERIALS AND METHODS

This descriptive analytical cross-sectional study was conducted among radiology personnel working in multiple public and private hospitals. Data collection was completed over a three-month period following approval of the study synopsis. The target population included personnel involved in radiological imaging services, including imaging technologists, diagnostic radiographers, radiology assistants or technicians, and consultant radiologists. Personnel working in general diagnostic imaging, computed tomography, fluoroscopic imaging, image-guided interventional procedures, and related radiology services were approached for participation.

Eligible participants were male or female radiology personnel aged 20–60 years who had worked in a radiology department for at least six months. Nurses, laboratory technologists, physicians from departments other than radiology, individuals who did not meet the minimum professional-experience requirement, and personnel who were unwilling to participate were excluded. Participants were selected using a convenience-sampling technique based on their availability and willingness to complete the survey. The required sample size was estimated using the single-population proportion formula:

$$n = Z^2 p(1 - p)/d^2$$

A 95% confidence level, an expected prevalence of 42.4%, and a 10% margin of error were used in the calculation. Based on these parameters and rounding of the estimated value, a target sample of 96 participants was included in the study.

Data were collected using a standardized self-administered questionnaire comprising demographic and occupational characteristics, adherence to radiation-safety practices, workload- and exposure-related information, and self-reported occupational health problems. Demographic and professional variables included sex, age category, duration of professional practice, area of practice, and current professional role. The radiation-safety component assessed practices such as the use of personal protective equipment, thyroid shields, personal dosimeters, and compliance with established radiation-safety procedures. The occupational-health component assessed self-reported problems including musculoskeletal pain, fatigue, headache, dizziness, skin irritation, burnout, occupational stress, and anxiety concerning radiation exposure.

The radiation-safety adherence scale contained 11 items, which were combined to generate an overall safety score. Higher safety scores represented greater reported adherence to radiation-safety measures. The occupational-health scale contained nine items, which were combined to generate an overall health-problem score, with higher scores representing a greater burden or frequency of self-reported occupational health problems. Because validated classification thresholds for low, moderate, or high scores were not established in the available study information, the scores were analysed as continuous variables and interpreted according to their observed distributions rather than being assigned unsupported categorical labels.

The internal consistency of each scale was assessed using Cronbach's alpha. An alpha coefficient of 0.70 or greater was considered indicative of acceptable internal consistency, while coefficients below this level were interpreted cautiously. Corrected item–total correlations were examined to assess how consistently individual items corresponded with their respective total scale scores.

Data were analysed using IBM SPSS Statistics version 27.0. Categorical variables were summarized using frequencies and percentages. Continuous composite scores were summarized using means, standard deviations, minimum values, and maximum values. Safety and occupational-health scores were compared between male and female participants using independent-samples comparisons. Because the number of male participants was substantially smaller than the number of female participants, sex-based findings were treated as exploratory and interpreted cautiously.

The association between the radiation-safety adherence score and the occupational health-problem score was examined using Pearson's correlation coefficient. Spearman's rank correlation coefficient was additionally calculated to assess whether the direction and magnitude of the association remained consistent when a rank-based method was applied. Correlation coefficients were interpreted according to their direction and magnitude, without inferring causality. All statistical tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant.

The analysis was designed to identify an association between radiation-safety adherence and self-reported occupational health problems rather than to determine whether safety practices caused or prevented health problems. Potential influences such as professional role, imaging modality, workload, duration of practice, access to protective equipment, and institutional safety culture were therefore considered relevant contextual factors when interpreting the findings.

RESULTS

A total of 96 radiology personnel completed the study questionnaire. Most participants were female (88/96, 91.7%), while eight participants (8.3%) were male. General diagnostic imaging was the predominant area of practice, accounting for 73 participants (76.0%). Computed tomography, image-guided interventional procedures, and fluoroscopic imaging services accounted for 11.5%, 10.4%, and 2.1% of the sample, respectively. Imaging technologists constituted the largest professional group (51.0%), followed by radiology assistants or technicians (26.0%), diagnostic radiographers (15.6%), and consultant radiologists (7.3%) (Table 1).

The mean radiation-safety adherence score was 16.97 ± 4.82, with observed participant scores ranging from 11 to 37. The 11-item radiation-safety adherence scale demonstrated acceptable internal consistency, with a Cronbach's alpha of 0.757. The mean occupational health-problem score was 19.34 ± 4.51, with an observed range of 9–27. The nine-item occupational health-problem scale showed comparatively weak internal consistency, with a Cronbach's alpha of 0.573; findings based on this composite score were therefore interpreted cautiously (Table 2).

Radiation-safety adherence scores were nearly identical among male and female participants. Male participants had a mean score of 17.00 ± 5.18, compared with 16.97 ± 4.82 among female participants. The mean difference was 0.03 points (95% CI: −3.52 to 3.58), with no evidence of a statistically significant difference ($t = 0.017$, $p = 0.987$). The standardized difference was negligible (Hedges' $g = 0.006$).

The mean occupational health-problem score was 18.50 ± 3.46 among male participants and 19.42 ± 4.60 among female participants. The mean difference was −0.92 points (95% CI: −4.24 to 2.40), and the difference was not statistically significant ($t = -0.550$, $p = 0.583$). The corresponding standardized effect was small (Hedges' $g = -0.202$). These sex-based comparisons were exploratory because the sample contained substantially fewer male than female participants (Table 3).

RESULTS

Table 1. Demographic and Professional Characteristics of Participants (N = 96)

Characteristic	Category	n (%)
Sex	Male	8 (8.3)
	Female	88 (91.7)
Area of practice	General diagnostic imaging	73 (76.0)
	Computed tomography	11 (11.5)
	Image-guided interventional procedures	10 (10.4)
	Fluoroscopic imaging services	2 (2.1)
Current professional role	Imaging technologist	49 (51.0)
	Radiology assistant/technician	25 (26.0)
	Diagnostic radiographer	15 (15.6)
	Consultant radiologist	7 (7.3)

Table 2. Descriptive Statistics and Internal Consistency of Study Scores

Measure	Items, n	Participants, n	Mean ± SD	Observed range	Cronbach's α
Radiation-safety adherence score	11	96	16.97 ± 4.82	11–37	0.757
Occupational health-problem score	9	96	19.34 ± 4.51	9–27	0.573

Higher radiation-safety adherence scores represented greater self-reported adherence to safety measures. Higher occupational health-problem scores represented a greater reported burden or frequency of occupational health problems. The observed ranges represent participant values and should not be interpreted as the theoretical scale ranges. Cronbach's $\alpha \geq 0.70$ was considered acceptable.

Table 3. Comparison of Radiation-Safety Adherence and Occupational Health-Problem Scores by Sex

Outcome	Male, mean ± SD (n = 8)	Female, mean ± SD (n = 88)	Mean difference[1]	95% CI	t (df = 94)	p-value	Hedges' g
Radiation-safety adherence score	17.00 ± 5.18	16.97 ± 4.82	0.03	−3.52 to 3.58	0.017	0.987	0.006
Occupational health-problem score	18.50 ± 3.46	19.42 ± 4.60	−0.92	−4.24 to 2.40	−0.550	0.583	−0.202

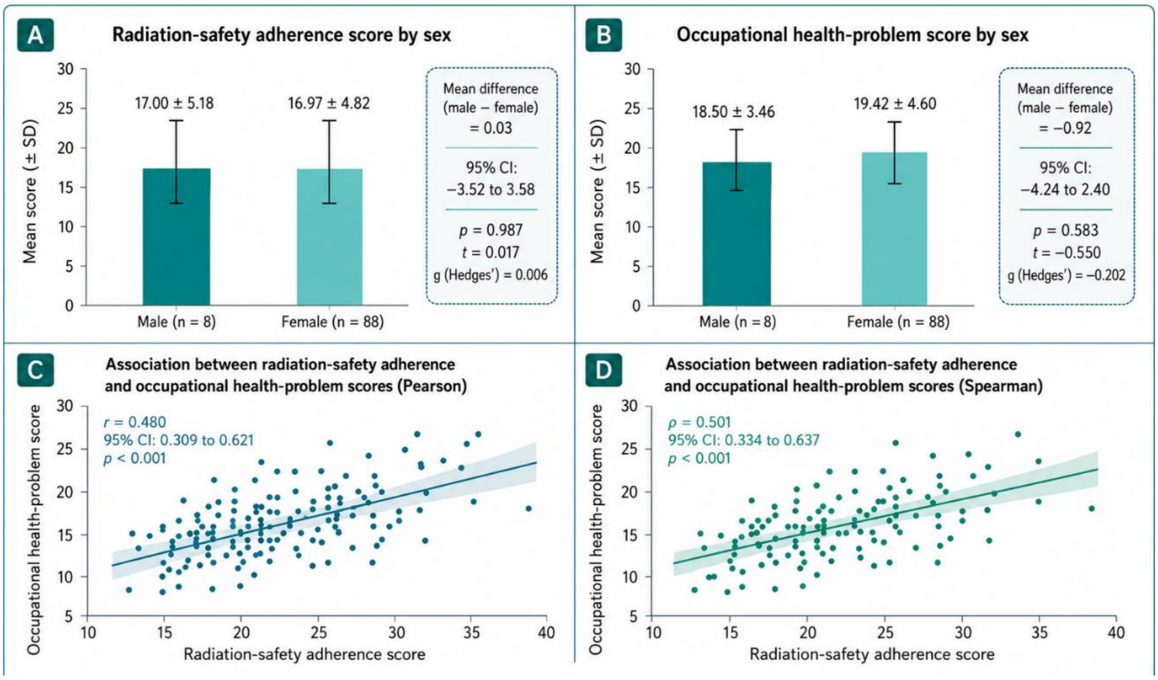
[1]Mean difference calculated as male minus female.

Comparisons were performed using independent-samples t-tests based on the reported group means, standard deviations, and sample sizes. Hedges' g was calculated as a standardized mean difference corrected for small-sample bias. Negative values indicate lower mean scores among male participants. Sex-based findings should be interpreted cautiously because only eight male participants were included.

Table 4. Association Between Radiation-Safety Adherence and Occupational Health-Problem Scores

Analysis	Correlation coefficient	95% CI	p-value	Interpretation
Pearson correlation	r = 0.480	0.309 to 0.621	<0.001	Moderate positive correlation
Spearman rank correlation	ρ = 0.501	0.334 to 0.637	<0.001	Moderate positive correlation

Confidence intervals were calculated using Fisher's z transformation. Pearson correlation was used as the primary analysis, while Spearman rank correlation assessed the robustness of the association using a rank-based method. A positive coefficient indicates that higher reported radiation-safety adherence scores were associated with higher occupational health-problem scores. The correlation does not establish causality or indicate that adherence caused occupational health problems.



The figure shows that radiation-safety adherence and occupational health-problem scores were similar between male and female radiology personnel, with no statistically significant sex differences in either outcome. Both Pearson and Spearman analyses demonstrated a moderate positive correlation between radiation-safety adherence and occupational health-problem scores (r = 0.480 and ρ = 0.501, respectively; both p < 0.001).

Radiation-safety adherence scores were moderately and positively associated with occupational health-problem scores. Pearson correlation analysis showed a statistically significant correlation of r = 0.480 (95% CI: 0.309–0.621; p < 0.001). The rank-based sensitivity analysis produced a similar result (Spearman's ρ = 0.501, 95% CI: 0.334–0.637; p < 0.001), supporting the consistency of the observed association (Table 4).

The positive direction of the association indicates that participants reporting greater adherence to radiation-safety measures also reported higher occupational health-problem scores. This finding should not be interpreted as evidence that radiation-safety practices caused adverse health outcomes. Given the cross-sectional design and use of self-reported composite scores, the association may reflect differences in occupational exposure, workload, professional risk awareness, symptom recognition, reverse causation, unmeasured confounding, or common-method reporting.

DISCUSSION

This study assessed adherence to radiation-safety measures, self-reported occupational health problems, and the association between these outcomes among radiology personnel working in public and private hospitals. The radiation-safety adherence scale demonstrated acceptable internal consistency, whereas the occupational health-problem scale showed weak internal consistency. Safety-adherence scores did not differ meaningfully between male and female participants. The principal finding was a moderate positive association between radiation-safety adherence and occupational health-problem scores, which remained consistent in both Pearson and Spearman correlation analyses.

The acceptable internal consistency of the 11-item radiation-safety adherence scale indicates that its items generally measured a related safety-practice construct. This finding supports the use of the total adherence score for the primary analysis. Nevertheless, the overall score should not be classified as representing poor, moderate, or good adherence because validated interpretation thresholds were not available. The observed findings should instead be interpreted descriptively and in relation to the reported safety behaviours. Previous studies have shown that radiology personnel may possess adequate radiation-protection knowledge while inconsistently applying protective measures in routine clinical practice (4,5,15). Organisational factors, including equipment availability, workload, supervision, training, and enforcement of institutional policies, may contribute to this knowledge–practice gap (5,6,9).

The occupational health-problem scale had a Cronbach's alpha of 0.573, indicating weak internal consistency. This may be partly attributable to the inclusion of heterogeneous physical and psychological concerns within a single composite score. Musculoskeletal pain, fatigue, headaches, dizziness, skin complaints, burnout, occupational stress, and anxiety about radiation exposure do not necessarily represent a single underlying health construct. These problems may arise through different occupational pathways, including prolonged standing, repetitive patient handling, awkward posture, screen exposure, shift patterns, workload, perceived radiation risk, and workplace stress (10–14). Consequently, the composite occupational health-problem score should be interpreted cautiously, and future studies should analyse clinically coherent symptom domains separately.

No statistically significant sex-based differences were observed for either radiation-safety adherence or occupational health-problem scores. The between-group difference in radiation-safety adherence was negligible, whereas the standardized difference in occupational health-problem scores was small. However, these findings should not be interpreted as evidence that sex has no relationship with either outcome because only eight male participants were included. The substantial imbalance between male and female participants reduced the precision and statistical power of the comparison, as reflected by the wide confidence intervals. Larger studies with more balanced representation are needed before reliable sex-based conclusions can be reached.

The moderate positive correlation between radiation-safety adherence and occupational health-problem scores was the most important and potentially counterintuitive finding. A simple protective hypothesis might predict that stronger adherence would be associated with fewer occupational health problems. Instead, participants reporting greater adherence also reported a greater burden or frequency of occupational health problems. This result does not indicate that radiation-safety practices caused adverse health outcomes. The cross-sectional design establishes temporal coexistence rather than the direction of influence, and several alternative explanations are plausible.

Personnel who experience occupational symptoms or perceive themselves to be at greater risk may become more attentive to radiation-safety procedures, producing a reverse-causation pattern. Individuals working in higher-exposure environments, such as computed tomography, fluoroscopy, or image-guided interventional procedures, may simultaneously demonstrate stronger safety adherence and report more occupational concerns. Workers with greater knowledge of radiation protection may also be more likely to recognise and report symptoms or safety risks. In addition, collecting both outcomes through the same self-administered questionnaire may have introduced common-method bias, whereby participants with heightened occupational concern reported higher values across both scales.

The association may also have been influenced by unmeasured confounding. Workload, patient volume, shift duration, professional role, imaging modality, years of practice, previous safety training, availability of protective equipment, dosimeter access, institutional policy enforcement, and perceived exposure were not included in an adjusted multivariable model. These variables could plausibly affect both adherence and symptom reporting. The positive correlation should therefore be regarded as an unadjusted association requiring further investigation rather than evidence of either a beneficial or harmful effect of radiation-safety adherence.

The findings nevertheless have practical implications for radiology departments. Radiation-safety programmes should not focus solely on individual knowledge or the availability of written protocols. Effective occupational protection requires accessible and properly maintained protective equipment, routine personal dosimetry where indicated, regular training, documented compliance monitoring, appropriate staffing, and designated radiation-safety oversight in accordance with established radiation-protection principles (2,3). Occupational-health programmes should concurrently address ergonomic risks, fatigue, psychological stress, and concerns regarding cumulative exposure rather than attributing all reported symptoms directly to ionising radiation.

This study examined radiation-safety adherence and occupational health concerns within the same analytical framework and included personnel from multiple professional roles and imaging areas. The use of both Pearson and Spearman correlation analyses demonstrated that the direction and approximate magnitude of the principal association were consistent across parametric and rank-based approaches. The study also reported the internal consistency of both composite scales, allowing the reliability of the findings to be evaluated.

Several limitations should be considered. Convenience sampling and the unspecified number and location of participating hospitals limit the representativeness and generalisability of the findings. The cross-sectional design precludes conclusions regarding temporality or causality. All information was self-reported and may have been influenced by recall bias, social-desirability bias, risk perception, and common-method variance. Objective occupational dose records, biological indicators, medical diagnoses, and ergonomic assessments were not available. The weak internal consistency of the occupational health-problem scale limits confidence in its composite score. The sample was heterogeneous in terms of professional role and imaging modality, and the eligibility criteria included MRI-related personnel despite MRI not using ionising radiation; the extent to which such personnel also worked in ionising-radiation modalities requires clarification. The marked sex imbalance restricted subgroup comparison, and the absence of adjusted regression analysis prevented control of important institutional, occupational, and exposure-related confounders.

Future research should use validated and clearly scored instruments, report individual safety behaviours and symptom domains, and incorporate objective personal dosimetry where relevant. Prospective or longitudinal designs would help clarify whether occupational symptoms precede increased adherence or whether adherence predicts subsequent health outcomes. Multicentre studies should also examine professional role, imaging modality, workload, equipment availability, institutional safety culture, training, and ergonomic exposure through appropriately adjusted analyses.

CONCLUSION

Radiation-safety adherence was moderately and positively associated with self-reported occupational health-problem scores among the participating radiology personnel, while no meaningful sex-based differences were identified in either outcome. Because the study was cross-sectional and relied on self-reported composite measures, the association does not demonstrate that radiation-safety adherence caused or prevented occupational health problems. The findings instead indicate that safety behaviour and occupational health concerns may coexist and may be influenced by professional awareness, occupational exposure, workload, institutional practices, or other unmeasured factors. Integrated institutional programmes addressing radiation protection, compliance monitoring, ergonomic risks, staff well-being, and occupational-health surveillance are therefore warranted.

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