The Importance of Radiation Safety in Terms of Hospital Administration and Research on the Awareness Stage of Radiology Technicians

Hastane Yönetimi Açısından Radyasyon Güvenliğinin Önemi ve Radyoloji Teknisyenlerinin Farkındalık Düzeylerinin İncelenmesi

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ABSTRACT

Objective: Hospitals are medical institutions that contain a lot of risk factors. One of these factors is that employees are exposed to radiation. The purpose of this study was to examine the awareness stage of radiology technicians in regards to radiation safety and to emphasize the importance of radiation safety in terms of hospital administration.

Methods: The study was carried out on 96 radiology technicians employed in hospitals in Kocaeli province, Turkey. Employees were given a survey obtained from a literature review, a questionnaire on radiation awareness by Turkish Society of Radiology, and other related resources. The results were then analyzed.

Results: The majority of the radiology technicians (96.9%) regularly use their personal dosimeters, but only 70.8% of them keep track of the dosimeter results. Usage rates of lead aprons were detected as 26% for both them and their patients. A semantic statistical relation between employees' use of lead apron and their insistence on the patients' use was also detected. More than 61.4% of the employees correctly answered more than half of the test questions regarding their radiation knowledge levels and 89.6% of them stated that radiological requirements should be given importance.

Conclusion: Both radiology technicians and hospital administration have very crucial tasks so as to protect healthcare professionals and patients from detrimental effects of radiation. This has irreplaceable importance in diagnosis and treatment in health sector. It has been determined that radiology technicians are qualified in the knowledge level of radiation safety, but they do not pay enough attention to this knowledge in practice.

Keywords: Radiation safety, hospital administration, radiation awareness

ÖZ

Amaç: Hastaneler birçok risk etkenini içinde barındıran sağlık kurumlarıdır. Bu risklerden biri de çalışanların radyasyona maruz kalmasıdır. Bu çalışmanın amacı, radyasyon güvenliği konusunda radyoloji teknisyenlerinin farkındalık düzeylerini incelemek ve radyasyon güvenliğinin hastane yönetimi açısından önemini vurgulamaktır.

Yöntemler: Çalışma, Kocaeli'ndeki hastanelerde çalışan toplam 96 radyoloji teknisyeni üzerinde yapılmıştır. Çalışanlara; literatür bilgisinden, Türk Radyoloji Derneği Radyolojinin yapmış olduğu radyasyon farkındalığı anketinden ve ilgili diğer kaynaklardan elde edilmiş anket uygulanmış ve sonuçlar analiz edilmiştir.

Bulgular: Radyoloji teknisyenlerinin büyük çoğunluğu (%96,9) kişisel dozimetrelerini düzenli olarak kullanmakta, fakat sadece %70,8'i dozimetre sonuçlarını takip etmektedir. Kurşun yelek kullanım oranı hem kendileri hem de hastaları için %26 olarak tespit edilmiştir. Çalışanların kurşun yelek kullanım durumları ile hastalara kurşun yelek kullandırma durumları arasında istatistiksel açıdan anlamlı bir ilişki tespit edilmiştir. %61,4'ünün radyasyon bilgi düzeylerine ilişkin yöneltilen test sorularının yarısından fazlasına doğru cevap vermiştir. % 89,6'sı ise radyolojik istemlere dikkat edilmesi gerektiğini belirtmiştir.

Sonuç: Sağlık sektöründe teşhis ve tedavide vazgeçilmez öneme sahip radyasyonun zararlı etkilerinden, sağlık çalışanlarının ve hastaların korunması konusunda hem radyoloji teknisyenlerine hem de hastane yönetimlerine oldukça önemli görevler düşmektedir. Radyoloji teknisyenlerinin genel olarak radyasyon güvenliği hususunda bilgi düzeyinin yeterli olduğu, fakat uygulamada güvenlik konusunu çok fazla önemsemedikleri tespit edilmiştir.

Anahtar Kelimeler: Radyasyon güvenliği, hastane yönetimi, radyasyon farkındalığı

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INTRODUCTION

Radiation is defined as energy spread from a source in the form of waves and particles (1, 2). Due to their professions, people are exposed to ionizing radiation in many fields such as industry, medicine, education, research, atomic power production, and fuel generation. Employees in these practices should be protected from radiation effectively and be provided with work safety resources (3).

Radiation safety can be defined as the protection of people and the environment against ionizing radiation beams. In other words, it is to provide protection against the harms of ionizing radiation in practices where radioactive substance and similar sources of radiation are being used (4, 5).

In the world, approaches and risks regarding the protection against ionizing radiation are regularly followed by The United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and UNSCEAR continuously presents their reports to the United Nations (UN) General Assembly. According to the International Commission on Radiological Protection (ICRP), which publishes scientific journals toward the protection against radiation, personal dose limits in beaming should be determined to for protection of personnel. Determining personal dose limits is to limit the amount of dose that individuals may be exposed to as a result of beaming (6).

In Turkey, The Atomic Energy Authority (TAEA) conducts regulation, authorization, and inspection procedures of the safe use of ionizing radioactive substances in accordance with law No. 2690. A license should be obtained from the TAEA to export, import, buy, sell, transport, store, maintain, repair, install, disassemble radiation sources, work with radiation, and use it (7). Radiation Safety Regulations by TAEA was last published on 24th March, 2000 (8). According to this regulation, the effective dose limits were determined for individuals working with radiation sources and exposed to radiation.

Medical practices are responsible for 96% of all artificial sources of radiation. In particular, radiation doses obtained during interventional radiology, computed tomography, mammography, and fluoroscopy examinations may reach high levels. Though the patient get the highest radiation dose, radiologists and technicians are also exposed to radiation during diagnosis depending on the type of examination (9).

When the human body is exposed to radiation doses over 1 Sv, gastrointestinal, neurological, and hematological disorders in the acute stage come out; or as a result of low dose exposure over a long time, genetic effects such as cataract, cancer, shortage in lifespan, or transmitting of genetic disorders to future generations may be observed (4, 5). Because genetic damage may influence the next generation, the safety of employees working with sources of ionizing radiation, other people around them, and the society at large should be provided. For that reason, it is very important that necessary measurements should be carried out, that radiation should be used in a controlled way, and that individuals working with radiation sources should be trained continuously (9).

All x-rays used for human health can cause patient and health personnel to be exposed to radiation. Although dose amounts used in diagnoses and examinations are low, irradiation that both patients and health staff get should be given special importance, and effort to minimize the irradiation are necessary (10). Medical personnel should have adequate information about the issue to protect both themselves and patients from harmful effects of radiation. Most of the mistakes made result from a lack of measures and knowledge. Accordingly, employees working with radiation should be given training on radiation, and then, they should be regularly updating their knowledge (9, 10).

Importance of Radiation Safety at Hospitals

Hospitals are medical institutions that contain lots of risk factors. One of these risks is exposure to radiation. This matters to employees, patients, and their relatives. Previous studies have shown that the number of tomographic examinations have increased 12 times in England and 20 times in the USA over the last 20 years. There are publications on having unnecessary tomographic scans one after another, and it is emphasized that these examinations have a role in increasing cancer risk. Recently, there have been studies showing that low dose radiation applications used for diagnosis may influence human health negatively (11).

Due diligence on how to protect from these risks must be shown by not only relevant personnel, but also by the administration. Accordingly, hospital administration should behave reasonably cautiously and provide safety to those working with ionizing radiation and exposed to radiation in diagnosis. Below, the issues that should be taken into consideration by hospital administration to provide radiation safety effectively are listed and explained.

The Committee on Radiation Safety

In 2012, for the protection of personnel working in places where diagnosis, treatment, and research are carried out by using a radiation source, setting up a radiation safety committee in all public or private health institutions and establishments became compulsory. In health institutions and establishments in which nuclear medicine, radiation, and oncology are present, it is essential that at least two of the radiology departments set up a Radiation Safety Committee.

Procedural rules and principles for the Radiation Safety Committee were determined by a regulation published by TAEA again in 2012. In Article 6 of the relevant regulation, hospital administration was held responsible for setting up the Radiation Safety Committee, its effective functioning, reporting issues about radiation safety, and implementing of decisions made by the committee. The Radiation Safety Committee is administratively subject to the chief-doctor in medical institutions and establishments and director in provincial directorates of health (12).

Employee and Patient Safety

Radiology is a field providing the most critical medical service to all clinical branches. It is very difficult to detect the harm to patients directly when the service is not provided well. Therefore, radiology units are suitable places where medical errors may occur (13). However, in a previous study, it has been stated that the radiation risk was determined as a medium hazard risk in the ER, intensive care clinic, post-operative care clinic, and thoracic service. In these units, it was seen that radiography per patient would increase the risk and it was determined that using a moving lead folding screen would decrease the medium level risks in these units (14).

In the Article 77 of labor law No 4857, it is written that employers are liable to take any necessary precautions, keep a complete set of devices and tools for occupational health and safety, and employees are liable to follow the precautions taken in occupational

health and safety (15). As part of radiation safety, radiation surveys and inspections of places with radiation are compulsory. It is important that personnel working in X-ray rooms should make sure of the safety of his or her working environment, control the radiation impermeability of protective barriers, and to stand behind them while working. Working in a safe environment affects the motivation and performance of personnel in a positive way (16).

Radiological imaging should be done within safety standards for the safety of radiology employees and patients (17). However, patients should also be informed about radiation safety under the patients' rights (11). Apart from the written request of the doctor, no other radiation procedure should be carried out for the patient. All necessary information should be applied as they were determined in advance to protect the patient from radiation during irradiation and to determine the dose the patient should get.

When radiological examinations are compared to alternative techniques, medical irradiation should be applied in the situations where the benefits of diagnosis by radiation and treatment overweigh the harms of radiation. Professional, legal, and health insurance propose medical irradiation cannot be recommended without a medical expectation and professional or institutional counsel, unless there is no specific expectation toward health. Radiological methods should be carried out only when economical and the social cost meets the health risk in the healthy screening of the society (4).

In the Article 6 of the Regulation on Providing Safety of Patients and Employees published by the Ministry of Health, it is determined that one of the regulations pertaining to patient safety that health institutions have to make is "to provide radiation safety." In accordance with Article 8 of the relevant regulation, common applications of patient and personnel safety were determined and it is regulated that health institutions have to "take protective measures with the purpose of diagnosis and treatment regarding radiation safety"; that is, radiation safety should be taken into consideration by hospital administration with regard to both personnel and patient safety (18).

Education

When it comes to protecting people from radiation, individuals also have responsibilities and the state and institutions' administration should have great responsibility. We need to make efforts to protect ourselves from harmful rays in addition to radiation sources surrounding us. Radiological tests are required more often and attempts toward treatment with radiation are applied more often, too. These trends put both patients and health personnel into potential risks. When health employees applying non-invasive practices do not have adequate knowledge on the harmful effects of radiation, it has been detected that health employees and patients may be exposed to high dose radiation (9). Another urgent issue is that all personnel working in the radiology department should be given training on protection against radiation and refresher training.

Hospital administration should carry out studies on both personnel and patient training. Training programs regarding patient training should be carried out every morning before beginning work. In every part of a hospital, posters should be hung to attract patients' attention, brochures including procedures regarding radiation safety and ones to reduce their worries about the issue should be hand out. All patients receiving radiation should be distributed these brochures. In addition, hospitals should regularly be inspected by legislative institutions (19).

Doctors are expected to obey the ALARA principle. Unless it is necessary, doctors should not make their patients be exposed to X or Gamma rays and always consider benefits vs. costs. While requesting radiological examination, doctors should be careful about radiological safety and this will contribute to patients' and personnel health. Therefore, personnel working in radiology units should have sufficient knowledge and skills (11, 17).

Awareness levels about radiation protection of personnel affects their behaviors. If they are knowledgeable enough regarding the issue, their behaviors will not be dependable and they may cause inaccurate procedures (20). Personnel exposed to radiation in the hospital and needing training can be classified into three general categories. Personnel in these categories should be given training as detailed below (21):

Personnel working with Radiation: Individuals in this category are comprised of employees working directly with radiation or ionizing radioactive substances (radiologists, nuclear medicine physicians, radiology/radiotherapy technicians, cardiology technicians working with fluoroscopy, and nurses giving continuous care to patients being treated by radionuclides). Training to these personnel should be directly be given by a health physician or training content should be examined by him/her. There should be detailed training regarding special work responsibilities.

Assistant personnel: All personnel contacting radioactive materials and having to enter the section with ionizing radiation sources (cleaning staff, staff collecting waste materials, and nurses sometimes giving care to patients being treated with radionuclides). Periodical refresher training about radiation safety should be given to these personnel.

Personnel working in a radiation-free environment: Personnel expected not to work with radiation sources under normal circumstances (nurses, administrative assistants, administrative staff, food service staff, and office workers). The training to be given to these personnel should contain the most basic rules for protection against radiation.

Due to ionizing radiation, radiology departments are settings that contain a lot of possible hazards. It is very important that especially radiology technicians should have knowledge and awareness levels regarding the adherence to relevant regulations for protection against radiation. Professional competence is meant to present communication, knowledge, technical skills, clinical competence, sense, values, and responses on behalf of the society in daily life. Clinical competence of an employee comes to light when knowledge and skills that he/she has are performed for a patient by applying objective outcomes in accordance with a certain procedure. That radiology technicians participate in different courses about radiation protection regularly will affect their behaviors in the work setting in a positive way by developing their awareness levels. In this respect, hospital administration has important tasks regarding providing radiology technicians with regular training (20).

Device Security

To prevent radiation-induced hazards, it is important, with regard to patient and personnel safety, that inventory lists of devices used in hospitals should be taken, testing and calibration needs of these devices should be determined, testing and calibration durations of these devices should be determined by experienced individuals, training and responsibilities of the personnel that will use the

devices should be determined, a program for systematic follow-up should be scheduled, and data from these devices should be followed by the user (22). Performing calibration and quality tests of X-ray devices is much more important than for other biomedical devices. If X-ray devices are not calibrated thoroughly, the obtained outcome can be wrong and radiation doses that the patient and employee receive can be more than it should be.

METHODS

This study was carried out on radiology department personnel (technicians) working at all state hospitals. For the study, permission was received from the Public Hospitals Association General Secretariat. In the study, sample selection was not applied and radiology personnel (technicians) (N: 182) working at all state hospitals in Kocaeli Province (n=10) were requested to be included into the study. Between 01/12/2014 and 01/01/2015, when the study was carried out, a questionnaire was sent to 146 personnel actively working because 36 were off. 96 of the questionnaires were returned back and n=96 radiology personnel formed the sampling of the study. Presentation rate of the sampling universe was 52.7%.

The questionnaire used was obtained from a literature knowledge study carried out by (17) (Turkish Society of Radiology, questionnaire study carried out toward radiology personnel by sub-working group of Molecular Imaging Physics and Radiation Safety in 2013) and relevant official regulations. The questionnaire was comprised of 35 questions and four sections. In the first section, there were 5 questions regarding demographic characteristics. In the second section, there were 17 questions regarding radiation safety, including general expressions. In the third section, there were 12 questions toward determining radiation awareness of radiation personnel. In the last section, there was the question toward recommendations to improve working conditions of radiology technicians. All steps of our study were designed according to the Declaration of Helsinki.

Statistical Analysis

Data obtained in the study, was transferred into Statistical Package for the Social Sciences (IBM SPSS Statistics; Armonk, NY, USA) 19.0 software and analyzed. In the analysis of the data, frequency, Pearson Chi-Square, and Exact Test analyses were used. Significance was tested at the $p<0.01$ and $p<0.05$ levels.

RESULTS

Findings in Relation to Demographic Indications

43.7% of the employees were male (n=42), and 56.3% of the workers were female (n=54). Individuals taking part in the study were 33.8 years old and term in office rate was 12.6 years. Considering their educational backgrounds, it was detected that 62.5% had an associate's degree (n=60), 19.8% had a high school diploma (n=19), 15.6% had a bachelor's degree (n=15) and 2.1% had a master's degree (n=2). 80.2% of the participants worked at state hospitals, while 19.2% of them work at training and research hospitals. Other information relating to demographic indications are in Table 1.

Findings in Relation to Radiation Safety

It was detected that 96.9% of the radiology personnel regularly used personal dosimeters; notwithstanding only 70.8% of them followed the results of the dosimeters regularly. A meaningful relation between dosimeter use by personnel and their following dosimeter results was detected ($p<0.01$) (Table 2). In radiopharmaceutical postings, therapeutic purpose radionuclide applications, and manual iridium 192 applications, it was detected that only 15.6% of the personnel used wrist and ring dosimeters.

Table 1. Demographic characteristics

		n	%
Age	18–27	27	28.1
	28–37	37	38.5
	38–47	24	25
	48–57	8	8.3
Gender	Female	54	56.3
	Male	42	43.8
Term of service	Below 5 years	19	19.8
	6–10	29	30.2
	11–15	12	12.5
	16–20	16	16.7
	21–25	14	14.6
	25 years and over	6	6.3
Educational background	High school	19	19.8
	Associate degree	60	62.5
	Bachelor's degree	15	15.6
	Master's degree	2	2.1
Organization	State Hospital	77	80.2
	Training and Research Hospital	19	19.8

Table 2. Dosimeter use cases of personnel and cases where they follow the dosimeter results

		Case that follow dosimeter results							
		Yes		No		Sometimes		Total	
		n	%	n	%	n	%		
Personal dosimeter usage case	Yes	68	70.8	7	7.3	18	18.7	**93**	**96.9**
	No	0	0	2	2.08	1	1.02	**3**	**3.1**
	Total	**68**	**70.8**	**9**	**9.4**	**19**	**19.8**	**96**	**100**

$x^2=13.323$, $p<0.01$

Table 3. Case of personnel and patients' use of lead aprons

		Case of personnels' use of lead aprons							
		Yes		No		Sometimes		Total	
		n	%	n	%	n	%		
Case to make patients use lead aprons	Yes	13	13.5	4	4.2	8	8.4	**25**	**26**
	No	3	3.1	10	10.4	4	4.2	**17**	**18**
	Sometimes	9	9.3	7	7.3	38	39.6	**54**	**56**
	Total	**25**	**26**	**21**	**22**	**50**	**52**	**96**	**100**

x^2=29.780, p<0.01

Table 4. Results of questionnaire on radiation knowledge level

Question	Correct answer	n	%
1. In Report No. 103 issued by ICRP in 2007, which organ/tissues' tissue factor below was reduced?	Gonads	13	13.5
2. What is the main institution that regulates the rules regarding radiation in Turkey?	TAEA	82	85.4
3. Which is not one of the principles of protection against radiation?	Diet enriched with protein and vitamin C	84	87.5
4. Which is not one of the main titles of patient's protection against radiation?	Assessment and evaluation	26	27.1
5. In developed countries, from what source does the highest part of ionizing radiation that affects personnel come from?	Natural (background)	28	29.2
6. What modality constitutes the greatest part of the radiation that individuals are exposed to from medical irradiation sources?	Computed tomography	69	71.9
7. What applications should be avoided to prevent the patient from being exposed to less radiation during radiographic examination?	Use of irradiation protocol with high mAs	67	69.8
8. What application increases the dose the pediatric patient gets during radiological examination?	Use of Grid	77	80.2
9. In fluoroscopic examination, what should not be done to cause radiology personnel to get the lowest level X-ray?	One needs to work with the highest number of images per second	33	34.4
10. In fluoroscopic examination, what should not be done to cause the patient to get the lowest level of X-ray?	X-ray receiver should be moved to the farthest point from the patient	58	60.4
11. What is the yearly upper dose limit determined by TAEA?	20 mSv	56	58.3
12. Which is one of the most sensitive organs?	Ovaries and Testicles	83	86.5

ICRP: International Commission on Radiological Protection; TAEA: Turkey Atomic Energy Authority; mSv: Millisievert

65.6% of the personnel said they felt themselves trained in radiation safety and it was detected that 57.3% of them had received training regarding radiation safety and/or protection against radiation. Radiation measurements were performed in 45.6% of the radiology units, 54% of the hospitals they worked in did not have a Radiation Safety Committee, 52.1% of them did not know who was responsible for protection against radiation, and 54.3% said that the one responsible for protection against radiation was not concerned about protection of the personnel. It was detected that in 76.5% of fluoroscopy applications, methods on protection against radiation were used, 53.8% of radiologists took care of protection of their team against radiation.

It was found that during radiological imaging, only 26% were regularly using lead aprons while 26% regularly made their patients use lead aprons. A meaningful relation was found between the usage of lead aprons by the personnel and making the patients use lead aprons (p<0.01) (Table 3). According to this, the ones using lead aprons also cared about making their patients use lead aprons, too.

Finding in Relation to Radiation Knowledge Levels of Personnel

This section introduces the findings related to radiation knowledge levels of the personnel. Twelve questions were addressed to employees regarding their radiation knowledge level and they were asked to mark one of the four options. Radiology person-

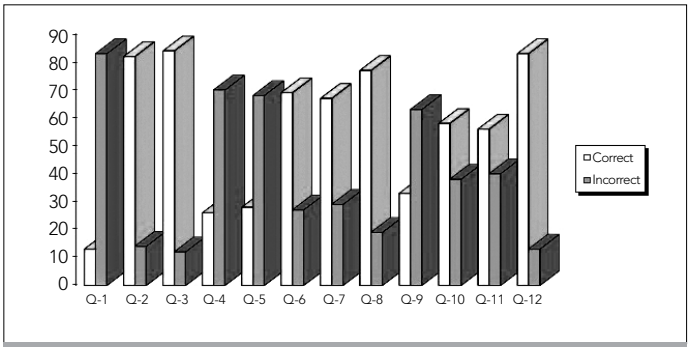

Figure 1. The wrong and right answers to each of the 12 questions for a total of 96 applicants

Table 5. Expectations on improving working conditions*

Suggestions (n=96)*	n	%
Requests should be given care	86	89.6
Quality devices should be used	76	79.2
Patients should be trained	67	69.8
Personnel should have private rooms	67	69.8
Periodic maintenance should be done	66	68.7
Personnel should be trained	65	67.7
Circulation capital should be regulated	47	48.9
Previous X-rays should be retained	31	32.3
Working hours should be regulated	12	12.5
Other	5	5.2

*Participants marked more than one answer.

nel achieved over 50% of success in 8 out of 12 questions. The percentage of the employees who answered more than half of the questions correctly was found to be 61.4% (n=59). It was detected that 37.2% of ones who answered the questions correctly were between the ages of 28–37, females gave more correct answers than males (61%), ones with an associate's degree (67.8%), ones working at state hospitals (79.6%), and ones with a professional background of 6–10 years (35.5) were more successful than others. personnel that got training on radiation safety (61%) and ones that felt themselves more trained compared to others that felt themselves less trained (62.7) marked more correct options. Information regarding questions and answers are in Table 4 (Figure 1).

Findings in Relation to Improving Working Conditions

Expectations of radiology personnel on improving their working conditions and providing more effective radiation safety are shown in Table 5. According to this, 89.6% of the personnel stated that requests should be given care and 79.2% said the devices used should be of high quality.

DISCUSSION

In the study we carried out in the province of Kocaeli, It was detected that 96.9% of the radiology personnel regularly use personal dosimeters; notwithstanding this, only 70.8% of them followed the results of dosimeters regularly. In a study carried out on radiologists, radiology technicians, and surgeons using fluoroscopy device with the purpose of assessing knowledge, attitudes, and behaviors regarding radiology unit personnel in state hospitals in Kayseri, it was also detected that 95.5% of the personnel used dosimeters (17).

In our study, 65.6% of the personnel said they felt themselves trained in radiation safety and it was detected that 57.3% of them had received training regarding radiation safety and/or protection against radiation. In a study to evaluate the knowledge level of doctors, nurses, radiology technicians, and medical interns on radiation safety, it was found that nurses had the highest knowledge level. It was observed that the knowledge level of radiology technicians was lower than nurses. Interns had the lowest knowledge levels. It was also observed that personnel with 1–5 year of professional experience had higher knowledge levels than those with more working experience. This was found to be a result of a lack of in-service training (23).

In our study, it was found that only 26% of the personnel were using lead aprons during radiological imaging, while 26% of them were making their patients use lead aprons regularly. Personnel giving importance to using lead aprons during imaging also cared about making their patients use them. The study in which awareness levels between health personnel in radiology units were evaluated, it was found that radiology technicians were more careful about wearing lead aprons than doctors and nurses were (2). In another study carried out in India, it was detected that doctors did mot behave carefully enough during radiological examinations applied to children and pregnant women regarding protection against radiation. In programs for medical training and in-service training, it is stated that it can be effective to train doctors to protect patients against radiation during examinations in reducing the dose the patient obtains (24).

In the Kocaeli state hospitals, it was found that 45.8% of the radiology units perform radiological surveys, 54.2% of the hospitals do not have a Radiation Safety Committee, 52.1% of the personnel do not know who is in charge of protection against radiation, and 54.3% of personnel in charge of protection against radiation did not show enough interest toward protection of personnel against radiation. It was detected that in 76.5% of fluoroscopy examinations, protection methods were applied and 53.8% of radiology physicians give enough care to protect their team against radiation. In another study done in Nigeria, it was also detected that in only 20% of the hospitals, radiological surveys were being performed and 60% of the hospitals had a person in charge of radiation safety. In general, it was determined that in all hospitals that did not perform radiological surveys, the hospital administration in all hospitals did not care about designating a person in charge of radiation safety, and they did not give any attention to following dosimeter results (25).

In a study to examine knowledge, attitudes, and behaviors of operating room staff regarding radiation safety by Vural et al. (26), it was found that operating room nurses and anesthesiology technicians were in a more risky group than other personnel. It was observed that the knowledge level of operating room personnel was at a satisfying level, but their behaviors toward taking measures on protection of the personnel was inadequate and the dose obtained during operation was ignored. In this study, it was recommended to give the personnel in-service training, to

inspect the applications, and equip the personnel with certification and consciousness.

Personnel given training about radiation safety answered the questions more correctly than those without any training (61%), and personnel feeling themselves more trained answered the questions more correctly than those feeling themselves less trained (62.7%). In a study carried out in Iran, it was found that there was a strong and direct relation between knowledge and awareness levels of radiology technicians and protection from the harmful effects of radiation. It was emphasized that more should be done academically, institutionally, and individually to improve the awareness levels of the new generation of specialists working the field of radiation technologies regarding protection against radiation (20).

71.9% of the radiology technicians marked the option "computed tomography" to the question in our study toward "What modality constitutes the greatest part of the radiation that individuals exposed to from medical irradiation sources?" In a study carried out at a university hospital in the province of Denizli that aimed to examine knowledge level of research assistants, medical students, nurses, and hospital personnel, a question "which one contains the most radiation?," 49.4% of the students answered BT, 43.5% of the doctors answered PET BT, 21.3% of the nurses equally answered BT and angiography, and 27.1% of the personnel answered PET BT (27). In a study in Canada aiming to evaluate knowledge levels and radiation awareness of specialist doctors, assistants, interns, and technicians working in radiology units, all personnel had insufficient knowledge levels regarding radiation safety. However, according to specialist doctors, assistants and interns claimed that the problem about having inadequate knowledge level belonged to radiology technicians (28).

CONCLUSION

As a result, it was found that training on radiation safety and radiological surveys were not done in a regular way, there were no radiation safety committees and/or they were not run effectively, radiology technicians did not have regular habits toward using lead aprons or making their patients use lead aprons during radiological imaging. It was also detected that, while performing radiological requests, doctors did not care about radiation safety much, only ¾ of them were using protection methods against radiation during radiological applications and only half of them gave necessary attention to protect their teams against radiation.

Hospital administration also has important responsibilities for the protection of health personnel and patients from harmful effects of radiation that have crucial importance in diagnosis and treatment. In departments where radioactive substances exist for diagnosis and treatment purposes, it is thought that protective measures should be taken and followed regularly and that radiation safety committees should be set up and be run efficiently. Also, awareness in radiation safety for all health personnel, including doctors, should be evaluated and training programs should be scheduled. Furthermore, radiological devices should be selected properly, their control tests should be performed regularly, and quality control records should be monitored. Lastly, personnel should be given training continuously and radiation that personnel and patients are exposed to should be reduced by decreasing the number of unnecessary examinations.

Ethics Committee Approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

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