Iranian Journal of Medical Physics

ijmp.mums.ac.ir

A Survey on the Radiation Protection Status among Radiology Staff

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ARTICLE INFO

Article type:
Original Article

Article history:
Received: Jul 15, 2017
Accepted: Jan 12, 2018

Keywords:
Knowledge Attitude
Professional Practice
Radiation Protection
Medical Staff

ABSTRACT

Introduction: Radiation exposure during radiological examination is a health concern, of which radiology professionals should be cognizant. We sought to evaluate the radiation protection knowledge, attitudes, and practice (KAP) amongst radiology staff of hospitals across 10 provinces of Iran.

Materials and Methods: For evaluating the level of radiation protection KAP, 553 radiology staff were enrolled. A 32-item questionnaire was designed to assess radiation protection KAP, the validity which was confirmed by members of the Medical Physics and Biostatistics departments. The questionnaire evaluated the respondents' knowledge, practice, and attitudes towards the basic principles of radiation protection, the necessity of using protective equipment, and their performance in the implementation of radiation protection recommendations.

Results: We found no significant difference in the level of radiation protection KAP between male and female radiology staff and among those with different educational levels and ages ($P>0.05$). However, there was a significant association between radiation protection KAP and working experience, hospital size, and hospital type ($P<0.05$). Further, no significant difference was observed in the radiation protection KAP level among radiology staff of different regions ($P>0.05$).

Conclusion: Our results showed that the level of radiation protection KAP among radiology staff is inadequate. This might be due to the lack of ongoing training courses concerning protection against ionizing radiation. Thus, sustained training of radiation protection principles can promote KAP among the staff of radiology departments, and in turn, reduce public dose from medical diagnostic modalities.

► *Please cite this article as:*
Masoumi H, Hasanzadeh H, Jadidi M, Mirmohammadkhani M, Bitarafan-Rajabi A, Abedelahi A Emadi A, Bokharaeian M, Shabani F, Moshfegh Sh, Seifi D, Khani T, Sanchooli M, Ehtiati A, Vali MH, Ziari A, Vali S. A survey on the radiation protection status among radiology staff. Iran J Med Phys 2018; 15: 176-182. 10.22038/ijmp.2018.24725.1249.

Introduction

Experience and literature review suggest that in diagnostic tests, referring physicians and radiologists often have limited information and awareness regarding the actual dose of ionizing radiation and the risks associated with it [1-7]. One way to assess the knowledge of physicians, technicians, and other medical personnel is to design questionnaires about radiation protection [8-18]. One report published in the Lancet estimated more than 430 cases of cancer related to diagnostic radiation [19]. The first recorded biologic effect of radiation was observed for becquerel, which was due to unintentionally leaving a radium container in his vest pocket and caused skin erythema, and consequently, ulcer [20].

A few years after the diagnostic application of X-rays, skin carcinomas, leukemia, dermatitis, cataract, and other adverse health effects were observed in physicians, medical radiology staff, and patients. So the guidelines and recommendations were necessary to protect patients and staff against ionizing radiation [21, 22]. One type of damage caused by ionizing radiation is the stochastic effect, which is independent of the absorbed dose and has no threshold. This

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highlights the importance of radiation protection and using protective equipment for radiosensitive organs [22-28]. There are routine diagnostic tests, in which clinical mistakes and sometimes inconsistent performance of medical staff are in contrary with justification principles [29-32].

Optimization includes systematic quality control, monitoring individual performance, and commitment to quality [22, 30-32]. It is notable that more than a third of all the requested radiological studies are totally or partially unnecessary [33]. Overall, the awareness of personnel regarding the importance of justification, having good practical knowledge, and risk assessment is an important issue considering the constant variations in practical patterns of diagnostic radiology, the novel relatively high-dose techniques, and changes in the social framework and individual rights [34].

With regard to the deleterious effects of ionizing radiation in X-ray diagnostic imaging and given the insufficient awareness of medical personnel as to protection against ionizing radiation, we sought to investigate the knowledge, attitude, and practice (KAP) of radiology personnel of hospitals in several provinces of Iran. Finally, the collected data from this study can be used to suggest changes in the current educational policies about optimizing the knowledge and practice of radiation personnel with sustained training courses, improve the practical skills, and provide organizations, such as IAEA, insight regarding into implementation of potential regional educational packages and courses.

Materials and Methods

Based on the opinions of experts in the field of radiation hazards and radiation protection, the first draft of the questionnaire was prepared and it was validated by a panel of experts. All the items were considered and the content validity ratio (CVR) was calculated with the direct advice of 10 panelists including seven academic specialists (one nuclear medicine specialist, four medical physicists, one epidemiologist, and one occupational health specialist) and three staff from the affiliated centers. To evaluate the necessity of the considered items in the questionnaire, 10 panelists were requested to score each item based on a three-point Likert scale (from 1 [*not necessary*] to 3 [*essential*]). CVR is calculated as (Ne - N/2)/(N/2), where Ne is the number of panelists indicating "*essential*" and N is the total number of panelists (CVR ≥ 0.62 was accepted). Then, a pilot study was conducted among a sample of 20 radiology staff to establish the reliability and face validity of the scale. The tendency of the scale towards consistency was confirmed by repeated measures. Two sets of responses (with a two-week time interval) were used for establishing test-retest reliability via estimating Pearson correlation coefficient, showing the acceptable reliability of the scale ($r=0.81$, $P<0.001$).

Before distributing the questionnaire, the project and its validated questionnaire were approved by the Ethics Committee of Semnan University of Medical Sciences, Semnan, Iran. This prospective study was conducted in radiology departments of several provinces of Iran to evaluate KAP among radiology staff. The validity of the questionnaire was approved by faculty members of Medical Physics and Biostatistics departments. The questionnaire included 63 items on demographic information (10 items), respondents' knowledge about basic principles of radiology protection (As Low As Reasonably Achievable [ALARA] and the annual dose limit and the 10 days rule; 26 items), and respondents' attitudes and their practice (27 items). Our participants were selected from teaching hospitals, non-educational hospitals, and private clinics across different regions (the capital, central, eastern, western, and northern regions).

The questions were designed to assess the respondents' attitudes and knowledge about the necessity of using protective equipment and their performance in the implementation of the radiation protection recommendations. Overall, 553 questionnaires were distributed among radiology staff (all the medical specialists, fellowships, interns, nurses, paramedics, and radiation medical imaging technicians); the response rate was 100%. In this study, we recorded factors such as age, gender, educational level, age, work experience, type of hospital, and region in the country. The collected data were entered into Microsoft Excel and analyzed by SPSS. To analyze the data, one-way analysis of variance was performed. P-value less than 0.05 was considered statistically significant.

Results

Overall, 55.15% of the participants were female. In terms of education, among 21.51% of the participants about 15 years had elapsed since their graduation. As for 67.08% of the participants, the interval since graduation was less than 15 years. Graduation year was not mentioned by 11.39% of the participants**.** Work experience was more than 15 years in 21.51% of the participants, and it was less than 15 years among 72.32% of the participants.

In general, 1.26%, 21.69%, 68.35%, and 5.06% had incomplete high school education, associate's degree, Bachelor's degree, and Master's degree, respectively, while 0.53% were general practitioners and 3.07% were specialists. According to Table 1, there was no significant difference in the percentage of radiation protection knowledge between the two genders (57.47±15.72 vs. 58.99±16.23; P=0.267). In addition, the time elapsed since graduation had no significant impact on the knowledge of radiology protection (P=0.892). The mean percentages of

knowledge were respectively 58.99% (SD=15.38) and 59.21% (SD=16.03) among those who had graduated ≤ 15 and > 15 years ago.

Table 1. Radiation protection knowledge among the participants

	Characteristic	Mean	SD	P-value
Gender	Male	57.47	15.72	0.267
	Female	58.99	16.23	
Years passed since graduation	≤15	58.99	15.38	0.892
	>15	59.21	16.03	
Years of professional practice	≤15	59.27	14.42	0.030
	>15	55.68	19.76	
Type of hospital	Governmental Educational	58.06	16.53	0.803
	Governmental Non Educational	59.53	10.97	
	Private	58.51	16.43	
Region	Capital	57.90	19.97	0.302
	Center	60.63	13.38	
	East	57.94	13.44	
	North	57.36	15.87	
	West	56.36	14.11	

Table 2. Radiation protection practice among the participants

	Characteristic	Mean	SD	P-value
Gender	Male	47.05	12.37	0.008
	Female	44.11	13.34	
Years passed since graduation	≤15	44.56	12.55	0.018
	>15	47.68	12.24	
Years of professional practice	≤15	45.82	12.98	0.716
	>15	45.33	12.88	
Type of hospital	Governmental educational	44.12	13.38	0.000
	Governmental non-educational	44.64	12.24	
	Private	49.87	11.05	
Region	Capital	46.47	15.29	0.168
	Center	45.23	10.35	
	East	42.50	12.01	
	North	47.03	14.26	
	West	44.43	11.65	

Table 3. Multiple comparisons for different hospital types

Center type (A)	Center type (B)	Mean difference (A-B)	SE	P-value
GE	GNE (Governmental Non-Educational)	-0.52912	1.81933	0.954
	P (Private clinic)	-5.75603*	1.33800	0.000
GNE	GE (Governmental Educational)	0.52912	1.81933	0.954
	P	-5.22691*	2.05590	0.030
P	GE	5.75603*	1.33800	0.000
	GNE	5.22691*	2.05590	0.030

There was a significant relationship between knowledge of radiation protection and years of professional practice (P=0.030). The mean percentages of knowledge were 59.27% (SD=14.42) and 55.68% (SD=19.76) among those with ≤ 15 years and > 15 years of professional practice, respectively. The type of hospital (i.e., teaching governmental hospital, non-educational governmental hospital, and private clinic) had no significant effect on the radiation protection knowledge of the radiology staff (P=0.803). Besides, there was no significant difference among different regions of Iran (P=0.302).

According to Table 2, there was a significant association between radiation protection practice and gender (P=0.008). The mean practice scores were 47.05±12.37 and 44.11±13.34 among the male and female staff, respectively. In addition, a significant difference was observed in radiation protection practice between the staff with ≤ 15 years and > 15 years since the completion of education (P=0.018). In other words, the time elapsed since graduation affected radiation protection practice. Further, radiation protection practice did not differ significantly between the staff with ≤ 15 years and >15 years of professional practice (P=0.716), while we found a significant difference among different types of hospitals in terms of radiation protection practice (P=0.000). Table 3 presents a significant difference in radiation protection practice between private and governmental teaching hospitals (P=0.000) and between governmental non-educational and private hospitals (P=0.03). According to Table 2, no significant difference was observed in radiation protection practice among various regions of Iran (P=0.168).

Table 4. Radiation protection attitudes among the participants

	Characteristic	Mean	SD	P-value
Gender	Male	77.41	17.53	0.485
	Female	78.38	14.78	
Years passed since graduation	≤15	78.98	13.98	0.997
	>15	78.97	13.84	
Years of professional practice	≤15	79.65	13.56	0.000
	>15	73.47	21.29	
Type of Hospital	Governmental educational	77.01	17.28	0.128
	Governmental non-educational	80.63	13.94	
	Private	79.58	12.55	
Region	Capital	76.30	17.07	0.569
	Center	78.80	17.36	
	East	78.82	13.88	
	North	79.16	15.37	
	West	77.25	14.36	

Table 5. Radiation protection knowledge, practice, and attitude among the participants

	Characteristic	Mean	SD	P-value
Gender	Male	60.64	11.45	0.873
	Female	60.49	10.97	
Years passed since graduation	≤15	60.84	10.03	0.291
	>15	61.95	9.84	
Years of professional practice	≤15	61.58	9.84	0.003
	>15	58.16	13.96	
Type of hospital	Governmental educational	59.73	12.01	0.033
	Governmental non-educational	61.60	9.15	
	Private	62.65	8.88	
Region	Capital	60.22	13.18	0.561
	Center	61.55	10.69	
	East	59.75	9.36	
	North	61.18	11.28	
	West	59.34	9.28	

Based on Table 4, the attitudes of radiology staff towards radiation protection was not different between the two gender (P=0.485). The mean scores of radiation protection attitudes in the male and female staff were 77.41±17.53 and 78.38±14.78, respectively. The time elapsed since graduation (≤ 15 years and > 15 years) did not have a significant impact on the radiation protection attitudes of the staff (P=0.997).

Nonetheless, we found a significant difference between the staff with ≤ 15 years and > 15 years of professional practice with respect to radiation protection attitudes (P=0.000). In other words, these factors were not effective in radiation protection attitudes of the staff. According to Table 5, gender and years since the completion of education did not have a significant impact on radiation protection knowledge, attitudes, and practice (P=0.873 and P=0.291, respectively). Years of practice and type of hospital significantly influenced the knowledge, attitudes, and practice of radiology staff regarding radiation protection (P=0.033 and P=0.003, respectively). There was no significant difference in the radiation protection knowledge, practice, and attitudes of the staff among different regions of Iran (P=0.561).

Discussion

We sought to address the level of radiation protection knowledge of radiology staff and compare their practice and attitudes. Several studies were conducted on occupational exposure to radiation [14, 35, 36]. Dehghani et al. failed to find any significant differences in radiation protection knowledge between the two genders [37]. Likewise, our results demonstrated that the level of radiation protection knowledge in the male and female staff was not different (the radiation protection knowledge scores for males and females were 59 and 57.47, respectively). Although gender did not affect the level of radiation protection knowledge among the staff, the score of radiation protection practice among the male staff (47.05) was higher than that of females (44.11), which could be due to sufficient proficiency of the male staff in implementing the practical principles of radiation protection.

The attitudes were similar among the male and female staff. In addition, occupational experience, educational level, and completion of training courses had no significant effect on radiation protection knowledge, which was in accordance with the results of previous studies [36, 38].

However, one study showed that radiologists with more than 15 years of occupational experience had lower awareness regarding radiation protection than did junior radiologists [37]. The results of a study performed in Gdansk Medical University, Poland, showed that the radiation protection awareness of employees with 6-10 and more than 16 years of service was alarmingly low [39].

A study carried out in Turkey showed that specialists with work experience less than 5 years had sufficient information as to the rules of ALARA [40]. Davoudian et al. reported marked differences in the radiation protection attitudes of radiographers with different levels of education. Thus, the attitudes, knowledge, and practice of radiology staff were found to be affected by the level of education [41]. Our results revealed that years passed since completion of education had no effect on the level of radiation protection knowledge of staff. Although the level of radiation protection knowledge of the radiology staff was inadequate (58.99 and 59.21 with ≤ 15 and > 15 years passed since the completion of education, respectively), years of practice had a significant impact on the radiation protection knowledge score of the radiology staff. The score of radiation protection knowledge among the staff with 15 years of professional practice or less was higher than those with work experience of greater than 15 years (mean: 59.27 vs. 55.68).

In terms of radiation protection practice, Behroozi et al. studied 33 hospitals in Khuzestan Province, Iran, and showed that while more than 91% of radiology centers provided protective equipment for patients, only in 13% of the hospitals, radiation delivery to sensitive organs was reduced to 5.2-14% [38]. Additionally, the radiation protection practice score of radiology staff with more than 15 years passed since the completion of education was more the mean score of the staff with 15 ≥ years passed since graduation. This finding could be explained by the fact that radiology staff has become accustomed to the application of radiation protection instruments.

Years of practice did not influence the performance of radiology staff and their radiation protection score. The time elapsed since graduation did not impact the attitudes of the staff towards radiation protection. However, the scores of radiation protection attitudes among the radiology staff with ≤ 15 years of practice were higher than those with > 15 years of practice.

Based on the type of hospital, a study conducted in Indonesia showed no significant difference in ionizing radiation risk assessment among public and private hospital personnel with various educational levels [38]. Awareness evaluation according to hospital type (i.e., teaching, public, and private clinics) was performed in Nigeria. The respondents working in private hospitals were satisfied with the available radiation safety devices, while in public hospitals, the staff were dissatisfied due to the absence of standard radiation safety equipment. Besides, awareness of the respondents was at an acceptable level in all the studied hospitals [9].

Eksioglu et al. conducted a study in Turkey's private, governmental, and public educational hospitals and stated that 95% of the respondents had no awareness regarding ionizing radiation doses and their effects and they had not received training regarding the unnecessary radiological exams for children. Pediatricians' awareness regarding children's radio sensitivity was higher in governmental hospitals than that of pediatricians in teaching governmental hospitals [40].

Radiation protection practice was different among the staff of different types of hospitals such that the highest practice score pertained to private clinics, which could be attributed to low workload, hospital directors' focus on the implementation of radiation protection principles, and adequate radiation protection equipment**.** The staff's attitudes toward radiation protection was homogeneous in different types of hospitals.

Further, the scores of radiation protection knowledge, practice, attitudes were not significantly different across various regions of Iran. Singh et al. revealed that effective training programs are required for medical radiation professionals to increase their knowledge of radiation protection [43]. Previous studies reflected that respondents with a satisfactory knowledge score had less than 10 years of professional practice, which could be due to higher levels of education [11, 13]. Ramanathan et al. found that knowledge about radiation dose and the carcinogenic risks of medical radiation was poor among medical doctors, fellows, residents, and radiation workers. They highlighted the need for further educational programs to promote the knowledge regarding these issues [44]. Maharjan in a study performed among radiographers and radiography students in Nepal showed that the overall awareness and knowledge regarding radiation was adequate, but it could be improved by holding regular training courses, workshops, and CME (Continuing Medical Education) programs [45].

During radiological examinations, it is strived to reduce the unnecessary radiation exposure, while maintaining the requirements to attain the diagnostic goals. In other words, benefits should outweigh the risks and the procedure should be performed properly, highlighting the justification and optimization principles. These items are affected by inadequate knowledge of personnel, which should be considered by the Iranian Atomic Energy Organization to enhance radiation health related services in Iran.

It can be concluded that although several factors are at play in the poor radiation protection practice in Iran, but the major reason could be the lack of adherence of radiology staff to ethical principles of radiation protection, lack of follow-up inspection of health physics authorities, poor knowledge, practice, and attitudes among staff, and lack of on-going radiation protection training for radiation workers, particularly radiology department staff.

The role of the Internet is increasing in every facet of life, facilitating time management. Besides, recent developments in the cell phone technology and the new high-speed generations of mobile networks provide a valuable foundation to base education on the state-of-the-art technologies. Relatively everyone has a personal smartphone and access to the Internet; thus, on-line courses could be used to evaluate and promote the knowledge of hospital staff. Also, online up-dated databases and mobile applications could be designed to enable professionals learn and ask questions about the principles of radiation protection. Moreover, university curricula should be revised to enhance knowledge and highlight the importance of radiation protection by embedding comprehensive and applicable contexts in curricula. Finally, implementing the measures taken in the developed countries and highlighting the position and authority of a well-educated medical physicist in hospitals and diagnostic departments could improve the status quo.

Conclusion

The radiation protection knowledge, practice, and attitudes were not satisfactory among the radiology staff. Therefore, on-going educational programs concerning the principles of radiation protection are required for hospitals' radiology staff in Iran.

Acknowledgment

We would like to thank the Clinical Research Development Unit of Kowsar Educational and Research and Therapeutic Center of Semnan University of Medical Sciences for cooperating with this study.

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