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Medical radiation workers' knowledge, attitude, and practice to protect themselves against ionizing radiation in Tehran Province, Iran

Seyedeh Shohreh Alavi, Sima Taghizadeh Dabbagh[1], Mahya Abbasi, Ramin Mehrdad

Center for Research on Occupational Diseases, Tehran University of Medical Sciences, [1]Research Center for Science and Technology in Medicine, Tehran University of Medical Sciences, Tehran, Iran

Address for correspondence:
Dr. Sima Taghizadeh Dabbagh, Imam Khomeini Hospital Complex, Keshavarz Boulevard, Tehran, Iran.
E-mail: alavi@tums.ac.ir

Abstract:

BACKGROUND: Medical radiation workers are potentially at a risk of unwanted ionizing radiation exposures. This study assessed the radiation protection knowledge, attitude, and practice (RP-KAP) of health-care workers who are occupationally exposed to radiation regarding protecting themselves from radiation.

MATERIALS AND METHODS: This study was cross-sectional in design and was carried out in 16 hospitals affiliated to the Tehran University of Medical Sciences between May and September 2014. Total health-care workers who were occupationally exposed to radiation comprising 670 individuals were included in the study based on census sampling method. In total, 413 individuals consented to complete an anonymous 32-item questionnaire comprising single best choice questions with a numerical value assigned to each correct answer. Each set of RP-KAP questions was scored and categorized as poor, medium, and good. The effect of independent variables for prediction of RP-KAP was explored using linear regression analyses.

RESULTS: A significant number of participants had poor RP-knowledge (78.9%), RP-attitude (70.7%), and RP-practice (32.4%). Based on linear regression analyses, it was found that field of study ($\beta = 0.1$, $P = 0.001$), marital status ($\beta = -0.14$, $P = 0.01$), and level of education ($\beta = 0.2$, $P < 0.001$) were the predictors of higher RP-knowledge. In-service RP-training ($\beta = 0.1$, $P = 0.04$) was associated with an increased RP-attitude. Being a woman ($\beta = 0.2$, $P < 0.001$) and longer years of experience with radiation ($\beta = 0.2$, $P < 0.001$) were significantly related to better practice.

CONCLUSION: In-service training with appropriate qualified and up-to-date materials based on radiation workers' educational needs and approved protocols and guidelines is recommended.

Keywords:

Attitude, health personnel, knowledge, professional practice, radiation protection

Introduction

In recent years, the application of ionizing radiation is being constantly widespread throughout the world for a variety of beneficial purposes.[1] Especially in the medicine field, a demand for medical radiologic imaging procedures consisting of diagnostic and therapeutic practices has increased, as 30–50% of the medical diagnosis is based on X-ray imaging reports.[2] Therefore, patients' and radiation workers' exposure to ionizing radiation is inevitable in medical practice,[3] and using radiation to enhance the health of the public exposes patients and radiation workers to the potential hazards of ionizing radiation.[4]

Exposure to ionizing radiation is known to cause serious effects on hematopoietic, immune, reproductive, circulatory,

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respiratory, musculoskeletal, endocrine, nervous, digestive, and urinary systems. Cataracts, skin burns, leukemia, and several other types of cancers are among the other adverse effects from ionizing radiation.[5-8]

Not only high doses of radiation, but also long-term low doses of radiation also potentially put people at a risk of mutagenic and carcinogenic hazards.[9] Medical radiation workers who apply radiation for diagnostic and therapeutic purposes are categorized as people with low-chronic doses and are potentially at a risk of unwanted exposures.

Every year, approximately, 7 million health-care workers worldwide are exposed to radiation doses attributable to their occupation.[10] Therefore, the use of ionizing radiation is a double-edged blade. Its benefits to patients are enormous. However, improper and unskilled use of radiation technologies can lead to health hazards for both patients and radiation workers.[10] As a result, there needs to be more attention to minimize the unnecessary exposure for occupational workers and members of public.[3]

Medical radiation protection (RP) should properly involve activities on infrastructure, equipment, QA programs, and workforce.[10] Rather than covering all the aspects of medical RP, this study focuses on radiation workers' knowledge, skills, and attitude in protecting themselves from the harmful effects of ionizing radiation.

A number of the most important challenges tackled by the World Health Organization (WHO) include in-service training, providing guidelines and technical documents, and facilitating the acceptance and observation of safety principles. The WHO believes that to minimize radiation hazards and guarantee safe and effective health care, substantial investment is needed to empower the workers with required skills, attitudes, and professional knowledge.[6] Health-care workers often do not have sufficient knowledge about the risks of being exposed to radiation and the criteria that should be taken into consideration to minimize those risks.[11] In a study in Karachi (2008), a significant lack of RP-knowledge and practice was found among studied cardiologists.[12] However, high RP-knowledge does not necessarily lead to compliance to RP-practice. A possible explanation is that a negative or neutral scientific attitude toward RP-practice prevents the significant knowledge translated to practice.[13]

Therefore, all health-care workers who are occupationally exposed to radiation should adopt current RP-improvements and try to apply their knowledge to protect themselves and patients against unwanted effects of ionizing radiation.[13] There are many studies worldwide, which assessed the RP-knowledge, attitude, and practice (RP-KAP) of different health-care workers who work in a radiation environment with different results.[14-17] However, there are few studies in this field in Iran, particularly surveys related to the KAP of radiation workers to protect themselves from the deleterious effects of ionizing radiation.

Thus, this study is designed to evaluate RP-knowledge, attitude, and compliance to practice among health-care workers working in educational hospitals of the Tehran University of Medical Sciences (TUMS) about self-protection against radiation.

Materials and Methods

This cross-sectional study design was carried out in 16 government referral hospitals affiliated to TUMS in Tehran, the capital of Iran, between May and September 2014. Based on census sampling method, all health-care workers who were occupationally exposed to radiation comprising 670 radiation workers were included in the study. Other health-care workers were excluded from the study. Two groups of health-care workers were exposed to ionizing radiation: (1) Radiation workers with a degree in radiology including radiologic technologist, nuclear medicine technologist, medical radiation technologists, radiotherapists, and medical physics technologists; (2) radiation workers who certified in other medical fields comprised nurses, anesthesiologists, cardiologists, orthopedic surgeons, neurologists, and urologists.

In total, 413 radiation workers were recruited to make a response rate of 61.6%. The participants had different educational backgrounds because working in radiation environments requires proper RP-KAP to protect oneself, regardless of employees' educational background. This study was set in 16 educational hospitals affiliated to TUMS.

Approval related to the study protocol was obtained from the Ethics Committee at TUMS, and all participants were provided a consent form comprising a statement about the voluntary nature of the study, its objectives, methodology, and procedures, as well as a guideline to complete a hand-delivered questionnaire. In addition, they were assured of confidentiality and privacy of the data gathered.

An anonymous 32-item questionnaire comprising single best choice questions was categorized into three sections including: the knowledge (K = 13 questions), attitude (A = 13 questions), and practice related to RP (P = 6 questions). RP-knowledge questions focused on issues such as the relationship between radiation exposure and skin pigmentation, headache, and blurred vision as potential side effects and the duration that scatter rays remain at X-ray room. Questions regarding RP-attitude assessed items such as the suitability of film badge in monitoring staff-absorbed dose and the reliability of safety standards and equipment in work environments in terms of studied population. Examples of the questions relating to RP-practice included regular/irregular use of personal dosimeter in radiation environment and applying personal dosimeter in correct/wrong places. It is noteworthy that RP-practice was assessed through self-appraisal.

To make more accurate judgments about participants' KAP, a numerical value was assigned to each correct answer: knowledge (each correct answer = 1.54), attitude (each correct answer = 1.54), and practice (each correct answer = 3.33) questions. In other words, the results of assessment from all the three sections were reported according to the Iranian academic grading (0–20) using the university's common 20-point grade scale. In this method, the minimum grade the universities require to pass any assessment is 10, so scores <10 are categorized "weak" and scores between 16 and 20 are considered "excellent." All scores from 11 to 15 are satisfactory.[18,19] Therefore, the minimum and maximum scores were 0 and 20, respectively, for each set of RP-KAP questions. Scores <10 were categorized as poor, 10–15 as medium, and ≥16 were defined as good scores.

The content validity of the questionnaire was approved by ten subject matter experts with different educational background including educational planning, epidemiology, radiology, and occupational health who assessed the questionnaire. In the first step, the structured questionnaire was developed based on the most recent update references and frequent experiences of the authors. The content validity of the questionnaire was assessed by the content validity ratio (CVR) and content validity index (CVI). The CVR was calculated between 0.61 and 0.76 to reject or retain each item of the questionnaire. For CVI, the wordings of the questions were evaluated in terms of relevance, simplicity, and clarity, and found to range from 0.77 to 0.93. To determine the face validity of the questionnaire, thirty radiation workers and ten previously mentioned experts rated each question in terms of clarity, understandability, and length of each question. Face validity was ensured by the revision of 7 items. The internal consistency reliability was calculated using Cronbach's alpha ($\alpha = 0.92$).

Demographic data such as sex, marital status, field of study, educational degree, years of working experience with radiation, and RP education over the past year were assessed as well.

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS 20, IBM, Armonk, NY, United States of America) for analysis.

We calculated the score of KAP for each participant and transformed them to a 20-scale score. Then, we compared KAP score between sex, marital status, field of study, and in-service training groups using Mann–Whitney U-test. After that, in three linear regression analyses, we set KAP as dependent variable and evaluated the effect of independent variables for the prediction of RP-KAP. $P < 0.05$ was considered statistically significant.

Results

Overall, 413 participants consisting of 235 (56.9%) women and 152 (36.8%) men completed the survey. Among the participants, 257 (62.2%) were married. In total, 263 (63.7%) had a degree in radiology and 150 (36.3%) were certified in other medical fields. RP in-service training over the past year was received by 259 (62.7%) participants. The educational qualification of the participants ranged from associate to professor. About 253 (69.5%) health-care workers had a bachelor degree, 63 (17.3%) had less than bachelor degree, and 48 (13.2%) had master to professor degree. The mean (standard deviation [SD] of experience duration with radiation was found to be 10.0 (7.3) years, with a range from 0 to 30 years.

The mean (SD), minimum, and maximum scores for radiation workers' KAP regarding self-protection against radiation are shown in Table 1. The highest and lowest mean scores belonged to the practice and knowledge aspects, respectively.

Participants' levels of the KAP were evaluated [Table 2] and only 11 (2.7%) and 9 (2.2%) had good scores in knowledge and attitude aspects, respectively.

RP-knowledge assessment revealed that 97 (23.5%) radiation workers knew how long scatter rays remain at the X-ray room. Questions related to the links between radiation exposure and skin pigmentation (30.5%), headache (35.4%), and blurred vision (33.9%) as potential side effects were answered correctly. In total, 160 (38.7)

Table 1: Participants' radiation protection-knowledge, attitude, and practice scores

Score	Minimum	Maximum	Median	Mean (SD)
Knowledge	0	16.9	7.7	7.2 (3.4)
Attitude	3.0	16.9	7.7	8.6 (2.7)
Practice	0	20	13.3	13.1 (3.3)

SD = Standard deviation

Table 2: Classification of the participants' level of radiation protection-knowledge, attitude, and practice

Score out of 20	Knowledge *n* (%)	Attitude *n* (%)	Practice *n* (%)
Poor (0-9)	326 (78.9)	292 (70.7)	134 (32.4)
Medium (10-15)	76 (18.4)	112 (27.1)	158 (38.3)
Good (16-20)	11 (2.7)	9 (2.2)	121 (29.3)

participants selected the best answer to a question related to as low as reasonably achievable approach to RP.

The results of participants' RP-attitude showed that only 197 (47.7%) believed that film badge is an appropriate monitoring device to measure staff-absorbed dose. There were 178 participants (43.1%) who did not trust the safety standards and equipment in their work environment. Furthermore, 247 participants (59.8%) believed that working with radiation is more dangerous compared to the other medical fields and 257 participants (62.2%) claimed that they do not choose to be a radiation worker, if they have another chance to select their job. In addition, 44 participants (10.7%) declared that occupational exposures in health-care settings during pregnancy could be associated with an increased fetal risk.

Analyses of the questions related to participants' practice showed that 392 participants (94.9%) had their own personal dosimeter, 227 participants (55%) declared that in some cases they work in radiation environment without using personal dosimeter, and 315 participants (76.3%) applied their personal dosimeter in wrong places.

Relationship between RP-KAP and sex, marital status, field of study, and participation in RP in-service training over the past year was assessed [Table 3].

There was a significant association between sex and radiation workers' attitude ($P = 0.006$) and practice ($P = 0.008$). It was not surprising that participants with a degree in radiology had better knowledge ($P < 0.001$) than other health-care workers.

The result of the linear regression analysis demonstrated that the field of study, marital status, and levels of education were the significant predictors of knowledge. In addition, a significant relationship was recorded between in-service training and RP-attitude. Sex and experience duration with radiation significantly predicted RP-practice [Table 4].

Discussion

The ongoing trend toward the application of radiation technologies in most medical procedures may expose radiation workers to radiation hazards.[20] Therefore, radiation safety remains as an occupational concern.[21] The primary aim of this study was to evaluate RP-KAP of health-care workers who were occupationally exposed to radiation to protect themselves against radiation. Based on the results, RP-KAP was not on a satisfactory level among the studied workers. On evaluating RP-attitude, only nine participants achieved a good score toward self-protection. This indicates an undesirable RP-attitude to work in radiation environment. Similar to the present findings, Flôr and Gelbcke also observed that nurses who worked in catheterization laboratories underestimate the potential hazards of radiation exposure and were not careful to work according to the guidelines for self-protection measures.[22] In addition, another research about nurses' perception of personal safety documented mistaken beliefs on self-protection from exposure to radiation.[23] Misconceptions about radiation may be due to the inability of the human to detect radiation with visual and tactile senses. In addition, many of the side effects of radiation usually occur after prolonged exposure, and radiation workers cannot certainly relate them with the exposure to ionizing radiation. These situations may cause either undue ignorance and failure to adhere to protection principles or concerns and fear of radiation. All these situations have negative influences

Table 3: Relationship between participants' characteristics and radiation protection-knowledge, attitude, and practice

Variable	Mean (SD)											
	Sex		*P*	Marital status		*P*	Field of Study		*P*	In-service training		*P*
	Male	Female		Married	Single		Radiology	Nonradiology		Yes	No	
Knowledge	7.3 (3.3)	7.2 (3.5)	0.8	7.0 (3.4)	7.7 (3.5)	0.07	7.6 (3.4)	6.3 (3.4)	<0.001	7.0 (3.1)	7.3 (3.6)	0.4
Attitude	9.2 (2.8)	8.4 (2.7)	0.006	8.9 (2.7)	8.5 (2.9)	0.2	8.6 (2.9)	8.8 (2.4)	0.3	8.9 (2.6)	8.5 (2.8)	0.08
Practice	12.6 (3.1)	13.5 (3.4)	0.008	13.2 (3.2)	12.7 (3.7)	0.1	13.2 (3.5)	12.9 (3.1)	0.3	13.1 (3.4)	13.0 (3.3)	0.8

SD = Standard deviation

Table 4: Linear regression analysis of independent risk factors influence on knowledge, attitude, and practice

Variable	Knowledge			Attitude			Practice		
	Beta	*t*	*P*	Beta	*t*	*P*	Beta	*t*	*P*
Sex (female)	0	0.008	0.9	−0.1	1.8	0.07	0.2	−3.8	<0.001
Marital status (married)	−0.14	2.4	0.01	0.03	−0.5	0.5	0.04	−0.8	0.4
Study field (radiology)	0.1	−2.3	0.01	−0.007	0.1	0.9	0.002	−0.03	0.9
In-service training (yes)	0.007	0.1	0.9	0.1	2.0	0.04	0.07	1.1	0.2
Experience duration with radiation (year)	0.1	1.7	0.07	0.09	1.4	0.1	0.2	3.6	<0.001
Level of education	0.2	3.7	<0.001	0.08	1.4	0.1	−0.1	−1.8	0.06

on the quality of working life and adverse effects on radiation workers' and patients' health.[24]

In the present study, RP-attitude was not associated with any of the studied variables, except in-service training. It shows that changing attitudes to radiation and overcoming these misconceptions is a challenge. However, the findings confirmed the conviction that in-service training is a way to enable them to have a more realistic RP-attitude.

Similar to attitude, RP-knowledge and adherence to RP practice were insufficient. This unacceptable RP-KAP means that radiation workers were unable to protect themselves from ionizing radiation effectively. Several studies documented the deficiencies in RP-knowledge and practice among various health-care workers who use ionizing radiation as a part of their work.[3,12,17]

With regard to safety knowledge, Paolicchi *et al*. revealed that radiation workers had a strong need to increase their RP-knowledge.[25] On the other hand, a study by Rassin *et al*. on RP-practice indicated that only 40% of the nurses and 75% of the physicians who performed ionizing radiation examinations in the catheterization wards were careful in safeguarding themselves from radiation hazards.[26]

In line with our study, low level of RP-knowledge and a little better practice among dental students were indicated in the study of Enabulele and Igbinedion.[27] In contrast, in other surveys, radiologic technologists had better safety knowledge than practice.[13,28] Shah *et al*. believed that the most important aspect in medical radiation science is the observation of RP principles.[29] On the other hand, the first step in the adoption and adherence to the principles and rules applicable in any environment is acquiring adequate knowledge of the mechanisms and provisions.[30] Radiation workers need training concerning diagnostic and therapeutic application of ionizing radiation in medicine, when their knowledge is evaluated as poor.[29] Findings from several studies have emphasized on continuous occupational education for medical radiation workers to improve their knowledge and capacities of RP issues and appropriately manage radiation exposure.[23,25,31]

Although most of our participants have attended in-service RP training over the past year, their attendance was not significantly related to their knowledge and practice. Similarly, in another survey, nearly, all participants (98.9%) participated in continuing education, but still adherence to safety practice was low.[28] It was surprising and alarming and showed that previous in-service training in our health setting was not effective. It seems contents of the classes were not completely relevant to participants' educational needs or their quality was not appropriate, so they could not influence radiation workers' knowledge and practice. Therefore, it is recommended that educational resources used for in-service training should be updated and it must include the most frequent issues to which they are exposed daily. Soye and Paterson stated that appropriate training helps medical professionals improve their knowledge about radiation.[32] Other reasons for no relationship between in-service training and RP-knowledge and practice may include inappropriate educational methods as well as the incentives and disincentives for transferring knowledge to practice. Unfortunately, in Iran, there are no special courses on RP in the educational curriculum of health-care professionals including physicians, nurses, and other health providers. However, the issues relating to ionizing radiation and RP as a core curriculum subject should be provided in their formal education.

As mentioned before, inappropriate in-service training may be a possible explanation of this rather poor RP-KAP among participants. Another reason could be insufficient supervision of RP activities by regulatory agencies and lack of regular performance feedback from supervisors and managers.

In comparison with the male radiation workers, females reported better RP-practice that agreed with the result reported by Tavakoli *et al.* and Salih *et al*. with significantly greater practice in female medical students compared to males.[14,15]

As expected, people who are graduated in the radiology field had better knowledge than radiation workers who are graduated in other fields of medical sciences. A similar result was obtained by Mihai *et al*. In their study, radiation professionals presented a better RP-knowledge compared to the general population and nonexposed medical doctors.[33] On the contrary, in another research, educational background was not related to adherence to safety practice.[28]

The results of this survey indicated that increasing the duration of professional radiation exposure is associated with the enhancement of radiation workers' practice. This finding was consistent with a previous study, which indicated a significant correlation between years in practice as a radiologic technologist and adherence to safety practice.[17] In our study, we can conclude that participants with less years of experience with radiation had a worse performance. Another study among invasive cardiologists showed that participants with working experience of <10 years had poorer knowledge and practice of radiation safety.[12] This is alarming because poor performance increases the risk of radiation exposure for both patients and radiation workers. Possible reasons for the poor performance of employees with less years of work experience could be due to insufficient number of health personnel, resource or equipment shortages, low level of job satisfaction and commitment to the organization, lack of job or other motivational factors, inappropriate training and education, and the need to review and update the curricula of universities. Notably, in most cases, these factors are likely to be interrelated and a combination of related factors may affect the performance of health‑care workers. Analysis of the determinants that influence radiation workers' performance must be considered when designing interventions. The effectiveness of interventions is dependent on ongoing planning to improve their knowledge and practice.

In this study, the more the educational level of participants was, the higher score they had in knowledge. We believe a higher education in the medical sciences as well as working in a radiation environment are more likely to be associated with a higher knowledge about radiology and seeking up‑to‑date knowledge based on educational needs. However, there was no relationship between RP‑attitude and practice and levels of education. In the study of Reagan and Slechta, higher level of education was not related to RP‑practice.[34]

This study had a number of limitations. It was not inclusive of medical students, residents, and radiology students who were exposed to radiation. In addition, it was a self‑reported questionnaire‑based study and the accuracy of the answers may not be seen in participants' practice. This study involved educational hospitals affiliated to TUMS and the results may not be generalizable to other health settings. Assessing participants' attitude and practice with close‑ended multiple choices questionnaire is a difficult task. Therefore, qualitative studies may be more helpful in exploring in depth RP‑attitudes and practice. Furthermore, in future studies, it is necessary to evaluate self‑care behaviors by observers using appropriate checklists. Finally, further qualitative studies are recommended to clarify the factors that may lead to poor RP‑KAP.

In planning a self‑care educational program, authors strongly recommend continuous medical education for radiation workers to be designed and developed in different educational levels based on their previous field of study and level of education. Experience has shown that just a single content and teaching method does not work for everyone. In addition, the quality of educational contents and teaching methods should improve based on the results of training evaluations and radiation workers' feedbacks. Based on the principles of adult learning, educational administrators should try to include the most common and important issues related to occupational exposure in educational contents and emphasize on strategies that can prevent and control exposure to ionizing radiation. In other words, issues with higher priority are placed in the spotlight.

According to the results of the study, radiation workers with more experience in radiation environment and with a degree in radiation field can play an important role in training processes of new partners and people with no degree in radiology, so training administrators should apply incentives to encourage experienced radiation workers with a university degree in radiology to share their experience and knowledge with other radiation workers.

Training programs can serve as a source for creating a positive attitude to self‑care. In other words, they foster a culture of self‑care in radiation environments. The self‑care culture induces the importance and necessity of KAP in the field of self‑care against radiation so that people can realize the role of continuing education in their health promotion.

Although this study had some weak points, there were some strong points. The majority of studies related to ionizing radiation focused on patients' health and assessed its therapeutic effects and side effects on the patients. A limited amount of literature examined the risk of occupational exposure to radiation. Therefore, this study tried to include "risk of occupational exposure" as an aspect of radiation surveys which has received relatively little attention.

Conclusion

The results of this study indicated that the RP‑KAP of radiation workers to protect them against radiation was undesirable. Health‑care workers with a degree in radiology had a higher RP‑knowledge. Hence, it is strongly recommended that medical radiation workers take a preservice RP training. Participation in in‑service training programs creates and maintains a positive RP‑attitude. It is essential to establish a culture of self‑care as a key factor to ensure higher performance.

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Conflicts of interest

There are no conflicts of interest.

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