Assessment of Healthcare Professionals' Knowledge and Awareness on Aspects Related to Ionizing Radiation Examinations in Athens, Greece

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Abstract

Background: Healthcare professionals involved with ionizing radiation must have sufficient knowledge of its effects on the human body in order to avoid potential risks for both patients and themselves. The aim of this study was to estimate the knowledge and awareness of healthcare professionals about the hazards of radiological examinations on their health and on their patients.

Methods: This is a cross-sectional study, and the data collection was carried out with a self-administered questionnaire. The study group included a total of 210 individuals from different professional groups: nurses, doctors, medical technicians, radiologists, and other staff working in different clinics that use radiation in their work. The study was carried out in a large hospital in Athens, Greece.

Results: The study population consisted of 210 subjects aged 44.7 ± 9.1 years. In a total of 23 questions, participants answered correctly to 6.4 ± 2.6 questions. The factors for predicting the correct responses were male gender ($\beta = -1.034$, $p = 0.004$), frequency of contact with imaging examinations of patients requiring ionizing radiation ($\beta = 0.496$, $p = 0.007$), participation in any educational process ($\beta = -0.918$, $p = 0.014$), the number of published articles on radiation protection ($\beta = 0.720$, $p = 0.001$), and knowledge of the principle of ALARA ($\beta = -0.391$, $p = 0.001$).

Conclusions: It is proposed to include a radiation protection course in the total healthcare professionals' undergraduate curricula in order to address the current knowledge gap in clinical practice.

Keywords

Ionizing radiation · Knowledge · Dose · Effects · Protective measures · Healthcare professionals

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1 Introduction

The primary purpose of an application that requires X-rays is to achieve the best image quality using the minimum dose (principle ALARA). However, the acceptable dose limits for both patients and healthcare professionals are in some cases exceeded by the unnecessary use of X-rays in diagnostic applications/examinations [24]. As a result, the potential and damaging effects of ionizing radiation on both the general population and healthcare professionals are increasing the likelihood of cancer. The degree of effects depends on the type of radiation and the exposure time [9]. The potential effects of exposure to radiation may be short term or long term, and lesions can emerge not only in the first but also in the next generations [15].

Radiation protection is considered necessary, and healthcare professionals should be knowledgeable to be able to move in the clinics safely and to protect both the patient and their selves [14]. The knowledge of radiation protection is not always included in the curriculum of basic education of each healthcare professional. So, the information and the sensitivity of healthcare professionals are not the same [1, 13, 20, 23]. Consequently, healthcare professionals are not aware of the dangers arising from the use of ionizing radiation [14], and due to bad practices, they endanger both patients and themselves exposure to ionizing radiation. Doctors who order examinations with ionizing radiation tend to underestimate the actual doses and potential risks of patients who refer to [5].

2 Materials and Methods

2.1 Aim

The aim of this study was to estimate the knowledge and awareness of healthcare professionals about the hazards of radiological examinations on their health and on their patients.

2.2 Study Design

It is a cross-sectional study and was conducted in a large hospital in Athens, Greece.

2.3 Participants

Healthcare professionals who use ionizing radiation in their daily clinical practice (doctors, nurses, radiologists, and technologist/technicians from all departments, including routine X-ray imaging, angiography, coronary angiography, CT, magnetic resonance imaging—MRI, ultrasound—US, fluoroscopy, endoscopy unit, operating theatres) and healthcare professionals who are in contact with ionizing radiation occasionally and not daily were invited to participate in the study. Out of 300, 210 accepted the invitation (response rate 70%). After explaining the aims of the research and obtaining the consent forms, participants were asked to fill out the questionnaire. The participants also were informed that the results would be used only for a scientific study.

2.4 Tools

A self-administered questionnaire was given to healthcare professionals and asked to fill and return it within one week. The questionnaire included demographic data of participants, questions about radiation protection, radiation doses that result from radiological examinations, and radiation-induced cancer risk. Questions in general radiation protection section were selected to evaluate the general knowledge and standards about radiation, ionizing and non-ionizing radiation types, knowledge about dose optimization, susceptibility to radiation damage, tissues more susceptible to injury from ionizing radiation, and diseases caused by radiation damage. Questions in radiation dose section included the safe dose of ionizing radiation in radiologic examinations, the average background radiation to which a person is subjected annually, the average effective dose for a standard chest X-ray for adults, and the average effective radiation dose for a standard chest CT scan for an adult. Moreover, participants were asked to estimate the chest X-ray equivalent doses for radiological applications that are commonly used. The questions were adopted from the previously published questionnaires [1, 5, 20]. The validity of the instrument was checked by a committee of 3 physicians and 2 other experts in medicine and radiation. They reviewed the content, the clarity, and the relevance of the items.

2.4.1 Ethics

Confidentiality and anonymity were maintained according to the regulations mandated by the Research Ethics Committee of the hospital, in accordance with the Declaration of Helsinki. The investigators did not provide any individual information to a third party.

2.5 Statistical Analysis

Statistical analysis was performed using the IBM SPSS Statistics v. 21.0. The results were expressed in mean and standard deviation for the quantitative variables and in number and percentage for the categorical variables. The value of $p \leq 0.05$ was considered as being statistically significant.

3 Results

The study population consisted of 210 participants aged 44.7 ± 9.1 years. The clinical practice/experience of the participants was 18.7 ± 9.8 years. The demographic and the work characteristics of the sample are shown in Table 1.

Sixty-eight respondents (32.4%) were exposed to ionizing radiation several times a day, 63 (30%) several times a week, 61 (29%) several times a month, while 18 (8.6%) were not exposed to ionizing radiation. The first thought that participants reported on hearing the word "radiation" was Chernobyl (63.8%), cancer treatment (49.5%), Hiroshima (59.5%), and X-ray imaging (51.4%). The participants supported that the doses resulting from the use of ionizing radiation to perform diagnostic imaging tests may increase the likelihood of cancer risk in the future (6.5 ± 2.5, where 1 means none and 10 too high).

Participants' responses to questions about the biggest sources of radiation in daily life, health risks of most concern, the most worrisome sources of "radiation exposure," health risks caused by radiation exposure, and radiological examinations in patients with the possibility of being pregnant are shown in Table 2.

The respondents reported that they would be concerned a lot, if they learned that they or their spouse was pregnant following a radiation examination (7.9 ± 2.5), and they supported that they would be a little concerned if their child or young nephews/nieces were required to undergo a radiological diagnosis (4.1 ± 2.5) or treatment (6.9 ± 2.6). Also, the participants believe that the dose resulting from the use of ionizing radiation in common radiological examinations is quite safe (6.2 ± 2.3).

The most famous patients' radiation protection measures that participants identified were lead aprons (92.9%) and shields (86.2%). The respondents increased distance from the source of radiation (86.2%) more than they did other personal protective equipment, and only 77.6% used lead aprons. However, 112 (53.3%) participants used the special protection room and 56 (26.7%) were standing at a distance of 5 m or more from the source point without protection (Table 3).

Table 4 shows that participants supported that the most sensitive organs to radiation are the thyroid glands (89.5%), the gonads (88.6%), and the bone marrow (73.8%), while the less sensitive organs are the lungs (51.9%) and the stomach (41.9%).

According to Table 5, only 10% of the participants knew that the radiation dose from 1 plain abdominal radiography exam is equal to that from 50 to 99 posterior–anterior chest X-rays; 15.7% knew that the radiation dose from 1 head CT is equal to that from 200 to 299 chest X-rays; and 63.3% indicated correctly that abdominal ultrasound scan has no radiation dose (Table 5).

Table 1 Personal and work characteristics ($N = 210$)

	Variable	*N*	%
Gender	Males	91	43.3
	Females	119	56.7
Marital status	Married	147	70
	Unmarried	63	30
Educational level	University/College	100	47.6
	High School	47	22.4
	Primary School	9	4.3
	Master/PhD	54	25.7
Profession	Nurses	82	39
	Doctors	66	31.4
	Technicians	40	19
	Other	22	10.5
Department/Clinic	Radiology	75	35,7
	Operating room	51	24.3
	Clinics/Emergency	44	21
	ICU	40	19

Totally, 30 (14.3%) respondents answered correctly to the question about the approximate mean annual dose (active dose) in mSv that population is exposed to natural sources of radiation (2.4 mSv). Also, 42 (20%) participants supported correctly that the approximate radiation dose (active dose) in mSv resulting from a chest X-ray is 0.02–0.04 mSv, and 39 (18.6%) participants supported correctly that the active dose resulting from a thoracic CT is 3–9 mSv.

The participants supported that they would like to learn more about safety measures relating to ionizing radiation (8.9 ± 1.8; min 1 and max 10) and to safe dose of radiation (9.1 ± 1.8; min 1 and max 10). The total mean score of correct answers ($N = 24$) was 7.8 ± 2.8 ranging between 1 and 17. The factors that were found to predict the total score of current answers were the frequency of use of ionizing radiation ($p = 0.007$, $b = 0.496$, 95% CI: 0.138–0.853), the participation in any course concerning radiation protection ($p = 0.014$, $b = 0.918$, 95% CI: 0.861–1.342), the number of published articles ($p = 0.001$, $b = 0.720$, 95% CI: 0.407–1.033), and the knowledge of the ALARA principle ($p = 0.001$, $b = 3.391$, 95% CI: 2.997–3.549).

4 Discussion

This study is the first to be conducted in Greece to assess the attitudes and knowledge of doctors and other healthcare professionals about the radiation protection and dangers of ionizing radiation for both patients and the staff. We found that only one-third of the participants had attended a radiation protection seminar. Although this percentage is small, it is ultimately much larger than what has been reported in the literature.

In Saudi Arabia, 28.5% of participants had attended a radiation protection seminar [13]; in Egypt, 11.2% of the participants [1]; in Ethiopia, 10.5% of the participants [21]; and in Palestine, 30.7% of the respondents [5]. All of these studies highlight the lack of knowledge of healthcare professionals about the dangers posed by radiological examinations to patients and staff.

The knowledge of healthcare professionals was associated with attending seminars. Participation in any radiation education process, as well as the published articles read by the participants on radiation protection, increased the likelihood of correct answers. Similar results were found in the studies of Zewdneh et al. [21] and Madrigano et al. [12] who reported that those who had received official training on ionizing

Table 2 Participants' responses to questions

Questions	Responses (%)
The biggest sources of radiation in our daily life	
Medical services at hospitals	97.6
Cosmic rays	86.2
Rocks and soil	85.2
Food intake	75.2
Building, including concrete and other building materials	74.3
Air travel	73.3
Nuclear power plant	40
Health risks of most concern	
Environmental pollution	97.6
Obesity (overweight)	96.7
Stress	96.2
Smoking (cigarettes)	95.7
Alcoholic beverages	95.2
HIV	95.2
X-ray and CT applications	91
Surgery	88.6
The most worrisome sources of "radiation exposure"	
Radiological treatments	96.7
X-ray and CT applications	93.8
Nuclear waste	93.8
Nuclear facilities	92.4
Nuclear terrorism and nuclear weapons	91.4
Health risks caused by radiation exposure	
Cancer	96.7
Genetic disorders	95.7
Infertility	95.2
Life shortening	93.3
Skin disorders	91.4
Growth retardation in children	89.5
Cataract	88.1
Hair loss	84.8
Radiological examinations in patients with the possibility of being pregnant	
Radiological examinations should be justified by doctor	52.8
Never perform radiologic examination	30
10-day rule	41.9
Whenever the patient wants to	29.5

radiation are more aware of the risks they pose than those who did not have any training. Much of this knowledge is gained through multidisciplinary clinical meetings, conferences, academic and research activities.

Table 3 Participants` responses to questions about the risk of radiation

Questions	Responses (%)
Aware of ALARA principle	24.8
Know any published articles on radiation hazards	59
Identify patient's radiation protection measures	
None	3.3
Lead aprons	92.9
Shields	86.2
Distance from the source of radiation	82.4
Time of exposure	68.6
Collimation of the radiation beam	58.1
Protection policies and personal protective equipment	
Increasing distance from X-ray device	86.2
Lead aprons	77.6
Minimal procedure time	71
Thyroid shields	67.6
Eyeglasses	20.5
Lead gloves	15.2
Distance from radiological device without protection during the procedure (meter)	
Use of special protection room	53.3
5 m	26.7
2 m	16.7
1 meter	1.9
Do not care about radiation	1.4

The sample of this study did not only include healthcare professionals who are directly in contact with ionizing radiation. There was a large percentage of participants who were working in other departments, and this is believed to be an important reason not only for low levels of knowledge found about ionizing radiation but also for low attendance rates of seminars and courses.

The knowledge and practices of doctors toward exposure to radiation are poor [1, 20]. The doctor must have knowledge about radiation protection in order to be properly protected and to protect patients and other healthcare professionals. Only 11% of doctors have received radiation safety training, and only 20% of them have read about radiation safety in Egypt [1]. A higher percentage of respondents (55%) attended a training program in Europe [18] on radiation safety and even higher (82.6%) in Poland [4].

Table 4 Participants' knowledge about the relative sensitivity of body organs to radiation

Estimated	1		2		3		4		Don't Know	
sensitive level[a]	N	%	N	%	N	%	N	%	N	%
Thyroid glands	2	1	3	1.4	**34**	**16.2**	154	73.3	17	8.1
Gonads	1	0.5	5	2.4	54	25.7	**132**	**62.9**	18	8.6
Bone marrow	4	1.9	18	8.6	**47**	**22.4**	108	51.4	33	15.7
Skin	6	2.9	**35**	**16.7**	78	37.1	61	29	30	14.3
Bladder	3	1.4	41	19.5	**70**	**33.3**	54	25.7	42	20
Breast	6	2.9	43	20.5	**58**	**27.6**	65	31	38	18.1
Lungs	5	2.4	59	28.1	**56**	**26.7**	53	25.2	37	17.6
Stomach	13	6.2	66	31.4	**55**	**26.2**	33	15.7	43	20.5

[a]Participants rank the radiation sensitivity of organs from 1 (lowest) to 4 (highest). Bold indicates the correct answer

Table 5 Participants' knowledge of chest X-ray equivalents for each type of radiological examination

Single chest X-ray equivalents	0	10–49	50–99	100–199	200–299	300–499	500–600
Plain abdominal radiography	23.3%	55.7%	**10%**	9.5%	0.5%	0.5%	0.5%
Extremity angiography	4.3%	22.4%	27.6%	16.7%	14.3%	**7.6%**	7.1%
Head CT	0.5%	17.1%	29.5%	21%	**15.7%**	9%	7.1%
Thoracic CT	1.9%	15.7%	26.2%	20.5%	18.1%	**9.5%**	8.1%
Abdominal and pelvic CT	1.9%	15.2%	21.9%	21%	17.1%	11%	**11.9%**
Voiding cystourethrogram	7.1%	28.1%	27.6%	**19%**	9.5%	6.7%	1.9%
Abdominal ultrasound scan	**63.3%**	23.8%	5.2%	4.3%	1.4%	1.4%	0.5%
Thyroid isotope scan	15.7%	**27.6%**	15.7%	13.3%	10.5%	11.4%	5.7%
Brain MRI	**56.2%**	17.1%	4.8%	7.1%	4.3%	4.3%	6.2%

Bold indicates the correct answer

Concerning the frequency of exposure to ionizing radiation, 29% of participants responded several times a month, 30% several times a week, and 32.4% several times a day. In one study, 37.5% of the participants reported exposure to ionizing radiation more than three times a week [1]. In another study in a urology clinic in 20 different European countries, 72.5% of healthcare professionals reported exposure to ionizing radiation more than 3 times per week [18].

There is a lack of information from healthcare professionals about the sources of radiation exposure. Most of the respondents in our study consider cosmic rays as the biggest source of radiation in their daily lives, as well as medical services in hospitals. This finding is in line with the literature on cosmic radiation and disagrees with medical services [13]. Only 20% of the respondents in our study were able to correctly respond to the average annual dose in mSv that the population is exposed to natural sources of radiation. The corresponding rate of a similar study was 7.6% [20].

In this study, the protection measures that participants used more were increased distance from the source of radiation and lead aprons, while lead glasses and lead gloves were the measures they used less. In contrast to our results, in Egypt, it was found that doctors use lead aprons more than other protective measures, and little more than half used lead gloves [1]. In another study, the use of body and thyroid protective measures was high, while no one used lead glasses and gloves [4].

In a study by Kuwait nurses working in a radiology department, it was found that most of the participants were unaware of the radiation protection measures and were also unaware of the radiation-related risks. When they noticed their lack of knowledge, they said they were worried about radiation and would like to know more about the health risks associated with exposure to radiation [2]. Similarly, in this study, the participants raised their concern about the impact on exposure to ionizing radiation, as almost all of them would like to know more about the protective measures and the effects of exposure to ionizing radiation.

The lack of knowledge on safety issues associated with ionizing radiation has been reported extensively in the literature [1, 4, 5, 10, 12, 13, 18, 20]. This lack of knowledge means that healthcare professionals cannot effectively protect themselves or their patients against ionizing radiation.

X-ray and CT scan in body areas other than the abdomen and the pelvis expose the embryo to minimal doses of radiation, and in cases where such examinations include the abdominal and pelvic region, the radiation dose rarely exceeds 25 mGy. The absolute risk for effects on the fetus is small for doses up to 100 mGy and minimum for doses <50 mGy. CT scan is not forbidden for pregnant patients, particularly in some clinical conditions such as multi-injured or pulmonary thromboembolism. Whenever possible, diagnostic methods known to be harmless for the fetus, such as ultrasound and MRI, should be prioritized [3].

In this study, one-third of the participants reported that there should never be any radiological examination carried out in a pregnant woman and half of the respondents supported the opposite. This result is in accordance with the literature [20]. In the same study, it was reported that only 8.7% believe that radiological examinations can be made in pregnant women with the first 10-day rule. In our study, this percentage was particularly high (41.9%).

The ALARA principle includes the core of the radiation protection philosophy and its knowledge as an assessment of the level of knowledge of healthcare professionals [11]. In the current study, only one to four participants were aware of the ALARA principle, which indicates a serious lack of knowledge of safety issues in radiology. In a study carried out on 163 doctors from 6 different specialties in Palestine, the knowledge rate of this principle was significantly lower than that found in this study (6.1%) [5], while the rate was very high in pediatricians (48%) because of the increased sensitivity that physicians have due to young age of patients [6, 19].

Healthcare professionals should be able to compare radiation doses associated with various forms of medical imaging and express effective doses in terms of chest X-ray equivalents. The benefit of this knowledge is that healthcare professionals, as well as patients and their relatives, can perceive the size of radiation exposure and understand the associated risks [7]. In our study, only few participants correctly recognized the correct dose of different radiation examinations compared to chest X-ray equivalent. It is noteworthy that, in both this study and the literature, a large proportion of respondents supported that MRI and ultrasound emit ionizing radiation [5, 16, 20].

In this study, one of the five participants responded correctly for the active radiation dose resulting from a chest X-ray and a chest CT. In the United Kingdom, 22–24% of doctors knew the correct dose of an adult chest X-ray [17]. On the other hand, there is a study in the literature where none of the participants knew the correct dose [16]. In Germany, 59% of the participants were aware of the radiation dose in adult chest X-ray, and only 5% underestimated it [6]. In Turkey, 41.4% of all participants underestimated radiation doses [22], while in China, none of the non-radiologists were aware of the dose of radiation, and 77% of them underestimated the dose of radiological examinations [10]. Underestimation of the radiation dose means that healthcare professionals are not aware of the dangers of radiation and are less cautious when ordering or performing radiation examinations in their patients, which in turn can be unnecessarily exposed to ionizing radiation [18].

An important issue in clinical practice is the effect of exposure to ionizing radiation. In this study, almost all participants identified cancer, infertility, genetic disorders, decreased life span, hair loss, skin disorders, and cataracts as an effect. This percentage is much higher than in other studies [5, 19].

In addition, in our study more than half of the participants reported that they had read published article(s) in scientific or professional journals concerning the risks associated with ionizing radiation. Similar percentages have been reported in the literature with rates ranging from 46% [5] to 48% [19]. The increased percentage found in our study is believed to be due to the wide use of the internet and ease of access to information through medical databases.

In this study, in a total of 23 questions of knowledge, the participants answered correctly to 6.4 questions, that is, about 28%. In a study in Egypt, the average rate of knowledge was 56.5% [1]. In Australia, the average doctors' knowledge of radiation exposure from the diagnostic examinations ordered in the Emergency department was 40% [8].

4.1 Limitations of the Study

This study has some limitations. It does not take into account the duration of the seminars. Instead, it simply asks the participants whether they have attended a seminar or not. Furthermore, the data collection was done with a self-referencing questionnaire, making it difficult to validate the knowledge and awareness of the participants in the medical radiological report.

Another limitation of this study is that the questionnaire was given to participants by the researcher himself. In such cases, participants may overlap in some answers. Also, this study includes only one large hospital in Greece, and therefore, the generalization of findings in other clinical environments may be limited.

5 Conclusions

A finding of this study is that a small percentage of healthcare professionals have attended a radiation protection seminar or course, and this is consistent with literature in various countries around the world, such as Saudi Arabia, Egypt, Ethiopia, and Palestine, highlighting the knowledge gap and the need to educate healthcare professionals about the negative effects of ionizing radiation. Also, in this study, it was found that attending seminars and reading scientific articles on radiation protection increased the probability of correct answers, which is consistent with the literature, emphasizing the importance of formal education in ionizing radiation.

Insufficient knowledge of healthcare professionals can alter the expected benefits in terms of risk and may affect medical decisions. The limited knowledge of healthcare professionals about ionizing radiation leads to increased exposure of them and patients than the allowed radiation doses. Therefore, this study emphasizes the need to inform all healthcare professionals about ionizing radiation. Explanation of the effects of radiation should be considered vital by any healthcare professionals, along with efforts to maximize basic radiation protection.

It is proposed to carry out training courses to improve basic knowledge and raise awareness of the biological effects of radiation on healthcare professionals and patients. Finally, it is proposed to include a radiation protection course in the healthcare professionals' undergraduate curricula in order to address the current knowledge gap in clinical practice.

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