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ARTICLE

Analysis of public perception about ionizing radiation

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Abstract – This study assessed the level of public knowledge regarding ionizing radiation, the sources of information available to the public, and the preferred sources of education. A descriptive cross-sectional study was conducted in Jeddah, Saudi Arabia. A 15-question survey was distributed to participants who attended a radiation awareness activity held for the public. Participants were asked to rank their confidence regarding ionizing radiation knowledge on a Likert-style scale. They also answered questions on their perception of risks, the source from which they received health information, and their preferred method of education. Only 3% of the 244 participants were "knowledgeable" about ionizing radiation. Nine percent stated they were confident about their ionizing radiation knowledge, and they were more knowledgeable than unconfident individuals ($p = 0.041$). Age, gender, and education level played no role in ionizing radiation knowledge ($p = 0.746$, $p = 0.245$, and $p = 0.060$, respectively). Among those who had undergone a medical imaging investigation during the past year, only 24% received an explanation of the risks and benefits. Participants overestimated the risk of nuclear plants, as this was selected as the source with the greatest risk to health, followed by medical sources. Most of those who had prior knowledge searched for the information on the internet (34%), however, more participants would prefer to receive education from their healthcare providers (36%).

Keywords: public / ionizing radiation knowledge / perception / ionizing radiation sources / ionizing radiation risks

1 Introduction

Ionizing radiation can be either naturally occurring background radiation or from a man-made source (UN, 2000; WHO, 2018). As natural background radiation is ubiquitous, the exposure of human beings is inevitable (UN, 2000, 2008). The sources of this background radiation include cosmic rays originating from outer space and radon, which is a naturally occurring radioactive gas present everywhere on Earth (Mewaldt, 1996; UN, 2000). Radon is classified as a known pulmonary carcinogen by the International Agency for Research on Cancer (Laurier *et al.*, 2001). Man-made radiation sources include X-ray equipment and nuclear reactors, which are used to generate nuclear energy (UN, 1993, 2000). Radiation in the medical field is a growing source of man-made radiation (UN, 2000). The use of medical procedures using ionizing radiation is increasing because of their value in diagnosing and treating various diseases (UN, 1993, 2000, 2008), however, this value comes at a cost. Well-documented late health effects of radiation include cancer, developmental abnormalities to the growing fetus, and some degenerative diseases (US National Research Council, 1990; Brenner *et al.*, 2003). Children are more sensitive than adults because they have a greater proportion of growing tissues (NRPB, 1991; UN, 2010). Therefore, it is essential for the public to be aware of the sources and risks of radiation.

Several global studies have indicated that the public have very little knowledge of the sources and risks of radiation (Markowsky and Peduto, 2012; Evans *et al.*, 2015). In a study conducted in Vermont, United States, general knowledge about radiation in the general public was found to be low, with only 8% of respondents confident in their knowledge of ionizing radiation. Those who were knowledgeable about sources of ionizing radiation had higher education levels and were more likely to work in science/healthcare (Evans *et al.*, 2015). In a similar study conducted in Port Harcourt, Nigeria, a survey was distributed to patients who had received X-rays to assess their radiation awareness. It was found that most patients had some formal education; however, 87% of the participants were not aware of any dangers associated with ionizing radiation (Briggs-Kamara *et al.*, 2013). Markowsky and Peduto (2012)

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conducted a study to assess the public perception, concerns, and awareness of medical radiation. They found that over half of the respondents were unaware of any risks associated with CT scans. They also reported that only 15% expressed concern about future risks.

In Saudi Arabia, there are insufficient data regarding the level of public knowledge about ionizing radiation. As the abovementioned studies indicate the importance of implementing methods to educate the public, data on the public's preferred methods of education should also be sought. The aim of our study is to assess the knowledge of ionizing radiation among the general population in Jeddah, Saudi Arabia, and to explore the public's preferences regarding the sources of information about ionizing radiation.

2 Subjects and methods

2.1 Study design and participants

In this cross-sectional study, a validated questionnaire was distributed to 244 participants who visited a radiation awareness campaign, which was open to the public in a shopping mall in the city of Jeddah, Saudi Arabia, over three days. The campaign title was "Radiation Awareness". It was organized by the department of radiology at King Abdulaziz University. Inside the site of the campaign, visitor passed by 7 healthcare professionals who educated them about the different types and sources as well as benefits and risks of radiation. Participants were asked to anonymously complete and return the questionnaires before entering the site of the campaign. Visitors who identified themselves as healthcare providers were excluded from this study. There was no time limit for completing the questionnaire. Paper questionnaires were distributed after obtaining ethical approval from the Research Ethics Committee of the Faculty of Medicine, King Abdulaziz University (Jeddah, Saudi Arabia). Participation was entirely voluntary.

2.2 Questionnaire

We used a validated questionnaire designed by Evans *et al.* (2015) to assess public perception and knowledge of ionizing radiation. The questionnaire comprised 15 questions in three parts. First, participants were asked for their demographic information, *i.e.*, age, nationality, gender, and education level. Then, they were asked to rank their confidence in their ionizing radiation knowledge on a Likert-style scale ranging from 1 (not at all confident) to 5 (highly confident). Participants who chose either 4 or 5 were classified as "confident" in their knowledge of ionizing radiation, whereas those who chose 1 or 2 were classified as "not confident". To evaluate participants' knowledge on ionizing radiation, we asked them to choose which of the following were potential sources of ionizing radiation: "computed tomography (CT) scan, magnetic resonance imaging (MRI), chest X-ray, mammogram, ultrasound, and dental X-ray". Of these, only the CT scan, chest X-ray, mammogram, and dental X-ray subject patients to ionizing radiation. Ultrasound and MRI do not expose patients to ionizing radiation. Participants who were able to correctly classify five or six of these imaging modalities were considered to be "knowledgeable". We then asked participants whether they (or any member of their family) had undergone an imaging investigation exposing them to ionizing radiation, and, if so, whether they had been counseled on the risks and benefits of the imaging investigation by the ordering doctors. Possible answers were "yes", "no", and "I don't know". They were also asked to rank their confidence in their doctor's knowledge on imaging investigations using ionizing radiation on the previously described Likert-style scale. To assess participants' perception of the risks of various ionizing radiation sources, we asked them to state what they believe poses the greatest and the least health risk to their own personal health and to the health of Jeddah inhabitants from the following: medical imaging tests that use ionizing radiation, radon, natural sources of ionizing radiation other than radon, nuclear power plants, or airplane travel. Finally, participants were asked to report the means by which they received information about ionizing radiation, and the preferred method of receiving such information. Possible answers included "newspaper/magazine", "television", "internet", "family/friends", "healthcare professionals", "scientific publication", and "I haven't received any information about ionizing radiation".

Table 1. Demographic characteristics of respondents ($n = 244$).

Age	
Mean ± SD	29 ± 12 years
Minimum age	16 years
Maximum age	65 years
Gender	*n* (%)
Male	28 (11.5%)
Female	216 (88.5%)
Level of education	*n* (%)
Less than high school degree	10 (4.1%)
High school degree	82 (33.6%)
Some university/college	52 (21.3%)
University degree	90 (36.9%)
Postgraduate	10 (4.1%)

2.3 Statistical analysis

Categorical variables were presented as frequencies and percentages. Continuous variables were presented as mean ± SD. The relationships between level of knowledge and age of the respondents and between the level of knowledge and confidence in healthcare professional's knowledge were calculated by independent sample *t*-tests. The association between the level of knowledge and gender was examined using a Chi-squared test. The dataset contained no missing data; hence, missing data management was not required. The analysis was performed at the 95% confidence interval using the Statistical Package for Social Science (SPSS), version 23 (IBM, Armonk, NY, USA).

3 Results

The demographic data of the 244 participants are presented in Table 1. Participants mostly held a university degree (90 participants, 36.9%), followed by a high school degree (82

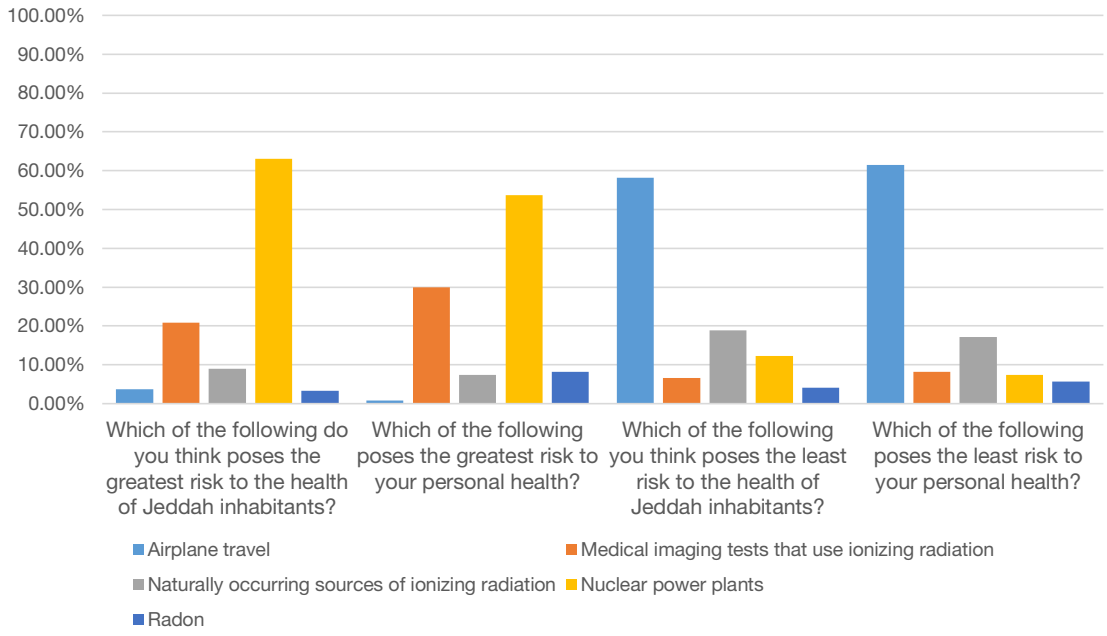

Fig. 1. Answers to questions related to knowledge of ionizing radiation ($n = 244$).

participants, 33.6%). Only 22 participants (9%) were found to be "confident" in their knowledge of ionizing radiation, whereas the majority (182 participants, 74.6%) were "not confident" in their ionizing radiation knowledge. We identified only seven respondents (2.9%) as "knowledgeable" about ionizing radiation, whereas 237 participants (97.1%) were "not knowledgeable". MRI and ultrasound were incorrectly identified as sources of ionizing radiation by 65.5 and 29.9% of respondents, respectively.

Those who were confident about their knowledge of ionizing radiation were found to be more knowledgeable than those who were not confident ($p = 0.041$). In contrast, there was no statistically significant difference in the level of knowledge across all age groups ($p = 0.746$), nor there was a difference in the level of knowledge between male and female participants ($p = 0.245$). Moreover, those with a higher level of education did not have more knowledge about ionizing radiation than those with a low level of education ($p = 0.060$).

Fifty-eight respondents (23.8%) said that they or a member of their family had been exposed to an imaging investigation that uses ionizing radiation within the past 12 months. Of those, only 24% definitely received an explanation of the risks and benefits of the performed imaging investigation from the healthcare professional, although 34% do not remember if they received an explanation or not. When we asked participants if they were confident in the healthcare professional's knowledge of risk and the benefits of the imaging investigations ordered, 53 participants (22.7%) answered that they were confident, whereas 91 (37.3%) indicated that they had little confidence in their healthcare professional's knowledge.

When asked about the risks to Jeddah inhabitants, 154 respondents (63.1%) selected nuclear power plants as the greatest risk and 142 (58.2%) chose airplane travel as the lowest risk. Similarly, 131 respondents (53.7%) thought that nuclear power plants posed the greatest risk to their personal health, and 150 (61.5%) identified airplane travel as presenting the least risk to their personal health among the given options (Fig. 1).

The majority of participants ($n = 143$, 58.6%) stated that they have never received any information about ionizing radiation, with 101 (41.4%) stating that they had received some degree of information. Among those, the majority (82 participants, 33.6%) received such information from the internet. The sources from which participants had received information about ionizing radiation are presented in Figure 2. When asked about their preferred source of receiving information about ionizing radiation, 36.1% selected "health-care professional", followed by "internet" (31.6%), "scientific publications" (21%), "television" (7%), and "family/friends" (3.3%) (Fig. 3).

4 Discussion

Despite the benefits of treatments and tests that use radiation, the risks associated with ionizing radiation prompted us to seek information on the level of public knowledge regarding this matter. The results of this study show that there is a severe lack of knowledge, which is in agreement with the results of other studies (Markowsky and Peduto, 2012; Briggs-Kamara *et al.*, 2013; Perko, 2014; Evans *et al.*, 2015). However, the participants in our study exhibited a poorer level of knowledge than that reported in previous studies. For instance, only 2.9% of our study group were knowledgeable, compared to the average of 13% in the study by Briggs-Kamara *et al.* (2013).

Unlike the study by Evans *et al.* (2015), our results do not indicate any significant relationship between the level of education and being "knowledgeable", despite the fact that more than half of the participants had been educated to above high school level. This indicates that the methods of raising awareness regarding ionizing radiation are ineffective. It is a good sign that 90% of participants admitted that they were

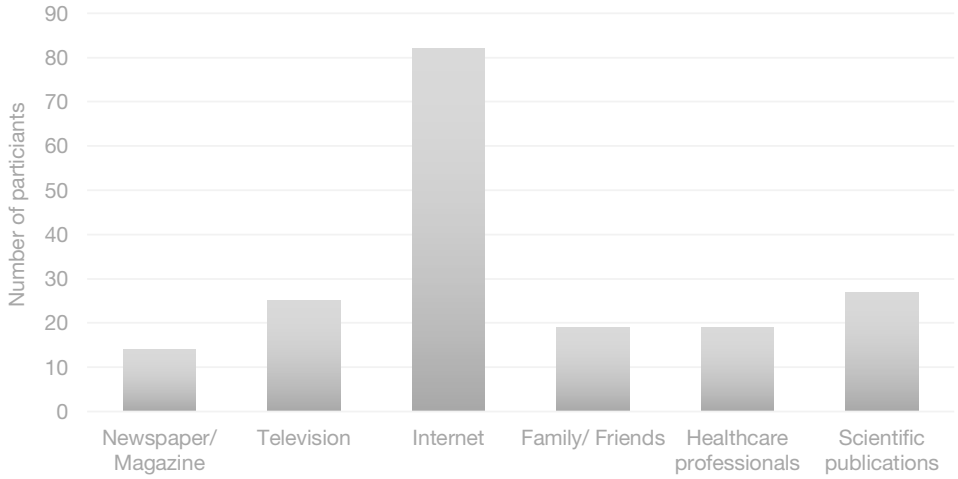

Fig. 2. Sources of information about ionizing radiation ($n = 101$). 143 (58.6%) respondents had not received information from any source.

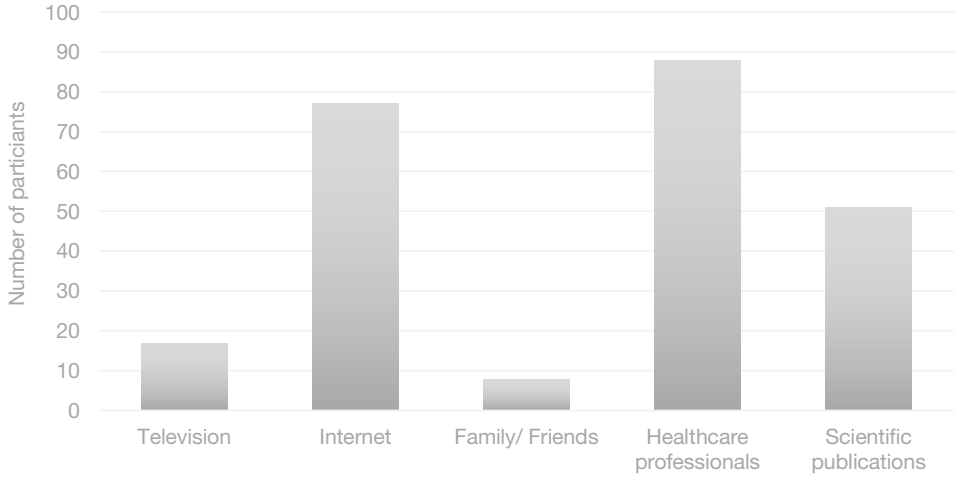

Fig. 3. Preferred source of receiving information about ionizing radiation ($n = 244$).

unconfident about their knowledge, as this shows a realization of their lack of knowledge. This percentage is similar to that reported by Evans *et al.* (2015).

It has been reported that the public tend to overestimate the risk to their health of nuclear power plants. (Perko, 2014). The participants in our study selected nuclear plants as the greatest risk to both their own health and that of Jeddah inhabitants, despite the fact that there are no nuclear plants in Saudi Arabia. This overestimation of nuclear power plants' risk can be attributed to the wide international media coverage of the well-known nuclear accidents in Chernobyl and Fukushima Daiichi nuclear power plants (Friedman, 2011). Medical imaging using ionizing radiation ranked second as the source that poses the greatest risk to health to Jeddah inhabitants (20.9%) and to the participants' own health (29.9%). These figures are similar to that found by Evans *et al.* (2015). Although, these percentages are generally low, given that all other mentioned sources of radiation are of low risk (Alaamer, 2012; CDC, 2018), this is a good sign that the public have some level of perception of medical imaging risks compared to those from other sources.

One important reason why the public lack knowledge regarding ionizing radiation risks is that they do not receive education from their healthcare providers (Evans *et al.*, 2015). In our study, most patients stated that they would prefer to receive education about ionizing radiation from their healthcare professional; however, only 19% of those who had received education about ionizing radiation did so from their healthcare provider. Indeed, doctors themselves lack knowledge regarding this matter (Barnawi *et al.*, 2018). Therefore, doctors need to be educated early in medical school, and radiation protection training should be mandatory (Barnawi *et al.*, 2018). Additionally, the need to educate patients about the cumulative effect of radiation prior to undergoing radiological investigations should be emphasized. The majority of those who had prior knowledge about ionizing radiation obtained their information from the internet. Although this is a valuable information source, the quality and accuracy of this information should be monitored because it is possible to receive biased information (Bastos and Ferrari, 2011). Doctors should be responsible for pointing patients toward trusted websites from which they can receive accurate information. Mass media should also attempt to educate patients, given their wide reach and strong influence on the public. Continuous education over a long period of time could

bring about changes in the attitude and behavior of people (Sharma and Gupta, 2017). Health awareness campaigns, similar to that which we delivered, are proven to effectively improve the knowledge of individuals (Ranjbar *et al.*, 2017). More public radiation awareness campaigns should be conducted, as such events are scarce in Jeddah.

One of the limitations of our study is that there was an overrepresentation of the female population in the studied sample, which could cause bias in the results. This overrepresentation could be due to the fact that more females than males visit shopping malls (Sohail, 2015). This should be corrected in future studies by attempting to bring the female to male ratio in the surveyed sample closer to that in the studied population. Our study also predominantly included participants from one geographical location, namely northwestern Jeddah. This could affect the generalization of this study to the Jeddah population. In addition, we did not compare the knowledge of those who had received education and those who had not to evaluate the validity of their sources and identify sources that may provide inaccurate information.

5 Conclusion

The inadequate responses of participants regarding ionizing radiation suggest that there should be more public education regarding this matter. Ideally, this education would come from healthcare professionals, as they were the preferred method of education among our study participants. In addition, patients should be directed toward reliable internet sources from which they can receive accurate information, as the internet was the second most preferred method of education and the source of information for most of those who had prior knowledge. Hospitals should encourage doctors to discuss the benefits and risks of radiological investigations with their patients. This could be monitored by regulatory authorities. Future studies should be devoted to assess the efficiency of different sources of information to gain further insight into the best methods of education regarding ionizing radiation.

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