Journal of Research in Medical and Dental Science
2022, Volume 10, Issue 2, Page No: 24-32

Available Online at: www.jrmds.in
eISSN No.2347-2367: pISSN No.2347-2545

Investigation of the Awareness Level Concerning Radiation Safety among Radiology Healthcare Professionals in Saudi Arabia

Yousif Abdallah*

Department of Radiological Science and Medical Imaging, Faculty of Applied Medical Science, Majmaah University, Al-Majmaah, 11952, Saudi Arabia

ABSTRACT

Objectives: Radiation protection is a critical issue in health care, especially for patients who have undergone high-dose exposure procedures and pediatric patients. The objective of this study was to assess the awareness level concerning radiation safety among radiology health care professionals.

Methods: The Institutional Review Board approved this study prior to data collection (IRB of King Fahad Medical City, Riyadh, Saudi Arabia; No. 18–532E). The survey consisted of 30 questions. Five inquiries were related to demographics, and the remaining 25 questions included radiation dose, ALARA principles, NCRP and IAEA regulations, childhood and fetal exposures, and risks. For analysis of the responses to each question, the chi-squared test was used. To assess the relationship between the answers and the demographic variables, the Kruskal–Wallis and Mann–Whitney tests were utilized.

Results: This study was conducted among 250 participants; 75% (188) were men and 25% (62) were women, and 78% of the participants scored 18.5 out of 20. The scores of the participants on radiation dose, ALARA principles, international and national radiological regulations, and radiation exposure risks were 19.7 ± 4.1, 16.8 ± 4.1, 18.3 ± 4.05, 16.2 ± 3.6 and 19.1 ± 5.3, respectively. A total of 87.2% (218) of the participants were aware of radiation protection procedures and optimization.

Conclusion: This study revealed that most of the participants (87.2%) had "excellent" radiation protection knowledge. The participants with good to fair knowledge accounted for only 4.4%.

Key words: Awareness, Radiation safety, Radiology, Healthcare team, Saudi Arabia

HOW TO CITE THIS ARTICLE: Yousif Abdallah, Investigation of the Awareness Level Concerning Radiation Safety among Radiology Healthcare Professionals in Saudi Arabia, J Res Med Dent Sci, 2022, 10(2): 24-32

Corresponding author: Yousif Abdallah
E-mail✉:y.yousif@mu.edu.sa
Received: 17/11/2021
Accepted:01/02/2022

INTRODUCTION

Medical imaging is considered a critical tool for diagnosing different diseases and monitoring prognosis. Ionizing radiation is considered one of these important imaging tools [1–3]. Radiation exposure has health risks for both patients and health care teams [1,4–7]. Excessive exposures should be avoided as it increases the risk of cancer development. There are two biological types of ionizing radiation effects depending on the radiation types and exposure amounts [8–9]. These types are categorized as deterministic or stochastic effects. Deterministic effects appear after exposure to a certain amount of radiation. This amount of radiation exposure is called a threshold. The deterministic effects involve the eyes and skin [10]. The long-exposure radiation modalities contribute to more radiation compared with other modalities, such as fluoroscopy and interventional radiological procedures are responsible for high-dose exposure and it has consequences for both patients and workers [11–14]. The effects of the radiation dose on human tissues are dependent on the magnitude of those exposures and the type of radiation. This is typically the result of referring patients to a radiology clinic for a radiogram for subsequent X-ray examinations [15–16]. In addition to handling and managing these patients' radiation doses, these referring physicians have a considerable obligation to control and minimize their exposure to radiation. The physician referred the patient because the potential benefit was estimated to be positive and greater than the risk from the radiation dose [17–18]. However, based on several studies, physicians estimated the amount of radiation delivered in an arteriogram to be 16 times lower than that received [19–22]. Other researchers found that six times more physicians in practice provided an estimated rather than an actual dose of radiation [23–25]. It has also been described that referring doctors have inadequate information about radiation and its hazardous potential as well as about the information that can be gained through its use and that most patients obtain their information about this type of radiation from the internet [26–27]. Doctors and medical professionals are generally ignorant about the long-term effects of radiation doses on the general population, and this issue has been brought to their attention. In this study, researchers investigated the influence of dose on patients' vulnerability to radiation exposure among Saudian and Middle Eastern doctors [28–31].

MATERIALS AND METHODS

The Institutional Review Board approved this study prior to data collection (IRB of King Fahad Medical City, Riyadh, Saudi Arabia; No. 18–532E). The questionnaire was distributed online using a Google Blogger Survey. Written consent and agreement of the participants were obtained before data collection. The participants' ages, education levels, and other information were collected from people who worked in radiology departments from 2019 to 2020. Information was collected on possible childhood exposures to ionizing radiation, as well as on nonionizing radiation, and the health risks for fetuses. I used comfod and snowball techniques and collected large enough amounts of data, resulting in an adequate sample size. Cohen states that if the chance of a 0.318 correlation existing in the remaining population is 90 percent, then 90% of the sample should be able to detect a correlation at that level. Sex, age, specialty, educational level, years of clinical experience, specific formal radiology courses in their curriculum, and the most common radiological examination routinely performed were all mandatory questions on the questionnaire. The second section of the questionnaire contained 25 questions about radiation dose, ALARA principles, NCRP and IAEA regulations, radiation quality-ionizing type, pediatric exposure, exposure during pregnancy, and radiation exposure consequences. All questions were written in English and included numerous selection options. The questionnaire was in agreement with the majority of thirty peer-reviewed published research studies. Some changes, such as the addition and removal of certain questions, was conducted after further review. The revised questionnaire was given to a panel of students, experts, and a group of radiologists who were not involved in the study. They were used to validate these changes. To ensure that the findings were accurate, three distinguished radiologists re-examined the survey data before publishing it. These physicians were excluded from completing the questionnaire during the actual study. To ensure the reliability of the study tool, a pilot study was performed with the same group of physicians twice with an interval of two weeks. The results were retested using the same methodology. Before being transferred to SPSS Version 26 for statistical analysis, the survey responses were manually entered into Excel. All variables' missing values and data entry accuracy were checked before analysis. The average score for each sample question was 20. To see if there was a meaningful relationship among the answers, the chi-square test was utilized for every question. The Kruskal–Wallis and Mann–Whitney tests were utilized to compare the replies among the population variable groups. All correct answers for the examination were calculated with numbers, percentages, maximum, minimum, fifth percentile, mean and 95th percentile. For calculating the knowledge, behavior, and practical results, the Khan et al. (2014) scale was used (30). A score of less than or equal to 50% shows that knowledge is poor, that 59–73% is fair, and 88% or greater suggests that knowledge is good. Statistical significance was defined as $p < 0.05$.

RESULTS AND DISCUSSION

A total of 250 participants completed the survey. In the sample, 75% (188) were men and 25% (62) were women between 20–30 years of age. Radiology technologists comprised 83.7% of the participants. Postgraduate radiology technologists made up 44.5%, and the remainder were specialists (6.2%). Nearly two-thirds (88.2% of the participants) had previous training in giving a PED injection and were asked to attend additional training for PED radiation dosing classes for imaging. Each radiation item was given a five-point rating on a second scale, with each point indicating an additional level of radiation knowledge or reporting. Over half of the time, the participants self-acknowledged that their knowledge level was "moderate." Among the participants who attempted the test, 82.1% responded to at least half of the questions correctly. Although the responses ranged from 17 to 20 on a scale of 0 to 20, the majority of them showed an excellent level of knowledge (Table 1). The responses in this section were related to different degrees of accuracy. The survey results indicated that 18% of the participants believed that radiologists had the most knowledge about radiation risk (there were 203 correct responses). The correct responses increased by 51.1%. With an average rate of 193 right answers, the radiation section had a 77.3% correct response rate. The women and junior participants showed universally high levels of knowledge and expertise on the relevant sections of the assessment of radiation on fetal health, while nearly all of the 158 (65%) of the junior participants (all but six of them) knew about the radiation risks to pregnant women (32.7%). The results of the calculated data showed that 95% of the participants had good to excellent knowledge (Table 1).

Table 1: Descriptive analysis of correct answers of the whole exam.

Measurements	N (%)
Maximum score	18 (90%)
Minimum score	3 (15%)
5th percentile	4.00 (20%)
Mean of correct answers	9.5 (47.5%)
95th percentile	13.00 (65%)

Table 2 shows the percentage of participants who responded to each questionnaire section. A total of 83.7% of the participants had sufficient information about radiation protection and were licensed to deliver a dose of radiation. Seventy-two percent of those who had spent sufficient time studying radiation emissions had an excellent level of knowledge of radiation safety. Only 39.8% of participants had acquired knowledge about background radiation levels. Sixty percent of the participants knew the dose of radiation received from a chest X-ray, while only 30% of participants knew the general population doses of radiation medical imaging to patients. A total of 3.8% of the participants in the study were able to determine the annual dose limits for each procedure. A total of 5.8% of the participants indicated that they needed additional information. Eighty-eight percent of the participants identified the average radiation dosage received by the public due to diagnostic modalities. Ninety percent of the participants answered correctly about the "ALARA" concept. A total of 84.9% of the participants' responses indicated that the most vulnerable tissues were a foetus prior to 20 weeks. Seventy-seven percent of the participants responded that pregnant women could undergo CT brain examinations. Seventy-two percent of the participants answered that the risk of cancer incidence increases when the radiation dose increases.

A total of 84.7% of the participants answered that radiological procedures were always justified. Eighty-eight percent of the participants answered that they kept the radiation dose during radiological investigations as low as the ALARA recommendations. Ninety-two percent of the participants answered that protective devices are recommended during X-ray examinations for both radiologists and technicians (Table 2).

Table 2: Participants' answers to the five sections.

	Answer	N (%)
	Radiation dose (Questions 1-6)	
Which of the following modalities is responsible for most of radiation dose?	Ultrasound	3 (1.0%)
	Chest x-ray	17 (5.8%)
	CT	227 (77.5%)
	MRI	34 (11.6%)
	Lumbar spine x-ray	2 (0.7%)
	I don't know	10 (3.4%)
Which of the following has a prolonged period of time of emitting radiation?	PET-CT	171 (58.3%)
	Abdomen CT	40 (13.7%)
	Abdomen MRI	29 (9.9%)
	Barium study	12 (4.1%)
	I don't know	41 (14.0%)
How does the radiation dose from a chest x-ray compare to the annual dose of background radiation?	0.111111111	92 (31.4%)
	1:10	44 (15.0%)
	1:01	9 (3.1%)
	10:01	27 (9.2%)
	I don't know	121 (41.3%)
What is the patients absorbed dose from a chest x-ray?	0.02 mGy	61 (20.8%)
	0.2 mGy	56(19.1%)
	2 mGy	34 (11.6%)
	i don't know	142(48.5%)
How much radiation does the public receive from medical imaging?	1.50%	40 (13.6%)
	5%	75 (25.6%)
	15%	36(12.3%)
	50%	12(4.1%)

	i don't know	130(44.4%)
What is the annual dose limit for patients in mSv?	10	46 (15.7%)
	20	63 (21.5%)
	50	28 (9.6%)
	Unlimited	12 (4.1%)
	I don't know	144 (49.1%)
	Ionizing radiation (Questions 7-10)	
Which of the following doesn't use ionizing radiation? (choose all that apply)	Ultrasound	194(66.2%)
	Chest x-ray	26(8.9%)
	CT	13 (4.4%)
	MRI	128(43.7%)
	Nuclear medicine	30 (10.2%)
	I don't know	19 (6.5%)
Do you know What does the acronym "ALARA" represent	Yes	26(8.8%)
	No	224 (76.5%)
	I don't know	43 (14.7%)
Which one of the following is less sensitive to radiation	Thyroid	11 (3.7%)
	Breast tissue	55 (18.8%)
	Gonads	43(14.7%)
	Kidney	142(48.5%)
	I don't know	42(14.3%)
Which one of the following is most sensitive to radiation	Children	225(76.8%)
	Adolescents	15 (5.1%)
	Adults	13(4.4%)
	Elderly	10 (3.4%)
	I don't know	30(10.2%)
	Pediatric radiation (Questions 11-13)	
In pediatric population what is the most sensitive organs to radiation	Liver	25 (8.5%)
	Kidneys	58(19.8%)
	Gonads	148 (50.5%)
	Stomach	5 (1.7%)
	I don't know	57 (19.5%)
	Less than 20 weeks	235 (80.2%)
Fetal tissue are susceptible to radiation especially during	Between 20 - 30 weeks	19 (6.5%)
	30 weeks to term	12 (4.1%)
	I don't know	27 (9.2%)
Estimate the radio-sensitivity of 5 year-old patient in comparison to an adult?	The same	21 (7.2%)
	Less	41(14.0%)
	5 times more	93 (31.7%)
	10 times more	35 (11.9%)
	I don't know	103 (35.2%)
	Pregnant women radiation (Questions 14-16)	

Can pregnant women be submitted to skull CT only?	Yes	126 (43.0%)
	No	124 (42.3%)
	I don't know	43 (14.7%)
Can pregnant women be submitted to or screening mammography?	Yes	119 (40.6%)
	No	139 (47.5%)
	I don't know	35 (11.9%)
Should every woman in childbearing age be submitted to a pregnancy test before being submitted to radiography of the pelvis	Yes	181 (61.8%)
	No	82 (28.0%)
	I don't know	30 (10.2%)
	Radiation risks (Questions 17-20)	
Does the risk for developing cancer increase with the dose value and may be present even with a single exposure?	Yes	177(60.4%)
	No	68 (23.2%)
	I don't know	48(16.4%)
Should any activity involving radiation be justified in relation to available alternatives	Yes	210(71.7%)
	No	44 (15.0%)
	I don't know	39 (13.3%)
Should all exposures to radiation be maintained as low as reasonably achievable (ALARA)?	Yes	165(56.3%)
	No	50 (17.1%)
	I don't know	78 (26.6%)
Should physicians and technicians who perform procedures utilizing ionizing radiation always be protected with shielding equipment and keep themselves as far as possible from the radiation source?	Yes	256 (87.3%)
	No	26(8.9%)
	I don't know	11 (3.8%)

*N is the number of participations, %percentage in relation to total. In bold letter, the correct answers.

Only 35.2% of participants correctly identified the radiation effect on the under 1 year age group compared to the other age groups (1–5 and > 5 years), with 36.8% and 28.0%, respectively.

A total of 5.1% of the participants indicated that it is safe to say that fetal tissue becomes nonviable (dead) at approximately 24–26 weeks of gestation if exposed to radiation. Regarding performing radiological procedures for pelvic examinations of pregnant women, 26.0% of the respondents reported that it could be done with proper precautions, while 72% of the participants recommended that a pregnancy test be performed before having a mammogram.

Seventy-two percent of the participants demonstrated an accurate understanding of the correlation between exposure dose and cancer risk, with only a single exposure contributing to cancer. A total of 88.0% of the participants felt that the number of different radiation doses should be kept to a minimum (ALARA). A total of 92.0% of participants understood that, in addition to being aware of alternatives, they must also know whether radiation techniques using ionizing radiation sources require protective efforts. There were significant differences between male and female participants regarding pediatric and pregnant women's exposure and radiation exposure consequences (p=0.038; p=0.011; p=.0.007).

The K-W test was applied. The women performed better on the radiation risk factor section (p=0.007). The results showed that statistically significant radiation risk differences were detected when scores were sorted by age (p=0.002), and participants aged 30 years and older had the highest scores. Education was strongly linked to increases in scores (p=0.053). Finally, in the pregnant women's specific occupational exposure section, both general and specialized occupational exposure had a significant effect (p=0.012).

However, at the same time, there were no significant differences in graduation years (Table 3).

Several researchers have concluded that doctors around the world do not have adequate understanding of the dangers of radiation exposure (Table 4).

Table 3: Knowledge score according to the physicians' characteristics.

Variables		Radiation Dose (6 Questions)	Ionizing Radiation (4 Questions)	Pediatric Radiation (3 Questions)	Pregnant Women Radiation	Radiation risks (4 Questions)					
					(3 Questions)						
	N	Mean	p-value	Mean	p-value	Mean	p-value	Mean	p-value	Mean	p-value
Gender											
Male	151	32.50%	0.766	46.50%	0.228	50.00%	0.044	41.00%	0.018	64.50%	0.009
Female	142	33.00%		43.50%		44.30%		33.00%		73.50%	
Age											
20-25 years	147	32.80%	0.664	43.20%	0.373	46.00%	0.303	34.00%	0.187	72.20%	0.001
25-30 years	124	32.30%		46.00%		47.00%		39.30%		62.50%	
>30 years	22	34.80%		47.50%		56.00%		45.30%		80.00%	
Education											
Internship	141	32.80%	0.895	44.00%	0.045	45.30%	0.192	33.00%	0.077	71.20%	0.045
Resident	135	32.60%		44.20%		56.60%		40.00%		65.00%	
Specialist	17	33.30%		58.70%		56.60%		49.00%		77.70%	
Specialty											
internal medicine	75	34.10%	0.303	45.20%	0.336	48.00%	0.508	39.30%	0.017	69.20%	0.435
Emergency doctors	24	27.60%		40.50%		48.30%		30.30%		62.50%	
General surgery	31	32.60%		51.50%		54.60%		48.30%		63.50%	
Special surgeries	23	31.00%		48.70%		46.30%		47.60%		86.20%	
Year of graduation											
< 1 year	116	31.00%	0.163	41.70%	0.172	45.00%	0.149	33.30%	0.105	69.50%	0.086
1-2 years	53	34.80%		45.00%		44.00%		35.60%		69.20%	
> 2 years	124	32.80%		48.70%		53.00%		43.00%		67.70%	
Bold font indicates statistically significant values <0.050											

Table 4: Comparison between the samples and results of the health professionals' knowledge about radiation studies in Saudi Arabia and other countries.

Country	Reference	Year	Sample	Level of Knowledge
Australia	[16]	2010	Doctors in the emergency departments	Poor
	[17]	2010	Student and intern	Lack of knowledge
	[3]	2011	Doctors from all grades	Poor
Hong Kong	[21]	2012	Local physicians, radiologists and interns	Unsatisfactory
	[22]	2012	Radiologists and non-radiologists doctors	Inadequate among radiologists, and particularly poor in non-radiologists
India	[26]	2014	Physicians and junior residents	Deficit of knowledge
Italy	[31]	2017	Physicians	Good level
This Study		2021	Internal medicine, emergency doctors, surgery internship and minor surgeries	Excellent
Malaysia	[25]	2012	Specialists, house officers, medical officers, trainee lecturers.	Poor
Morocco	[32]	2017	Medical specialists, surgeons, general practitioners and residents	Poor
Nigeria	[24]	2012	Medical doctors apart from radiologists	Poor
Northern Ireland	[15]	2008	Consultants and junior doctors from a range of specialties	Poor

Norway	[23]	2010	General practitioners	Poor
Turkey	[14]	2007	Doctors and intern doctors	Inadequate
United Kingdom	[13]	2003	Senior house officers, specialist registrars, consultants, and consultant radiologists	Poor
	[19]	2006	Radiologists, nuclear physicians, dual-accredited radiologist–nuclear medicine physicians, medical physicists, and pulmonologists.	Lack of knowledge
	[18]	2017	Senior medical students	Poor
	[20]	2002	Doctors of all grades, including consultant radiologists	Lack of knowledge

Despite the fact that the study participants reported having moderate knowledge of radiation, the participants had no significant experience with radiation exposure. If the reported knowledge levels are significantly higher than the actual knowledge levels, this could mean that doctors may be unaware of their own shortcomings. Similar previous studies [13,25,28,31,32,33] found that physicians in other countries had limited knowledge of radiation. Only 31.7% of the respondents expressed a general lack of knowledge about the radiation doses used in diagnostic imaging prior to the survey. According to Bosanquet et al., there is a correlation between a lack of education and a lack of knowledge [34,35]. This study examined the different ways physicians are able to use X-rays and found that radiologists are better trained in image diagnosis and interpretation than in radiation protection [23]. Quinn et al. [34] discovered that radiation protection clinicians and physicians were not equally skilled. The majority of participants, 69%, a slight increase from previous findings, had a good understanding of the radiation risk, although it was not as broad as they had hoped [9,32,35]. According to this study's findings, participants possessed a high degree of information regarding the methodology for estimating the radiation dose, in contrast to the findings of other studies. Additionally, the participants thought that the radiation dose was unpredictable (32.7%). While doctors may be able to answer some of the queries, technologists must provide additional assistance. According to previous research, doctors have significantly more advanced knowledge of ionizing radiation than was previously discovered [13,25,28,32]. Individuals over the age of 65 are more likely to be exposed to higher levels of radiation than younger people (under 30 years old). This could be due to a combination of age and experience. This is, without a doubt, theoretically possible. Older physicians, according to Bohl et al. have a better understanding of radiation and its effects on patients. According to a recent study, experts were significantly more aware than the general public of the dangers of ionizing radiation and radiation. When compared to other studies, it was discovered that the participants possessed only a limited amount of knowledge [13,17,18,25,28,32]. There were distinctions between populations [13,25,32]. Radiation exposure to a patient may be underestimated, resulting in unnecessary radiologic testing. Patients must be informed of the risks inherent in imaging procedures [22]. Physicians who routinely refer their patients for these tests should receive intervention education (i.e., about radiation exposure). Researchers in medicine, quality control, compliance with reference standards, and public awareness campaigns should all be involved in on-going education through research projects focusing on proper image quality and dosage optimization. Due to the questionnaire's widespread distribution via the internet, it is possible that the results will be inaccurate. Second, validating a physician's true knowledge about their patients' radiation doses is challenging due to the inadequacy of the self-report questionnaires used to collect data on the subject.

CONCLUSIONS

This study discovered the same thing as previous research: doctors are uninformed about the radiation dose compared with radiology technologists. Radiation training deficiency is assumed to be the cause of the information problem. Ionizing radiation is the area of greatest concern with respect to the pediatric population, followed by radioactivity, and the most critical of all is the radiation risk to foetuses. This demonstrates how critical it is for doctors to increase their understanding of radiation, more so than through conventional teaching, to take advantage of new and effective tools.

ACKNOWLEDGEMENTS

The authors are thankful to the Deanship of Scientific Research, at Majmaah University for funding this research [Project No. R-2022-59].

REFERENCES

1. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/pregnant-pts.pdf
2. Borgen L, Stranden E. Radiation knowledge and perception of referral practice among radiologists and radiographers compared with referring clinicians. Insights Imaging 2014; 5:635-640.
3. Campanella F, Rossi L, Giroletti E, et al. Are physicians aware enough of patient radiation protection? Results from a survey among

physicians of Pavia District–Italy. BMC Health Service Res 2017; 17:1-6.

4. Chun-sing W, Bingsheng H, Ho-kwan S, et al. A questionnaire study assessing local physicians, radiologists and interns' knowledge and practice pertaining to radiation exposure related to radiological imaging. Eur J Radiol 2012; 81:e264-8.
5. Cornacchia S, Errico R, La Tegola L, et al. The new lens dose limit: Implication for occupational radiation protection. La Radiol Med 2019; 124:728-735.
6. https://ec.europa.eu/energy/sites/ener/files/documents/175.pdf
7. European Society of Radiology. White paper on radiation protection by the European Society of Radiology. Insights Imaging 2011; 2:357–362.
8. Faggioni L, Paolicchi F, Bastiani L, et al. Awareness of radiation protection and dose levels of imaging procedures among medical students, radiography students, and radiology residents at an academic hospital: Results of a comprehensive survey. Eur J Radiol 2017; 86:135-42.
9. Guleria R, Bhushan B, Guleria A, et al. Harmful effects of ionizing radiation. International J Res Applied Sci Eng Technol 2019; 7:887-889.
10. Haylock RG, Gillies M, Hunter N, et al. Cancer mortality and incidence following external occupational radiation exposure: an update of the 3rd analysis of the UK national registry for radiation workers. Br J Cancer 2018; 119:631-637.
11. IAEA. Radiation protection and safety in medical uses of ionizing radiation safety standarts. Marketing and Sales Unit, International Atomic Energy Agency 2018.
12. Khan MO, Khan MS, Janjua O, et al. Knowledge of radiation legislation and radiation exposure in common radiological investigations among final year medical students, foundation doctors, specialist radiology registrars and radiographers at a UK university teaching hospital. BJR Open 2018; 20180014.
13. Lee CI, Haims AH, Monico EP, et al. Diagnostic CT scans: Assessment of patient, physician, and radiologist awareness of radiation dose and possible risks. Radiol 2004; 231:393-398.
14. Lee RK, Chu WC, Graham CA, et al. Knowledge of radiation exposure in common radiological investigations: A comparison between radiologists and non-radiologists. Emerg Med J 2012; 29:306-308.
15. Macía-Suárez D, Sánchez-Rodríguez E. Radiation protection knowledge among radiologists in northwest Spain. Radiol 2018; 60:318-323.
16. Ministry of Health. Regulation on radiation dose, limits and working principles of personnel working with ionizing radiation source in health care.2012.
17. https://www.aapm.org/pubs/NCRP/NCRP_Report_184_overview.pdf
18. Paolicchi F, Miniati F, Bastiani L, et al. Assessment of radiation protection awareness and knowledge about radiological examination doses among Italian radiographers. Insights Imaging 2016; 7:233-242.
19. Ramanathan S, Ryan J. Radiation awareness among radiology residents, technologists, fellows and staff: where do we stand?. Insights Imaging 2015; 6:133-139.
20. Saeed MK, Al-shaari H, Almarzooq MM, et al. Radiation awareness among physicians about the hazards of radiological examinations on the health of workers and their patients in Saudi Arabia. J Radiat Res Applied Sci 2018; 11:299-304.
21. Schauer DA, Linton OW. National Council on radiation protection and measurements report shows substantial medical exposure increase. Radiol 2009; 253:293-296.
22. Ünal ES, Geliş K, Baykan P. Investigation of awareness levels about the radiation safety of personnel working in the imaging units of the hospitals in Agri, Turkey. J Radiat Res Applied Sci 2018; 11:111-115.
23. Sheng AY, Breaud AH, Schneider JI, et al. Interactive learning module improves resident knowledge of risks of ionizing radiation exposure from medical imaging. Curr Probl Diagn Radiol 2016; 45:258-64.
24. Stewart F, Akleyev A, Hauer-Jensen M, rt al. ICRP publication 118: ICRP statement on tissue reactions and early and late effects of radiation in normal tissues and organs–threshold doses for tissue reactions in a radiation protection context. Annals ICRP 2012; 41:321–322.
25. Szarmach A, Piskunowicz M, Świętoń D, et al. Radiation safety awareness among medical staff. Polish J Radiol 2015; 80:57.
26. Tang FR, Loganovsky K. Low dose or low dose rate ionizing radiation-induced health effect in the human. J Environ Radioact 2018; 192:32-47.
27. https://www.iaea.org/sites/default/files/turkey-national-report-for-7th-rm-cns.pdf
28. Wakeford R. The growing importance of radiation worker studies. Br J Cancer 2018; 119:527-529.
29. Yurt A, Çavuşoğlu B, Günay T. Evaluation of awareness on radiation protection and knowledge about radiological examinations in healthcare professionals who use ionized radiation at work. Mol Imaging Radionucl Therapy 2014; 23:48.
30. Borgen L, Stranden E, Espeland A. Clinicians' justification of imaging: do radiation issues play a role? Insights Imaging 2010; 1:193-200.
31. Keijzers GB, Britton CJ. Doctors knowledge of patient radiation exposure from diagnostic

imaging requested in the emergency department. Med J Australia 2010; 193:450.

32. Scali E, Mayo J, Nicolaou S, et al. Senior medical students' awareness of radiation risks from common diagnostic imaging examinations. Can Med Educ J 2017; 8:e31.
33. Gour S, Maurya RK, Singh PP, et al. Evaluation of physicians and junior residents' knowledge and awareness of radiation dose and its risks: a cross-sectional survey in tertiary health centre of central India. Int J Res Med Sci 2018; 6:99-105.
34. Semghouli S, Amaoui B, El Kharras A, et al. Physicians knowledge of radiation risk in prescribing CT imaging in Moroccan hospitals. Br J Appl Sci Technol 2017; 20:1.
35. Bohl DD, Hijji FY, Massel DH, et al. Patient knowledge regarding radiation exposure from spinal imaging. Spine J 2017; 17:305-312.