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Perception of medical radiation risk in Ireland: Results of a public survey

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ABSTRACT

The Basic Safety Standards (BSS) directive 2013/59/EURATOM places a new emphasis on the practitioner and/or referrer to inform the patient of the benefits and risks associated with radiation dose. To communicate effectively, a prior knowledge of what a person comprehends is beneficial. The aim of this study was to evaluate the Irish public's current level of understanding of ionising radiation and its associated risks. We designed a survey consisting of ten multiple choice questions and asked members of the public to respond. There were 326 responses to the public survey. All survey data was collected anonymously using snowball sampling. Overall, the data collected from this survey indicates that the respondents do not have a clear understanding of radiation risks. In particular there was a misunderstanding in which modalities use ionising radiation and there was a perceived limit in the number of X-rays a person can have in a year, implying that the public have not been informed of the principle of justification. Patients must be presented with the benefits of an exam involving ionising radiation together with a clear explanation of the risks.

1. Introduction

Risks associated with ionising radiation are difficult concepts for members of the public to understand. The Basic Safety Standards (BSS) directive 2013/59/EURATOM [1], transposed into Irish legislation via S.I. 256 [2], places a new emphasis on the referrer or the practitioner to inform the patient of the benefits and risks associated with radiation dose from their medical exposure prior to the exposure taking place. In order to determine an effective method for communicating benefits and risks of ionising radiation to patients, it is prudent to first ascertain the current level of knowledge and perceptions that exist about ionising radiation in Ireland.

In this modern, digital era information is readily available at our fingertips. The twenty-first century patient is becoming more involved in their own medical care. Prior to attending hospital, patients 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. They are worried about the unknown and ask questions such as “What happens if I have too many X-rays?”, “Do I need this X-ray, what are the alternatives?”. Occasionally patients contact hospitals to find out where is the most modern and most technologically advanced equipment available. The misinformation available online can intensify the person's concern and lead to increased anxiety.

Furthermore, occasional media coverage of ionising radiation brings a heightened awareness, mostly after an accident or radiation overexposure has occurred. The associated scaremonger headlines tend to exaggerate and misinform the public and lead to confusion and concern. One such example is a popular television show host who claimed that the lack of thyroid collars in mammography was leading to increased cases of thyroid cancer in women [3,4]. This resulted in incidences of patients cancelling exams or requesting inappropriate thyroid shielding. Cases such as this can skew public opinion of ionising radiation towards the dangerous side.

It is while they are attending for their imaging exam that patients have the opportunity to learn about ionising radiation and ask questions of the experts. They have the opportunity to discuss potential risk and clarify any misconceptions or misunderstandings. The benefit and risk information provided should reassure the patient and make them feel safe. Medical situations can be stressful for patients, being able to clearly communicate benefits and possible risks of an imaging exam helps ease their concerns.

A patient-centered approach to medical decision making emphasises the need for patients to be informed, to help make decisions about their procedures, and to have opportunity for their questions to be answered prior to the procedure. In high stress situations people have difficulty processing information being explained to them. Radiation benefits and risks should be explained in a clear manner that the patient will

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understand. Development of material to adequately inform the patient about risks associated with routine procedures is an ongoing challenge.

The aim of this novel study was to gauge what the Irish public understand about ionising radiation used in diagnostic imaging. Better knowledge of what the public understand help healthcare professionals to provide improved, clearer information about the benefits and risks of ionising radiation. Although anecdotally it is believed that the public do not have a good understanding of radiation doses and risks in medical exposures, few studies have investigated this hypothesis [5]. Indeed, no Irish studies that we are aware of have addressed the public's perspective on radiation benefits and risks in medical exposures.

2. Materials and methods

A multiple choice survey was conducted over 7 months from November 2018 to May 2019. Respondents were recruited using snowball sampling and all survey data was anonymous. All respondents were members of the general public, patients were not approached for this survey. The survey did not exclude those who previously had a radiological examination. The survey was designed to assess public perception and knowledge of ionising radiation with a particular focus on radiation use during pregnancy, comparison of high and low dose modalities and level of risk for different modalities used in diagnostic imaging. The survey was designed and analysed using SurveyMonkey (SurveyMonkey Inc., California, USA).

The survey was separated into two sections. The first section consisted of ten multiple choice questions relating to imaging modalities used in Radiology Departments and aimed to evaluate knowledge of basic aspects underpinning radiation awareness. Questions specifically relating to the benefit of ionising radiation were not included since this varies too much depending on an individual's personal experience or clinical history. The second section asked for demographic information (gender, age range, radiology history and profession) so that the sample could be characterised. In the analysis, responses given as "strongly agree" or "agree" have been combined and similarly responses given as "strongly disagree" and "disagree" have also been combined. For those unsure of an answer, "neither agree nor disagree" was available as a response option.

As part of the survey design, an initial pilot survey was first issued [6]. Following on from the pilot study, the survey used for this study was issued. The questions in the second survey were guided by those from the pilot survey. The survey questions are shown in Appendix 1. To aid clarification as to why responses were given, a small number of participants were recruited to answer the survey in a semi-structured interview style. This subset of respondents was recruited from a local athletics club. The club was chosen as there was a good cross section of ages and genders available. In these cases the participant was provided with a paper copy of the survey and after they completed the entire survey the researcher asked respondents one follow up question to each survey question i.e. they were asked "why did you chose this answer?". This allowed open ended data to be collected.

3. Results

There were 326 respondents to the survey (197 female, 124 male, 5 unanswered). The average online response time was 4 min. Of the 326 respondents 8 were people who had been invited to take part in the semi-structured interview. The majority of respondents (38%) were aged between 35 and 44 years old. Table 1 shows the demographic information about the participants.

In response to the first question 72% of respondents disagreed with the statement that a person who has had an X-ray is radioactive for 24 h. A common theme in the responses from those that completed the structured interview was that if the statement was true, it would be common knowledge and they would've heard otherwise.

Table 2 shows the responses to the second question which queried how respondents would rank the amount of radiation associated with common procedures. 67% of respondents incorrectly identified MRI as using ionising radiation. Similarly, 51% incorrectly identified Ultrasound as using ionising radiation. 29% failed to recognise coronary angiogram as an ionising radiation modality, 17% failed to recognize DEXA as an ionising radiation modality and 12% failed to recognise Mammography as an ionising radiation modality.

Table 1
Demographic information (number, percentage of overall).

Gender		Profession	
Male	124 (39%)	Administration	19 (6%)
Female	197 (61%)	Business	27 (8%)
Unanswered	5	Education	25 (8%)
Age		Engineering	22 (7%)
18–24	7 (2%)	Finance	34 (11%)
25–34	67 (21%)	Healthcare	48 (15%)
35–44	121 (38%)	Homemaker	19 (6%)
45–54	68 (21%)	IT	29 (9%)
55–64	37 (12%)	Law	6 (2%)
65–74	17 (5%)	Media	5 (2%)
75–84	4 (1%)	Public service	17 (5%)
85 +	0	Science	15 (5%)
Unanswered	5	Student	8 (2%)
		Tradesperson	4 (1%)
		Retired	19 (6%)
		Other	24 (7%)
		Unanswered	5

Among the participants who stated that they have had an MRI in the past (n = 152) only 39% correctly identified that MRI had no X-ray radiation. Participants that stated they work in healthcare (n = 53) were better able than those from all other occupational categories (n = 271) at identifying that an MRI has no X-ray radiation (51% compared to 30%). Although this percentage is still quite low for healthcare workers.

During interview respondents admitted they were guessing some answers and some had not heard of DEXA or coronary angiogram. Ultrasound was recognised by some as something a pregnant person has and had no radiation. Some respondents noted that they marked an exam as low if they had had one. One respondent remarked that they assumed all are generally low, if they were high the public would be better educated about it. Reasons for stating that MRI had X-ray radiation included (i) that people don't come into the room during the scan and the Radiographer stays outside and (ii) a person is in the scanner for a long time.

57% of respondents to question three agreed with the statement that a breastfeeding mother could have an X-ray. Male and female respondents both answered this question similarly (58% of females agreed, 56% of males agreed). Those in agreement gave answers such as they never heard otherwise while those not in agreement thought the radiation might affect the breast milk.

In response to question four 61% of respondents thought that there is a limit to the number of X-rays a person can have in a year from medical examinations. Reasons for believing this included having heard it somewhere before.

Table 3 shows the responses when participants were asked to compare common exams to the equivalent time period of natural background radiation. It was noted in the question (question five) that an X-ray of the spine is equivalent to 4 months of natural background radiation.

A majority of respondents to question six (71%) agreed that a child is more at risk from X-ray radiation that an adult is. Responses for agreeing with this included that generally kids more at risk for everything and that a child is small and still developing.

Question seven of the survey asked for a level of agreement with the statement "A pregnant woman cannot have a CT exam". Respondents were divided in their answers, 44% agreed, 33% disagreed and 23%

Table 2
Responses to question on ranking amount of X-ray radiation associated with modalities (number, percentage of overall).

Q2. How would you rank the amount of X-ray radiation (i.e. ionising radiation) associated with the below?

	No X-ray radiation	Very low	Low	Medium	High	Very high	Total
Abdominal Ultrasound	161 (49%)	49 (15%)	62 (19%)	36 (11%)	15 (5%)	3 (0.9%)	326
Chest X-ray	2 (1%)	59 (18%)	102 (31%)	97 (30%)	52 (16%)	13 (4%)	325
Chest MRI	108 (33%)	30 (9%)	54 (17%)	67 (21%)	45 (14%)	20 (6%)	324
Coronary Angiogram	92 (29%)	32 (10%)	67 (21%)	75 (23%)	43 (13%)	11 (3%)	320
DEXA Scan	52 (16%)	44 (14%)	92 (29%)	77 (24%)	36 (11%)	15 (5%)	316
Mammogram	40 (12%)	57 (18%)	97 (30%)	80 (25%)	37 (11%)	12 (4%)	323

Table 3
Responses to question on equivalent amount of exposure associated with imaging exams (number, percentage of overall). Approximate exposure levels for typical exams in Ireland are: Knee X-ray 1 h, Chest CT 2 years, Head CT 6 months, Nuclear Medicine Bone Scan 1 year [7].

Q5. Radiation dose received from medical exams is often given in terms of equivalent amount of exposure to natural background radiation. For example, for an X-ray of the spine, the equivalent period of natural background radiation is 4 months. Select the equivalent amount of exposure that corresponds to the exam below.

	1 Hour	1.5 Days	6 Months	1 Year	5 Years	Total
Knee X-ray	78 (24%)	140 (43%)	92 (28%)	11 (3%)	5 (2%)	326
Chest CT	39 (12%)	77 (24%)	149 (46%)	36 (11%)	22 (7%)	323
Head CT	36 (11%)	74 (23%)	148 (46%)	50 (15%)	15 (5%)	323
Nuclear Medicine Bone Scan	27 (8%)	43 (13%)	95 (29%)	110 (34%)	49 (15%)	324

neither agreed nor disagreed. Slightly more females (48%) agreed with the statement than males (38%). Reasons for agreeing included that there are signs in X-ray asking if women are pregnant. Note that the question did not specify a part of the anatomy to be imaged.

In response to question eight only 63% identified that a CT of the head and an X-ray of the head give different amounts of radiation. The majority (88%) of respondents from healthcare (n = 53) correctly identified that the two modalities give different amounts of radiation.

Question nine was similar to question one and was designed to test whether responses would change once pregnancy was involved. 73% correctly responded that a pregnant woman need not avoid a person who had an X-ray earlier that day. This showed agreement with the result of question one. Slightly more females (20%) than males (10%) thought that a pregnant woman should avoid a person who had an X-ray earlier that day.

The final question in the survey asked respondents to rank common exams and occurrences in order of lowest to highest radiation exposure. Respondents more commonly thought that a return flight from Dublin to London had the lowest exposure, followed by the annual average dose of Radon in the home and workplace in Ireland. An intra-oral dental X-ray was ranked mid table while a Chest X-ray followed by a Chest CT were ranked the highest. The correct ranking order for typical exposures in Ireland would be: (1) intra-oral dental X-ray [7], (2) return flight from Dublin to London [8], (3) Chest X-ray [7], (4) annual average dose from radon in the home and workplace [8] and (5) Chest CT [7].

Responses to the final question included that the Dentist never asks about previous X-rays, teeth are smaller than the chest so must be less radiation and that the Dentist doesn't stay behind a wall. One person also remarked that they had never heard of radiation risk from flights or radon so the exposure must be low.

4. Discussion

This study was designed to gauge what the public understand about ionising radiation in order to better understand their concerns and enable medical professionals to explain the benefits and risks of ionising radiation used in medical exposures. Patients rely on healthcare workers to be an educated source of information and new legislation [2] has put an emphasis on communication of information on radiation from medical exposures. Overall, our results demonstrate that respondents do not have a good understanding of ionising radiation. For example, as shown in Table 2, our results showed significant misconceptions in terms of which modalities use ionising radiation.

The results indicate a tendency to perceive naturally occurring radiation as lower risk than artificial sources of radiation. A return flight from Dublin to London (0.008 mSv) followed by the annual average dose of Radon in the home and workplace in Ireland (2.23 mSv) were chosen as the lowest sources whereas in fact a dental X-ray has a lower dose (0.005 mSv) than the return flight and both the dental X-ray and Chest X-ray (0.02 mSv) contribute a lower dose than Radon in homes and workplaces.

Two questions regarding pregnancy were included in the survey in order to evaluate the perceived radiation risk during pregnancy. The majority of respondents (73%) were able to correctly identify that a pregnant woman did not have to avoid a person who had just had an X-ray. However, 20% of women (1 in 5) believed this to be true. Furthermore, respondents were not knowledgeable about whether a pregnant woman could have a CT with only 33% stating that she could.

The results show that there is a perceived limit on the number of X-rays a person should have in a year. Although a large percentage think there is a limit, most marked individual common exams as either low or medium radiation and less than or equal to a year of background radiation. It is unclear whether respondents are worried about cumulative effect of multiple numbers of X-rays or if their concern arises from hearsay. Given the concern regarding limit on the number of X-rays, the justification process should be emphasised in communication with the patient. Patients should be provided with clear information regarding the benefit of their imaging exam and the risk involved in opting not to undergo the exam.

The questions in this survey were designed to avoid use of the term ionising radiation. In cases were the term was used, it was noted that we were referring to X-ray radiation. It is reasonable to assume that the general public do not understand term "ionising radiation" and when explaining the imaging procedure to a patient it should be noted that technical language used plays a role in miscommunication.

Professionals should use a modified language when communicating radiation concepts.

Ideally a patient will receive consistent information at all stages of their healthcare journey. As part of the legislative requirement for a provision of information given to patients prior to exposure, leaflets may be provided. Studies have shown that leaflets are an effective tool to improve understanding of radiation use in CT [9]. The availability of good radiation protection information for the public is an ongoing challenge, however, online resources are available [10,11] and the professional bodies in the U.K. have developed information posters [12]. A simple, clear, concise information sheet endorsed by professional bodies for the Irish public would be advantageous and assist with consistent information being provided to patients. More outreach programs by these professional bodies would also assist in communicating radiation benefit and risk information to the public.

Doctors have an important role in the justification of imaging procedures but they may not be as well informed as the public think [13]. It is important for health care professionals to be aware of radiation doses as well as risk associated with the diagnostic imaging procedures they order, perform or interpret. Medical professionals must also know how to communicate this to the patient. There are many useful resources for medical professionals [14,15,16,17] on risk levels and information on how to communicate [18]. Although some would argue that communication is hindered by lack of clarity on the linear no threshold (LNT) model and stochastic risks and that information relating to carcinogenesis risk shouldn't be given as risks at low level are not well understood [19].

Medical Physics Experts (MPEs) have expertise in the application of the LNT model, dose calculations and risk estimation and the new Irish legislation, S.I. 256, has tasked the MPE with responsibility for dosimetry. The key role medical physicists play in communication of benefit and risk information is in training and supporting other healthcare professionals. A team approach is required for effective communication to the patient and other healthcare professionals should avail of the specialist advice from the MPE.

Promotion of radiation risk awareness is a core element of an effective culture of radiation safety. Radiation safety training should be included for all hospital staff at induction. Porters, administration staff, radiology assistants although not directly involved in X-ray exposures, all work in controlled areas and need to have some general knowledge. This is likely to have a positive impact on public understanding of ionising radiation.

A limitation of the study is the snowball sampling approach used to collect responses. Snowball sampling involves a process whereby one participant refers a survey to additional participants who may be interested in the topic. Although snowball sampling is an effective method for sharing online surveys it is not ideal and can lead to a biased sample. Our study showed a higher response from healthcare workers this is likely due to their interest in the subject. It is also possible that those who have had an imaging exam in the past were more likely to complete this survey. Furthermore, our results showed an age associated bias, those aged between 25 and 54 made up 80% of respondents. Another limitation was that the sample size for the semi-structured interviews was small (n = 8). The interview process gave some clarification on why respondents were answering certain options and responses from a larger sample would have been beneficial. Unexpected answers arose from the semi-structured interview, including the awareness of who was or was not present in the exam room during a procedure and the association that had with risk perception.

The results of this study reflect the opinions and attitudes of the Irish public towards ionising radiation in medical exposures. Areas of concern to the respondents and misunderstanding have been identified. These issues should be considered when communicating benefit and risk information to patients.

5. Conclusions

The aim of this study was to ascertain the Irish public's level of understanding of ionising radiation from medical exposures. Through this survey we identified knowledge gaps in the public's understanding of radiation risk, providing us with the opportunity to improve our communication in order to increase awareness and understanding. Our results show that justification should be emphasised and the benefits of an imaging exam should be highlighted. In addition we conclude that there is confusion over which modalities use ionising radiation, there is a good awareness of increased sensitivity to ionising radiation in children and there is an uncertainty in exposure levels from different modalities. With these results, healthcare professionals should be able to improve the effectiveness of communication with patients.

Appendix 1. Survey questions

* 1. A person who has had an X-ray is radioactive for 24 hours

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 2. How would you rank the amount of X-ray radiation (i.e. ionising radiation) associated with the below

	No X-ray radiation	Very Low	Low	Medium	High	Very High
Abdominal Ultrasound						
Chest X-ray						
Chest MRI						
Coronary Angiogram						
DEXA scan						
Mammogram						

* 3. A breastfeeding mother can have a chest X-ray

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 4. There is a limit to the amount of X-ray radiation a patient can have in a year from medical examinations

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 5. Radiation dose received from medical imaging exams is often given in terms of an equivalent amount of exposure to natural background radiation.

For example an X-ray of the spine, the equivalent period of natural background radiation is 4 months.

Select the equivalent amount of exposure that corresponds to the exams below.

	1 hour	2.5 days	6 months	1 year	5 years
Head CT	◯	◯	◯	◯	◯
Chest CT	◯	◯	◯	◯	◯
Knee X-ray	◯	◯	◯	◯	◯
Nuclear Medicine Bone Scan	◯	◯	◯	◯	◯

* 6. A child is more at risk from X-ray radiation than an adult

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 7. A pregnant woman cannot have a CT exam

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 8. A CT and X-ray of the head give the same amount of radiation.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 9. A pregnant woman should avoid a person who had an X-ray earlier that day

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

* 10. Please rank the following in order of radiation exposure, where 1 is lowest radiation exposure and 5 is highest radiation exposure.

- [ ] Chest CT
- [ ] Return flight from Dublin to London
- [ ] Chest X-ray
- [ ] Annual average dose from radon in the home and workplace in Ireland
- [ ] Intra-oral Dental X-ray

11. Gender

- Male
- Female

12. Age group

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65-74
- 75-84
- 85+

13. Have you ever had any of the following exams? (tick all that apply)

- [ ] X-ray
- [ ] CT
- [ ] MRI
- [ ] Ultrasound
- [ ] Mammogram
- [ ] DEXA scan

14. Did you previously complete our first survey on Radiation Awareness

- Yes
- No

15. Occupational category

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