Original Article

Knowledge, attitude and practice of nuclear medicine staff towards radiation protection

Danial Seifi[1], Hadi Hasanzadeh[2,3], Ahmad Bitarafan-Rajabi[4,5], Alireza Emadi[6], Mitra Bokharaeian[2,7], Fatemeh Shabani[2,7], Hamed Masoumi[8], Shima Moshfegh[9], Tahereh Khani[2,7], Mohamad Pursamimi[2,7], Athar Ehtiati[2,7], Shima Amin[7]

[1]Mazandaran University of Medical Sciences, Sari, Iran
[2]Department of Medical Physics, Semnan University of Medical Sciences, Semnan, Iran
[3]Cancer Research Center, Semnan University of Medical Sciences, Semnan, Iran
[4]Echocardiography Research Center, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran
[5]Cardiovascular Intervention Research Center, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran
[6]Deputy of Research and Technology, Semnan University of Medical Sciences, Semnan, Iran
[7]Student Research Committee, Semnan University of Medical Sciences, Semnan, Iran
[8]Department of Medical Physics and Radiology, Faculty of Medicine, Gonabad University of Medical Sciences, Gonabad, Iran
[9]Torbat-e-Jam Faculty of Medical Sciences, Torbat-e-Jam, Iran

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ABSTRACT

Introduction: Ionizing radiation in medical imaging is one of the dominant sources of exposure, and correct knowledge of radiation protection, affects staff safety behaviors during procedures. This study aimed to assess the radiation protection Knowledge, Attitude and Practice (KAP) amongst nuclear medicine centers' staff in Iran.

Methods: To evaluate the level of radiation protection KAP, a validated questionnaire was distributed between 243 participants considering demographic characteristics in different geographical regions in Iran from 2014 to 2015.

Results: There were statistically significant differences in the level of nuclear medicine staff KAP radiation protection with gender ($p<0.05$), practice age KAP level and radiation protection ($p<0.05$) among nuclear medicine staff with different working regions and healthcare market. There is no significant connection between educational age and KAP level of radiation protection of nuclear medicine department staff ($p>0.05$).

Conclusion: Our findings have shown that radiation protection KAP level of nuclear medicine staff was inadequate in some regions. This might be due to the lack of continuous training and absence of adequate safety knowledge about ionizing radiation. It seems that awareness about radiation protection rules and regulations, along with continuous training and preparations has a direct effect on radiation practice leading to enhanced KAP of staff in nuclear medicine centers.

Key words: Knowledge; Attitude; Practice; KAP; Radiation protection; Nuclear medicine staff

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Corresponding author: Dr. Ahmad Bitarafan-Rajabi, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran. E-mail: bitarafan@hotmail.com

INTRODUCTION

Nuclear medicine includes the use of a widespread range of radiopharmaceuticals for diagnostic and therapeutic purposes. Annually, thirty-seven million nuclear medicine processes are carried out globally [1]. Exposure to ionizing radiation can cause cancer, genetically induced mutation, developmental abnormalities and degenerative diseases [2]. Unwanted harms and complications can be prevented by good policies and regulations. So, a technologist must be well-educated and skilled to attain this aim. An exceedingly trained and expert technologist is a substantial participant of the healthcare staff and could afford suitable facilities using imaging methods and appraises radiographs of methodological quality. An excellent occupational program for technologists, which yields skilled technologists for both diagnostic and therapeutic working situations, is the origin of the development of a technologist's ability. With the contemporary modifications in the field of imaging, it is compulsory to improve imaging standards to achieve the goals of the healthcare community [3-6]. Consequently, it is essential to assess the status of imaging training courses and awareness level and compare them with related curriculums in the developing countries [7, 8]. The extra tasks of today's technologist make it crucial to elevate the educational programs to adequately train students without overpowering them in common procedures [9, 10]. An ideal program would compromise various techniques that could be involved more efficiently in the future of medical-imaging sciences and depends to a great extent on the result of its training and education [11, 12]. Technologists that work in nuclear medicine departments are one of the most exposed groups of workers and therefore are the highest significant contributors to the entire collective doses. But, other workers, such as nurses, physicians and physicists might potentially expose to internal pollution. From an internal dose measurement, perception due to the nature of their work, nuclear medicine workers are pointed out as being more at risk for internal contaminations. The radiation protection of nuclear medicine staff, predominantly in the management of beta-emitters, in the calculation of the dose to the extremities and in the risks of internal pollution in medical cyclotron personnel involved in synthesis processes, have been reviewed elsewhere. In the field of nuclear medicine, radiation protection is a very comprehensive topic, with the repercussions for a range of classifications: patients, members of the public, friends or relatives, caregivers and medical, technical and nursing staff. Several circumstances of inner exposures have already been known at medical centers [13]. Individual monitoring processes of internal radiations for personnel of nuclear medicine centers were informed based on practical screening executed for most radionuclides used in nuclear medicine, containing gamma and beta-emitting isotopes [14, 15]. For Iodine-131, a standardized surface contamination monitor is located in front of the thyroid to distinguish whether the activity threshold has been exceeded or not [16]. For other radionuclides with short half-lives such as ^{99m}Tc, ^{11}C, ^{18}F and ^{68}Ga, measurements contain daily dose rate assessment in front of the abdomen and also for gamma emitter radionuclides used for imaging such as ^{111}In and ^{201}Tl, dose measurements acquired with scintillation detector that positioned in front of the thorax. Internal monitoring curriculums in several European countries were legally applied [17-19]. However, the current study has been performed to assess radiation awareness between nuclear medicine staff. This study was directed to explore the staff's awareness and radiation-safety condition in Iranian hospitals, so as to realize the shortages and develop the situation.

METHODS

This study shows up with self-administered and cross-sectional survey questionnaires to evaluate the level of awareness and training of radiation protection in Iranian hospitals. The aim of this study was to assess the Knowledge, Attitude and Practice (KAP) status of the nuclear medicine centers' staff. To achieve this, questionnaires were distributed in selected nuclear medicine departments. The questionnaires were checked in terms of validation before distribution.

Considering the scientific evidences regarding radiation hazards and the existing literature on radiation protection, the primary draft of the questionnaire was developed under supervision of some expert panels consisting 10 panelists, including four medical physicists, one nuclear medicine specialist, one occupational health specialist, one epidemiologist and three of the linked center's staff. The items were assessed carefully calculating CVR (Content Validity Ratio) with the direct advice of the expert panelist. They were requested to specify the necessity of items in the questionnaire and score each item from 1 to 3 as (1) not necessary, (2) useful but not essential and (3) essential, respectively. The CVR was calculated as $(N_e - N/2)/(N/2)$, in which the N_e is the number of panelists indicating "essential" and N is the total number of panelists (CVR≥0.62 was the limit of accept of an item). After finalizing the questionnaire, a pilot study was conducted on 15 employees in nuclear medicine departments to check out the reliability of scale and ensure its face validity. The consistency of the scale was confirmed by repeated measurements. Two sets of responses (with a two-week interval of time) were considered in test-retest reliability measurements via estimating the Pearson's coefficient. The reliability of the final questionnaire was good enough(r=0.81, P<0.001).

It is notable that the validated questionnaire was approved by the ethical committee of the research council of Semnan University of Medical Sciences. A written consent was provided at the beginning of the questionnaire which was read by the participants before questionnaire completion and they were assured about the security of their completed questionnaire.

Questionnaire comprised of questions regarding demographic data and questions in general radiation protection fragment was designated to assess general knowledge and understanding background radiation exposure in comparison to medical X-ray radiation exposure and ionizing and non-ionizing radiation types such as the principle of ALARA, the annual dose limit received by employees, the annual dose limit for public and the 10- day rule. So as to appraise the level of radiation safety awareness, the questionnaires were distributed among 243 personnel working in Nuclear Medicine centers of 14 hospitals.

The questionnaires were distributed by Medical Physics students who were aware about the goal of the study, so they were asked to give the questionnaire to the exact technician and wait to fill it and answer any possible question clarifying the points may exist for technicians. So, there was no way for the technicians to ask, the answers from anybody or search in books or the internet.

Staff and technologists who were available and who were eager to participate have completed the questionnaire. A questionnaire based cross-sectional study was established to examine knowledge, attitude and practice of Nuclear Medicine Staff toward radiation protection in selected Iranian hospitals in 12 provinces in 2014-15. The questions were divided into four parts as: 1) demographic data like age, sex, job and etc. 2) personnel's knowledge, 3) personnel's attitude and 4) personnel's practice. Number of questions related to knowledge, attitude and practice were 10, 26 and 27, respectively.

The questions embedded in the questionnaire were selected carefully as explained above, so we could estimate somewhat exactly each of attitude, knowledge and practice terms separately.

Hospitals were selected in three types (Educational, Non educational and private clinic) and five regions (Capital, Center, East, North and West). The collected data were analyzed using descriptive statistics and paired sample t-test.

The questions each had a score and the final completed questionnaire by everyone, had a score which was some of attitude, knowledge and practice parts scores and so, our method was fully objective and the tests used were all parametric tests.

All the statistical analyses were executed using SPSS (version 21.0). One way ANOVA statistical test was used to analyze data based on the selected factors and parameters (knowledge, attitude and practice) and $p<0.05$ was considered significant.

RESULTS

A total of 87.3% of participant had returned their questionnaires. The general demographics of the participants presented in Figure 1 to 5. Table 1 represents the level of staff radiation protection knowledge.

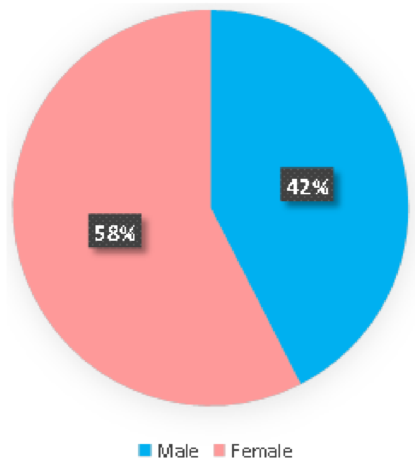

Fig 1. Distribution of gender among participants.

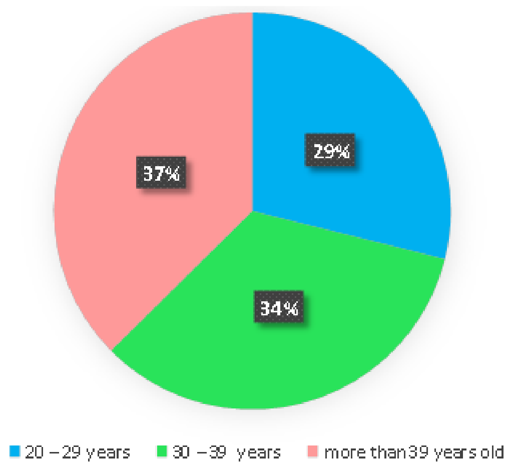

Fig 2. Distribution of age group among participants.

According to the gender, this study found statistically significant differences among the percentage of radiation protection knowledge of nuclear medicine staff ($p<0.05$). As distinguished in Table 1, the average knowledge level was 63.5 (SD=18.3) and 55.5 (SD=20.3) for males and female nuclear medicine staff, respectively.

Table 1. Radiation protection Knowledge among participants

	Characteristic	Mean	SD	P-value
Sex	Male	63.5	18.3	0.018
	female	55.5	20.3	
Educational age (yr.)	≤15	59.2	20.2	0.997
	>15	59.2	15.8	
Practice age (yr.)	≤15	57.6	21.7	0.053
	>15	63.6	11.6	
Region	Capital	57.8	22.6	0.004
	Center	47.3	16.1	
	East	66.0	18.3	
	North	59.2	12.9	
	West	62.2	12.7	

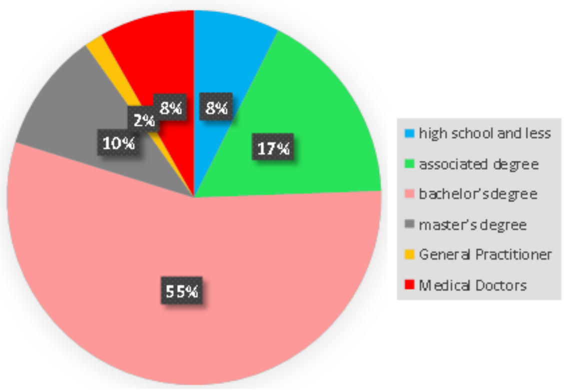

Fig 3. Distribution of academic educations among participants.

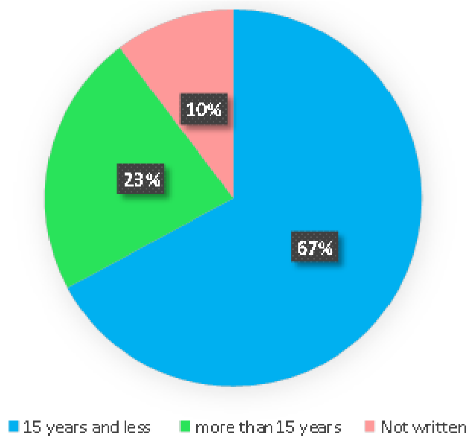

Fig 4. Distribution of work experience among participants.

In terms of time since graduation (educational age), there was not perceived any significant relation among staff (p>0.05). Consistent with the analysis of acquired data, there wasn't any relation between radiation protection knowledge and working experience in years (p>0.05). The average value of participant knowledge percentage was 57.6 (SD=20.27) and 63.6 (SD=11.6) for ≤15 years and >15 practice age, respectively. The staff with low level of working experiences had less knowledge about harmful effects due to radiation, but this difference was not statistically significant (p=0.05). Besides, there is a statistical relationship between knowledge of radiation protection and participant's working region (p<0.05).

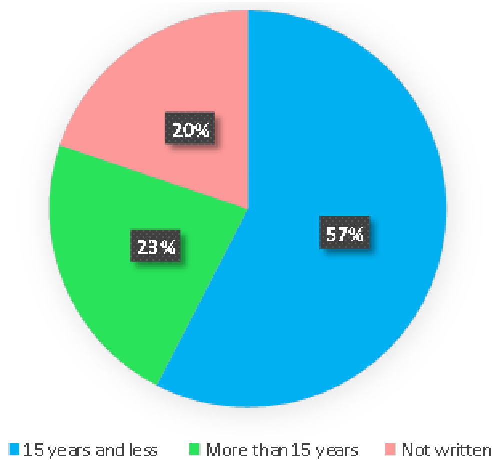

Fig 5. Distribution of elapsed time after graduation among participants.

Table 2 demonstrates that according to gender, there was statistically significant difference in the percentage of nuclear medicine staff radiation protection practice (p<0.05). Also, statistically significant difference was detected between clusters in the percentage of staff radiation protection practice with working experience (≤15 years and >15 years) (p<0.05). Moreover, the time since graduation was not notable on department staff radiation protection practice and we did not find any relation among the percentage of staff radiation protection practice with educational age (≤15 years and >15 years) of participants (p>0.05). As well, there is a statistical relationship between radiation protection practice and participant's working region (p<0.05).

Table 2: Radiation protection practice among participants.

	Characteristic	Mean	SD	P-value
Sex	Male	63.2	13.2	0.049
	female	56.4	14.0	
Educational Age (yr.)	≤15	58.3	14.1	0.653
	>15	59.3	11.0	
Practice Age (yr.)	≤15	58.0	14.8	0.007
	>15	63.9	10.0	
Region	Capital	59.9	14.0	0.0409
	Center	57.1	18.9	
	East	61.6	13.1	
	North	58.7	11.3	
	West	54.9	11.6	

Table 3: Radiation protection attitude among participants

	Characteristic	Mean	SD	P-value
Sex	Male	61.4	17.9	0.670
	female	58.5	18.8	
Educational Age (yr.)	≤15	59.3	17.1	0.364
	>15	61.8	17.2	
Practice Age (yr.)	≤15	59.6	18.5	0.265
	>15	62.7	15.8	
Region	Capital	60.5	18.8	0.00
	Center	45.6	22.8	
	East	63.3	13.9	
	North	65.2	14.5	
	West	64.6	13.1	

Table 4: Radiation protection knowledge, practice and attitude (KAP) among participants

	Characteristic	Mean	SD	P-value
Sex	Male	62.7	12.4	0.010
	female	56.8	13.4	
Educational Age (yr.)	≤15	58.9	13.2	0.563
	>15	60.1	10.0	
Practice Age (yr.)	≤15	58.4	14.1	0.014
	>15	63.4	8.4	
Region	Capital	59.2	14.5	0.001
	Center	50.0	15.4	
	East	63.6	10.9	
	North	61.0	7.9	
	West	60.7	7.5	

The results in Table 3 indicate that the mean level of radiation protection attitudes of men and women personnel, were 64.45 (SD=17.9) and 58.54 (SD=18.8), respectively. So, there was not perceived any significant relation among staff's gender and radiation protection attitudes ($p>0.05$). In addition, we did not find any relation between education level of participants and working expertise with their radiation protection attitudes ($p>0.05$). In terms of attitude, like two last parameters, there is a statistical relationship between radiation protection practice and participant's working locality ($p<0.05$). Consistent with Table 4, the statistical difference observed in the percentage of staff radiation protection knowledge, attitude and practice with gender, practice age and the participant's working locality as well as geographical region ($p<0.05$). Nevertheless, in terms of educational age, the statistical difference was not observed in the percentage of staff radiation protection knowledge, attitude and practice ($p>0.05$).

DISCUSSION

This study reveals many significant defects in nuclear medicine staff's knowledge about imperative features of radiation protection and could evaluate their practice and attitude that should be deliberated when developing the radiation protection curriculum to encounter challenges of the future. Bearing this in mind, the aim of the radiation protection protocol should emphasize to avert the existence of deterministic effects and to decrease the probability of stochastic effects by diminishing the exposure to patients and the workplace staffs [20-22]. If the technologists do not have an appropriate awareness of the radiation protection issues, it may be answerable for unreasonably accumulated radiation dose delivered to patients for a given diagnostic test. Application of radiation protection courses and training, practical subjects, as well as radiation dose received by patients and radiation safety, through medical education curriculums could be an operative technique to decrease the patient's dose in medical examinations. As well, the application of radiation protection for nuclear medicine staff is unavoidable. The acquired data demonstrate that most of the staff who contributed to this study is familiar to radiation protection rules and recommendations. Numerous studies have shown occupational exposure to radiation [23-26]. The results of this survey revealed that gender affects the level of staff radiation protection knowledge and practice (As it displayed in Tables 1, 2 and 4), but the percentage of attitude was almost similar among male and female staff. According to the level of staff radiation protection knowledge, attitude and practice, it can be concluded that, in male employees (Mean= 62.7), the percentage of all these parameters were higher than females (Mean=56.8). This could be due to the appropriate male staff's ability in applying practical skills of radiation protection.

In comparison, dehghani et al. couldn't demonstrate any significant differences of radiation protection knowledge among different genders [27]. Joñczyk-Potoczna et al. measured the awareness and knowledge of the students related to exposure and the results of statistical analysis, indicated that there is no statistically significant difference in radiation protection knowledge in terms of gender [28]. Moreover, in this study there is a significant relationship between job experience and radiation safety knowledge and practice of participant around necessity performance of periodical examination and also application of organ shield for patients, but educational age (Elapsed time since graduation) has no effect on the level of nuclear medicine staff radiation protection knowledge and practice. This consequence is amazing and alarming. Although they have educated recently, but there is insufficient awareness about radiation effects. It is strongly recommended that they recover their understanding about the biological effects of radiation and renew them through upward their skill. On the other hand, neither job experience, nor educational age didn't affect the level of staff radiation protection attitude. It means that the level of staff radiation protection attitude with 15 years working duration or less was similar to staff with working duration greater than 15 years. This might be due to the low availability of radiation protection trainings and the lack of passion towards altering professional routines between senior workers. In comparison to another study, it was reported that the attitude, knowledge and practice of radiation protection to be impressed with the level of education [29]. According to Mojiri et al. [30], there is a relation between awareness of radiation effects and working experience (years) and they conclude that personnel with lower levels of working experiences had less knowledge about the harmful effects of radiation. Besides, they terminated statistical association between awareness and participant's educational level. Also Su et al. [31] showed that there is a relation between knowledge of radiation effects and working experience. Szarmach et al. demonstrated that the radiation protection awareness of employees with more than 16 years of familiarity was low down and disturbing [32]. Consistent with these consultations, many factors were donated to the poor knowledge percentage would be realized. The undergraduate personnel never have proper preparation and the insufficiency of knowledge of basic ethics in postgraduate personnel and lack of systematized non-stop educational courses in hospitals about radiation protection. Furthermore, there were poor accessibility of radiation safety tools as new radiation dosimeters and this could be one of the main reasons for not consuming them. There was no systematic monitoring of radiation exposure per year and consequently, it is challenging to consider the regular radiation exposure in medical centers. The discouraging answers regarding participant knowledge of several basic values of radiation protection were deduced as being caused by shortage of proper intensive teaching in radiation safety. From this investigation, the training platform for the nurses, technologists and other staff in the nuclear medicine departments would be very effective. However, the knowledge, attitude and practice on radiation protection between nuclear medicine staff in more working regions are still at the adequate level. Besides, that prospect plans to expand nuclear medicine staff's knowledge, attitude and practice on radiation protection, also need to be examined, advanced, executed and appraised. They should be extremely recommended to expand their knowledge about biological effects of radiation and modernize themselves through developing their skills. We suggest considering strategies to respectable usage of imaging tests, continuous education on radiation protection in hospital, practice and embedding radiation protection training to staff in the basic syllabus and information about radiation harms through online courses to reduce unwanted harmful effects of radiation and increase radiation protection KAP.

CONCLUSION

In conclusion, health physicists have studied and pronounced in feature numerous issues about radiation protection, many researchers have tried to find techniques of reducing the radiation burden, and uncountable articles on the regulatory parts of radiation protection have been distributed. Bearing in the mind the results of this study, it is essential for nuclear medicine centers, to ongoing professional expansion; by holding up additional workshops, short-term preparation courses, tuition and sharing of posters on the radiation protection counter to radiations so as to increase nuclear medicine departments staff information and performance to develop a respectable trend in radiation protection and safety.

REFERENCES

1. World Health Organization. Global initiative on radiation safety in health care settings. Geneva: WHO Headquarters; 2008.
2. Migliore L, Coppedè F. Genetic and environmental factors in cancer and neurodegenerative diseases. Mutat Res. 2002 Dec;512(2-3):135-53.
3. Mettler Jr FA, Guiberteau MJ. Essentials of nuclear medicine imaging. Philadelphia, PA: Elsevier Health Sciences; 2011.
4. Hendel RC, Corbett JR, Cullom SJ, DePuey EG, Garcia EV, Bateman TM. The value and practice of attenuation correction for myocardial perfusion SPECT imaging: a joint position statement from the American Society of Nuclear Cardiology and the Society of Nuclear Medicine. J Nucl Cardiol. 2002 Jan-Feb;9(1):135-43.
5. Figley MM, Margulis AR. The impact of new imaging technology on health care, research, and teaching: an international symposium. AJR Am J Roentgenol. 1987 Dec;149(6):1111-26.
6. Heller GV, Links J, Bateman TM, Ziffer JA, Ficaro E, Cohen MC, Hendel RC. American Society of Nuclear Cardiology and Society of Nuclear Medicine joint position statement: attenuation correction of myocardial perfusion SPECT scintigraphy. J Nucl Cardiol. 2004 Mar-Apr;11(2):229-30.
7. Picano E. Sustainability of medical imaging. BMJ. 2004 Mar 6;328(7439):578-80.
8. Muhogora WE, Ahmed NA, Almosabihi A, Alsuwaidi JS, Beganovic A, Ciraj-Bjelac O, Kabuya FK, Krisanachinda A, Milakovic M, Mukwada G, Ramanandraibe MJ, Rehani MM, Rouzitalab J, Shandorf C. Patient doses in radiographic examinations in 12 countries in Asia, Africa, and Eastern Europe: initial results from IAEA projects. AJR Am J Roentgenol. 2008 Jun;190(6):1453-61.
9. Picano E. Informed consent and communication of risk from radiological and nuclear medicine examinations: how to escape from a communication inferno. BMJ. 2004 Oct 9;329(7470):849-51.
10. Correia MJ, Hellies A, Andreassi MG, Ghelarducci B, Picano E. Lack of radiological awareness among physicians working in a tertiary-care cardiological centre. Int J Cardiol. 2005 Sep 1;103(3):307-11.
11. Brown N, Jones L. Knowledge of medical imaging radiation dose and risk among doctors. J Med Imaging Radiat Oncol. 2013 Feb;57(1):8-14.
12. Thomas KE, Parnell-Parmley JE, Haidar S, Moineddin R, Charkot E, BenDavid G, Krajewski C. Assessment of radiation dose awareness among pediatricians. Pediatr Radiol. 2006 Aug;36(8):823-32.
13. Osko J, Golnik N, Pliszczynski T. Cases of post-accident contamination with iodine 131I, registered in the Institute of Atomic Energy POLATOM in Swierk, Poland. Radiat Prot Dosimetry. 2011 Mar;144(1-4):560-3.
14. Baechler S, Stritt N, Bochud FO. Individual monitoring of internal exposure for nuclear medicine workers in Switzerland. Radiat Prot Dosimetry. 2011 Mar;144(1-4):464-7.
15. Kerekes A, Kocsy G, Pellet S. Individual monitoring for internal exposure of workers: regulation and practice in Hungary. Radiat Prot Dosimetry. 2007;125(1-4):33-6.
16. Chen S, Yu L, Jiang C, Zhao Y, Sun D, Li S, Liao G, Chen Y, Fu Q, Tao Q, Ye D, Hu P, Khawli LA, Taylor CR, Epstein AL, Ju DW. Pivotal study of iodine-131-labeled chimeric tumor necrosis treatment radioimmunotherapy in patients with advanced lung cancer. J Clin Oncol. 2005 Mar 1;23(7):1538-47.
17. Armpilia CI, Dale RG, Coles IP, Jones B, Antipas V. The determination of radiobiologically optimized half-lives for radionuclides used in permanent brachytherapy implants. Int J Radiat Oncol Biol Phys. 2003 Feb 1;55(2):378-85.

18. Marhas KK, Goswami JN, Davis AM. Short-lived nuclides in hibonite grains from Murchison: evidence for solar system evolution. Science. 2002 Dec 13;298(5601):2182-5.

19. Lopez MA, van Dijk JW, Castellani CM, Currivan L, Falk R, Olko P, Wernli C. Individual monitoring for internal exposures in Europe: conclusions of an EURADOS action. Radiat Prot Dosimetry. 2006;118(2):176-81.

20. Hamada N, Fujimichi Y. Classification of radiation effects for dose limitation purposes: history, current situation and future prospects. J Radiat Res. 2014 Jul;55(4):629-40.

21. Kovoor P, Ricciardello M, Collins L, Uther JB, Ross DL. Risk to patients from radiation associated with radiofrequency ablation for supraventricular tachycardia. Circulation. 1998 Oct 13;98(15):1534-40.

22. Tien HC, Tremblay LN, Rizoli SB, Gelberg J, Spencer F, Caldwell C, Brenneman FD. Radiation exposure from diagnostic imaging in severely injured trauma patients. J Trauma. 2007 Jan;62(1):151-6.

23. Loose R, Wucherer M. Occupational exposure to radiation. Radiologe. 2007 May;47 Suppl 1:S27-38; quiz S39.

24. Guénel P, Laforest L, Cyr D, Févotte J, Sabroe S, Dufour C, Lutz JM, Lynge E. Occupational risk factors, ultraviolet radiation, and ocular melanoma: a case-control study in France. Cancer Causes Control. 2001 Jun;12(5):451-9.

25. Sont WN, Zielinski JM, Ashmore JP, Jiang H, Krewski D, Fair ME, Band PR, Létourneau EG. First analysis of cancer incidence and occupational radiation exposure based on the National Dose Registry of Canada. Am J Epidemiol. 2001 Feb 15;153(4):309-18.

26. Muirhead CR, O'Hagan JA, Haylock RG, Phillipson MA, Willcock T, Berridge GL, Zhang W. Mortality and cancer incidence following occupational radiation exposure: third analysis of the National Registry for Radiation Workers. Br J Cancer. 2009 Jan 13;100(1):206-12.

27. Dehghani A, Ranjbarian M, Mohammadi A, Soleiman-Zade M, Dadashpour-Ahangar A. Radiation safety awareness amongst staff and patients in the hospitals. Int J Occup Hyg. 2015; 6(3):114-9.

28. Jończyk-Potoczna K, Strzelczuk-Judka L, Szłyk E, Stefaniak Ł. Medical students' awareness of radiation exposure related to radiological imaging procedures. J Med Sci. 2016;83:244-9.

29. Davoudian Talab A, Badiee Nejad A, Beit Abdollah M, Mahmoudi F, Barafrashtehpour M, Akbari G. Assessment of awareness, performance, and attitudes of radiographers toward radiological protective principles in Khuzestan, Irangraphers. J Health Res Comm. 2015;1(3):16-24

30. Mojiri M, Moghimbeigi A. Awareness and attitude of radiographers towards radiation protection. J Paramed Sci. 2011;2(4):1-5.

31. Su WC, Huang YF, Chen CC, Chang PS. Radiation safety knowledge of medical center radiological technologists in taiwan. Radiat Oncol. 2000;50(2):1-3.

32. Szarmach A, Piskunowicz M, Świętoń D, Muc A, Mockałło G, Dzierżanowski J, Szurowska E. Radiation safety awareness among medical staff. Pol J Radiol. 2015 Feb 1;80:57-61.