



Awareness of radiation hazards in patients attending radiology departments

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Abstract

Evaluating the knowledge of patients attending radiology departments regarding ionizing radiation used in medical imaging and its associated hazards can provide knowledge of the patient's awareness level of the associated risk of the radiation used in medical imaging. The aims of this study were to evaluate the awareness of patients regarding medical radiation types used in medical diagnostic imaging and its influence on their decision to proceed with that procedure. Over an 8-months period, a total of 418 patients, 48% Men and 52% Women, presenting for diagnostic imaging in the department of radiology, completed a 15-point questionnaire. The questionnaire included demographic and radiation awareness sections. Less than 32% of the participants had a potential risk of radiation explained by the doctor before the procedure. 59% of the participants expressed that the potential risk of radiation makes them anxious; less than about 25% of the participants showed that the potential risk of radiation affects their decision to have the procedure. Overall, the data collected from this survey indicate that there is a lack of information about radiation risk provided to the patients prior to the diagnostic procedure. Efforts should be made to ensure that patients receiving multiple medical imaging tests are aware of the radiation they are receiving.

Keywords Radiological risk perception · Patient's awareness · Medical imaging

Introduction

Ionizing radiation is well recognized as a causative agent of acute and chronic health problems (e.g., cancers and genetic mutations) that can lead to mortality and morbidity (Brenner and Hall 2007; Christodouleas et al. 2011; Giles et al. 1956; Howe and McLaughlin 1996; Linet et al. 2009, 2012; Smith-Bindman 2010; Smith-Bindman et al. 2009; UNSCEAR 2000. The United Nations Scientific Committee on the Effects of Atomic Radiation 2000). The increase utilization of ionizing radiation in medical imaging and health care practice has increased over the past decades, which is regarded as a potential health hazard (Berdahl et al. 2013; Chung et al. 2019; Coleman et al. 2005; Smith-Bindman et al. 2008).

Individuals can be exposed to radiation from various resources, including naturally occurring, medical imaging, and other human-made non-medical equipment. The perception and awareness of ionizing radiation effects varies between the general population and radiation experts due to their knowledge and competence (Kanda et al. 2012; Mainous and Hagen 1993; Ria et al. 2017; Schauer and Linton 2009; Slovic 1996).

Many patients might not be aware of the risks associated with radiation diagnostic examination; others trust their treating physician and simply follow their orders without attempting to understand the risks associated with the requested procedures. Some referring physicians feel hesitant giving the patient sufficient information about the potential risk of exposure to radiation, and this might be due to the fear that the patient may refuse a procedure that is critical for diagnosis and treatment (Banerjee et al. 2019; Hollada et al. 2015; Mattsson and Nilsson 2015; Schuster et al. 2018). Sometimes the referring physicians do not have sufficient information or time to discuss complex technical details about the procedures and levels of radiation exposure that result from their use (Ricketts et al. 2013; Schuster et al. 2018). Increasing patient information is an important

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aspect of patients' autonomy. Earnest suggested that having a written organ specific consent would give patients the information that a reasonable person would want to know prior to having a screening chest CT examination (Earnest et al. 2003). Underestimation of radiation hazards might put the patients at high risk of frequent ionizing radiation exposures. This can increase the radiation hazard, especially with the availability of a new generation of medical equipment that lead to higher radiation doses, such as computed tomography (Almaghrabi 2016; Avramova-Cholakova et al. 2015; Doss 2014; Montes et al. 2013; Salerno et al. 2018; Salvatore et al. 2019). A lack of systematic radiation monitoring and documentation of radiation exposure history in the patient file increases the risk of exceeding the safe limits of radiation exposure for individuals. The European Directive 2013/59/EURATOM requires patient radiation dose information to be included in the medical report of radiological procedures (European_Soc_Radiology 2015). On the other hand, we increasingly see patients becoming more involved in their own medical care. Prior to attending the hospital, they seek information to be better prepared for their hospital examination. They increasingly use online search engines to read about the risks and effects of their imaging procedure (Kenny et al. 2019).

To provide effective communication to the patient, it is necessary to first assess the patient's level of knowledge regarding medical exposure. To evaluate the level of radiation awareness, qualitative assessment among patients would help in better understanding the current situation and the best ways to improve radiation awareness.

The goal of this work is to survey patients' current knowledge level of both medical exposure to ionizing radiation and professional disciplines and communication means used by patients to garner information.

Methods

A cross-sectional survey-based design was used. A consecutive series of 418 eligible patients attending the radiology department for investigation at King Khalid University Hospital, Riyadh, Saudi Arabia, from January 2017 to August 2017 were included in this study. 500 questionnaires were distributed and 418 were the final responses. Approval from the institutional review board was obtained before the commencement of the study, Ref. No. 17/0037/IRB. Candidates attending their radiologic examination, including routine X-ray imaging, CT, fluoroscopy, MRI, US, or nuclear medicine and agreed in participating, were provided an informational sheet that explained the intentions of the study before undergoing the procedure.

The questionnaire was designed by the authors and was available in both Arabic and English languages and consisted

of fifteen multiple-choice questions, included demographic information (gender, age range, radiology history and education level). Respondents were asked if they were provided with radiation information upon examination from the health workers' team and whether that has an influence on their decision on proceeding with the radiology procedure. The questionnaire included a question on the participants' knowledge about radiation used in medical imaging and the source of this knowledge, the respondents were asked to choose whether it was from TV and Radio, Magazines and Newspapers, school, internet, family and friends or from the radiology technician. The questionnaire also included a question about which radiology modality posed the greatest health risk, the respondents were asked to choose between CT, X-ray or they have the same risk. The remaining questions covered the radiation awareness knowledge of ionizing radiation, which represents the basic aspects of underlining radiation safety awareness, such as radiation-induced cancer, and cause of infertility and fetal malformations.

The statistical analysis was carried out using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). The quantitative variables were expressed as mean plus-minus standard deviation while the qualitative variables were recorded as proportions or percentages. Different groups were made according to age, sex and educational level and the different responses were compared between the groups. A chi-square test was used to test for significant differences in proportions between the different groups. Moreover, we did linear by linear association analysis to see the trend of different variables or the questions response's according to sex, education level and to different age groups. *p* values less than 0.05 were considered significant.

Results

There were 418 respondents to the survey (217 women, 201 men). The majority of respondents (52%) were aged between 21 and 40 years (Table 1).

Most (68.1%) of the respondents replied that the doctor did not explain the potential risk of radiation, and 57.2% of the respondents answered that they have read/heard about the radiation risk of medical imaging. They derived their information from various sources: TV/radio, school, an article in the newspaper, the Internet, or people around with no significant variation between the sources. Only 50.5% of respondents thought that CT is more dangerous than an x-ray. More than half (59.1%) of the respondents replied that the potential risk of radiation makes them anxious (women showed a higher percentage: 65.0%). Most of the respondents answered that the potential risk of radiation did not affect their decision about doing the procedure (76%) (Table 2).

Table 1 Demographic information (number, percentage of overall)

Sex	
Men	201 (48.1%)
Women	217 (51.9%)
Age	
Less than 20	30 (7.2%)
21–40	220 (52.6%)
41–60	145 (34.7%)
More than 60	23 (5.5%)
Education	
No	19 (4.5%)
Primary	29 (6.9%)
High school	31 (7.4%)
College	90 (21.5%)
University	249 (59.6%)

42% of our respondents did not believe that frequent exposure to radiation can cause cancer (Table 2). Only 41.6% of our respondents thought that frequent radiation can cause infertility (Table 2). 90.2% of respondents agreed that radiation exposure can cause fetal malformation.

Awareness of radiation hazards and its possible relationship with cancer was noticed to be higher in the middle-aged group (60%). This decreases among the older age group (40%). Infertility and its probability in case of frequent radiation were not well recognized among all age groups. All age groups show good awareness regarding pregnancy risks associated with radiation. We found that age had a significant impact on the general knowledge about the risk related to medical imaging (p value = 0.001). Young aged patients have read/heard more about the risk related to medical imaging than old aged patients (Table 3).

With respect to education level we found knowledge about the possible risk related to medical imaging increased with the level of education (p value = 0.004) (Table 4). Also, education had a significant impact on the awareness of the relation between frequent exposure to radiation and the possible risk of developing cancer (p value = 0.001). Education

Table 2 Respondent's awareness about ionizing radiation

Awareness question	Yes N (%)	No N (%)
Q-1: The potential risk of radiation is explained by the doctor	132 (31.6)	286 (68.4)
Q-2: The potential risk of radiation makes you anxious	247 (59.1)	171 (40.9)
Q-3: Potential risk affects your decision about doing the procedure	98 (23.4)	320 (76.6)
Q-4: Have you read/heard about the risk of medical imaging?	240 (57.2)	178 (42.8)
Q-5: Do you think frequent exposure to radiation can increase the risk of cancer?	242 (57.9)	176 (42.1)
Q-6: Do you think frequent exposure to radiation can increase the risk of infertility?	174 (41.6)	244 (58.4)
Q-7: Do you think radiation exposure in pregnancy can increase the risk of fetal malformation?	377 (90.2)	41 (9.8)

Table 3 Comparison of knowledge and awareness based on age

	Age < 20 Yes n (%)	Age 21–40 Yes n (%)	Age 41–60 Yes n (%)	Age > 60 Yes n (%)	p value*
Q-1	10 (43.5)	40 (27.6)	75 (34.1)	7 (23.3)	0.746
Q-2	10 (43.5)	91 (62.8)	132 (60)	14 (46.7)	0.791
Q-3	4 (17.4)	32 (22)	55 (25)	7 (23.3)	0.434
Q-4	15 (65.2)	96 (66.2)	118 (53.6)	10 (33.3)	0.001
Q-5	8 (37.8)	88 (66.7)	133 (60.5)	13 (43.3)	0.755
Q-6	3 (13)	71 (49)	90 (40.9)	10 (33.3)	0.998
Q-7	19 (82.6)	135 (93.1)	199 (90.5)	24 (80)	0.374

See Table 2 for the content of the questions

* p value is linear by linear association

level was not significantly related to the patient been anxious to the potential risk of radiation nor affects the patient decision about doing the procedure (Table 4).

In respect to sex, we found that women were more anxious about the potential risk of radiation than men (p value = 0.031). Women also thought that radiation exposure in pregnancy can increase the risk of fetal malformations more than men (p value = 0.024). Men significantly more often than women thought that frequent exposure to radiation can increase the risk of infertility (p value = 0.001). Sex had no impact on affecting patient decision about doing the procedure with respect to the potential risk of radiation (Fig. 1).

Discussion

The involvement of radiation imaging in the health care system has been evolving rapidly over recent years. Although it has a great impact on clinical practice and management of patients, it is associated with a risk of adverse health effects.

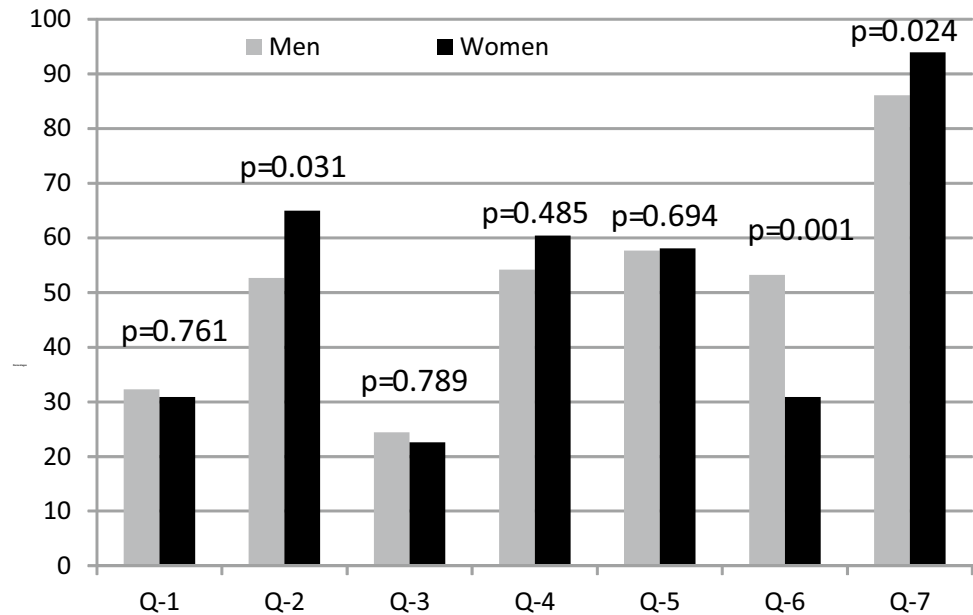
Awareness and appreciation of the risks associated with undergoing these modalities are an important element of modern societies. We aimed through this study to assess awareness of radiation hazards among our study population.

Table 4 Comparison of knowledge and awareness based on education level

	University Yes <i>n</i> (%)	College Yes <i>n</i> (%)	High school Yes <i>n</i> (%)	Primary Yes <i>n</i> (%)	No Yes <i>n</i> (%)	<i>p</i> value*
Q-1	78 (31.4)	32 (35.6)	8 (25.8)	6 (20.7)	8 (42.1)	0.892
Q-2	159 (63.8)	47 (52.3)	14 (45.2)	14 (48.2)	13 (68.4)	0.135
Q-3	55 (22.1)	26 (28.9)	5 (16.1)	5 (17.0)	7 (36.8)	0.602
Q-4	162 (65.1)	41 (45.6)	11 (35.5)	17 (58.6)	8 (42.1)	0.004
Q-5	162 (65.1)	43 (47.8)	17 (54.8)	13 (48.2)	7 (36.8)	0.001
Q-6	105 (42.2)	38 (42.2)	15 (48.4)	12 (41.4)	4 (21)	0.333
Q-7	232 (93.2)	78 (86.7)	23 (74.2)	25 (86.2)	19 (100)	0.189

See Table 2 for the content of the questions

**p* value is linear by linear association

Fig. 1 Comparison of sex-based patient's awareness of ionizing radiation. See Table 2 for the content of the questions. *p* values are based on Chi-square test

Only 58% of studied participants thought that frequent exposure to radiation can increase the risk of developing cancer. Only 50.5% of respondents thought that CT is more dangerous than an X-ray. These findings demonstrate a need for patients to be appropriately informed of the benefits and risks associated with the radiation used in medical imaging.

Our study variables were mainly age, sex, and educational level. Although our sample size was small, it properly reflects our population with respect to age and sex. It also includes different education levels and can give us a comprehensive assessment of awareness among patients visiting the radiology departments.

In comparison with other studies, we found similar results on that educational level does not play a major role in regard to radiation hazard awareness (Alshammari et al. 2019). At some aspects of radiation hazard, the percentage of awareness was higher in the low education level group.

Awareness of possible radiation-induced infertility was obviously affected by sex. Unfortunately, women were less aware of radiation hazards and their possible negative effects on their fertility. With regard to adverse effects of radiation, this result suggests that patients' awareness about teratogenic risk associated with ionizing radiation was very high, most of the respondents (90.2%) do think that radiation exposure in pregnancy can increase the risk of fetal malformation, this was higher than the findings in Aldossari study 49.3% (Aldossari et al. 2019).

Based on our survey regarding knowledge and awareness, we concluded that people in young and old adult age groups, in contrast to the middle-aged groups, had a relatively low level of knowledge and awareness of radiation hazards. There needs to be more focus on health education to improve awareness among these age groups.

Most of the participants stated that the potential risk of radiation was not explained to them by their doctors (68.4%),

demonstrating the lack of proper communication between the radiologist and the patient. An important element of modern medical procedures is shared decision making, which implies involving patients in the decision regarding the need of medical imaging.

The knowledge and awareness of the radiation doses and risks can help the clinicians better discussing the risks and benefits of radiology procedures with their patients. It also guides them when making decisions regarding the need and the frequency of scans (Al-Rammah 2016).

Limitations

This study was conducted in the department of radiology in the university hospital and provides information relevant to a single radiology department in Saudi Arabia. It is possible that patients from different practices including private and large public hospitals, as well as patients in other geographical locations, in particular small cities or remote areas, would have responded to the survey differently. Thus, the study findings have limited external validity. In addition, in this study the health risk of radiation used in medical imaging was generalized and was not related to a specific kind of imaging modality. Therefore, the participants may have responded to some of the questions differently if they were asked about a specific kind of radiology procedures.

Conclusions

The findings of this study suggest that in general there is a lack of knowledge among patients leading to an underestimation of risks associated with ionizing radiation exposure. Clearly, there is a need for improved communication between health professionals and patients. Radiation hazard is a critical issue in the health care system that needs to be addressed by clinicians and radiation protection officers. The patient should be more involved in the decision to proceed with radiology procedures and should be more aware of the level of radiation that they will be exposed to as well as the previous radiation exposures that he/she received. The radiation exposure and the associated risks should be discussed with the patient at different points and levels. Radiologists, radiographers/technologists and referring physicians have different roles. Referring physicians will discuss the clinical need for the imaging procedure but the discussion about radiation exposure is more likely to occur at the point of imaging. It is very important that health professionals are well prepared to communicate and discuss in simple language that can be easily understood the risks associated with radiological imaging.

Recommendations

Radiology departments need to provide adequate information to patients to ensure that patients are informed of the benefits and risks associated with the exposure derived from imaging procedures. Healthcare practitioners should be able to inform patients about the benefits and potential risks of ionizing radiation for medical purposes based upon evidence-based practice and guidelines (Ribeiro et al. 2020).

More health education is required for the general population. This will help to emphasize the situation of awareness toward the radiation hazard and improve health care in general.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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