Research Article

Comparison of physicians' knowledge regarding radiation exposure and risks in common radiological investigations – A cross-sectional study

Shruti Gothoskar, Seerat Anand, Padmaja Walvekar

Department of Community Medicine, Jawaharlal Nehru Medical College, Belgaum, Karnataka, India

Correspondence to: Shruti Gothoskar, E-mail: shruti.gothoskar@gmail.com

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ABSTRACT

Background: Radiations have been proven to increase the risk of cancer, heritable defects, and radiation associated non-cancer diseases. Inappropriately advised radiology investigations can lead to avoidable radiation exposures and expenses. The referring physician is overall responsible to prescribe the most appropriate imaging procedure for the patient clinical condition, by providing supporting data justifying that choice. Clinical Imaging Referral Guidelines (CIGs) have, therefore, been established or adopted in some countries to support the physicians' referral for the most suitable imaging procedure. However, there is a strong unmet need in advocating acceptance of these guidelines among referring physicians. As most of the investigations are initiated by non-radiologists, it is imperative that they have adequate knowledge of radiation exposure and risks. Radiologists play a key role in locally educating their non-radiology colleagues on the associated radiation imaging hazards. **Objectives:** The objectives of the study were to compare the knowledge of radiologists and non-radiologists regarding ionizing radiation exposure and risks in common radiological investigations and to increase awareness of risks of various imaging techniques, among non-radiological physicians. **Materials and Methods:** A total of 200 physicians working in tertiary hospital were enrolled in the study. A pretested questionnaire was prepared and given to the participants after taking their consent. Questionnaire included demographic details and questions relating to radiation exposure during diagnostic imaging. **Results:** The highest mean correct score in the radiology group was 15.70% (range 11–20) standard deviation (SD) 2.32, while the lowest mean correct score in the non-radiology was 9.56% (range 5–14) SD 2.50 $P < 0.001$. All other departments except pulmonary medicine, orthopedics and urology department differed significantly in their mean correct scores compared to the radiology department. 19.4% and 16.4%, of non-radiology physicians also wrongly associated (overestimated) magnetic resonance imaging and ultrasound with ionizing radiation, respectively, and 20% were not aware of the radiation dose. **Conclusion:** Non-radiologists underestimated the real radiation doses, and their knowledge of the risks was inadequate. It may be possible that physicians tend to order more radiological investigations due to increased patient load. Awareness of radiation dose of imaging procedures and their risk to exposure must be increased among all medical professionals. Therefore, training on radiation protection and local adoption of CIGs has become necessary. A large multi-centric nation-based study will not only help in assessing the gaps in knowledge but also help build consensus and encourage adoption of clinical imaging referring guidelines on a national level.

KEY WORDS: Radiation; Exposure; Radiation Dose; Radiation Risk; Diagnostic Imaging; Awareness

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INTRODUCTION

Routine radiology investigation has become one of the pillars of evidence-based approaches in modern clinical practice. With frequent use, the hazards of diagnostic radiology investigations are ever increasing.[1] Complicated interventional radiological procedures are increasingly

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being used even in smaller centers. With the increase in the routine use of such imaging techniques, fears regarding high radiation exposure to patients continue to arise. According to a study published in 2009, the authors highlighted the fact that the use of computed tomography (CT) scans in the US had increased more than 3-fold since 1993 to approximately 70 million scans annually. The authors stressed that even though CT scans provide great medical benefits, there were concerns about their potential future cancer risks because of higher radiation doses involved compared to diagnostic X-rays. They also estimated that CT scans performed during 2007 in the US could have been related to about 29,000 future cancers.[1] Not all of the scans advised are clinically beneficial or necessary. Such requests for radiology investigations depend on the physician's knowledge about radiation doses related to these investigations. Unfortunately, studies show a widespread underestimation of radiation doses among non-radiology physicians in both advanced and developing health centers.[2] Radiations have been proven to increase the risk of cancer, heritable defects and radiation associated non-cancer diseases. The cancer-causing biological effects of ionizing radiation, including low doses received during medical diagnostic imaging, are well documented.[3,4] It is well known that inappropriate imaging can lead to unnecessary medical radiologic exposures and costs. The referring physician is overall responsible to prescribe the most appropriate imaging procedure for the patient clinical condition, by providing supporting data that justifies the choice. Clinical Imaging Guidelines (CIGs) have, therefore, been established in some countries to support the physicians' prescription of the most suitable imaging procedure. However, there is a strong unmet need in advocating acceptance of these guidelines among referring physicians. In 2012 and 2013, the International Atomic Energy Agency hosted technical meetings on radiation protection of patients through the development of appropriateness criteria in diagnostic imaging. Participants in these meetings identified and agreed on issues concerning the development of imaging referral guidelines.[5,6] It was agreed on that referring physicians must become aware of the level of patients' radiation doses and the possible harmful effects of this exposure to justify irradiating medical imaging procedure.

Similar studies have been conducted assessing knowledge about radiation risks, among physicians in the US and Europe and elsewhere. Studies conducted in Asian countries to assess physicians' knowledge about the safety of radiation, particularly in smaller cities, are few in the available literature.

The aim of our study was to compare the knowledge of radiologists and non-radiologists about exposure and risks in common radiological investigations. In addition, the objective of this study was to increase awareness of exposure risks of various imaging techniques, particularly among physicians of the non-radiological fields. Through our study itself, we hoped to promote the above, by providing participating physicians with the correct answers.

MATERIALS AND METHODS

Our study was approved by the Institutional Ethics Committee. The study was a cross-sectional study conducted in a tertiary 2,400 bedded, multi-specialty hospital in a small city. The study included radiology and non-radiology consultants and clinical residents doing postgraduate studies in their specialty. The data were collected in the month of September 2014. The study inclusion criteria were**,** physicians, working or studying at the study hospital, and who advise radiological investigations routinely. Physicians of specialties not required to advise radiological investigations were excluded from the study.

A pretested questionnaire was prepared after referring to previously used questionnaires and given to the participants after taking their consent.[7-9] The questionnaire which was anonymous included questions on the commonly requested radiological investigations. The physicians were questioned to determine the radiation exposure dosage on a routinely done chest X-ray. The radiation dosage of the chest X-ray was calculated in mSv (milliSievert) units. The participants were informed to consider one chest X-ray as one benchmark unit as done in a similar study conducted in Queensland.[9] They were also informed to approximate the equivalent number of units of radiation doses based on the benchmark unit for other specific types of imaging commonly used in the hospital, choosing from six standard answers. The answers were evaluated based on the dosage ranges listed by the manufacturer of the machines and the UNSCEAR 2000 report.[10] After taking their informed consent, the questionnaire was distributed to all radiology and non-radiology physicians, without prior knowledge, to rule out the possibility of any prior preparation. The questionnaires were collected immediately after completion. The physicians who had been involved in validating the questionnaire were not enrolled in the study. The study did not require any investigations or interventions to be conducted on patients or animals. After submitting the questionnaires, the participants were provided with the correct dose ranges for retrospective self-evaluation to help increase their awareness about the radiation dose and exposure.

Statistical Design

The study was designed as a cross-sectional study. The total duration of the study period was around 4 weeks. The total sample size calculated was 200. The sample size was calculated using the following formula:

$n = 4pq/d^2$ where: $P = 40\%$ based on a previous study where mean knowledge score for doctors was found to be 40%.[7]

$q = 100-p = 100-40 = 60$; $d = 7$

Hence, n comes to 196, which is rounded up to 200. Therefore, the sample size was 200.

Statistical Analysis

The data were analyzed using tabulations, percentages, and the *t*-test. The analysis of variance (ANOVA) with unequal sample size and the Dunnett's Multiple Comparison Test,[11] were applied for final analysis. Statistical analysis was done with Statistical Package for the Social Sciences for windows (SPSS software 16th edition-trial version), descriptive statistics including, mean, median, standard deviation, and percentages. Level of knowledge was calculated as a percentage of correct answers in each section. The one-way ANOVA test was used, and the F ratio was calculated.

RESULTS

Questionnaires were distributed totally to the 200 eligible physicians, both in the radiology and the non-radiology groups, working during the study period, and all 200 completed questionnaires were returned (100% response rate) [Table 1]. In the radiology group (n = 30), all completed questionnaires were returned. Correct estimate of the radiation dose for the chest X-ray was given by 36.7% radiologists while 6.7% and 56.7% underestimated or overestimated the radiation dose, respectively [Table 2]. Similarly, the radiation dose estimates given by the radiologists for all other imaging techniques are listed in Table 2. Around 30% of all radiologists tended to overestimate the radiation dose for all imaging techniques other than the chest X-ray. Overall, the mean correct score in the radiology group was 15.70 (range 11–20) standard deviation 2.32 [Table 3].

In the non-radiology group (total n=170), all completed questionnaires were returned. Correct estimate of the radiation dose for the chest X-ray was given by 26.5% non-radiology physicians while 35.2% and 30.5% underestimated or overestimated the radiation dose, respectively. Some participants wrongly associated (overestimated) magnetic resonance imaging (MRI) and ultrasound with ionizing radiation (19.4% and 16.4%, respectively) while some were not aware (8.2% and 6.4%, respectively). Roughly around 20% of non-radiology physicians did not know the radiation dose of routine imaging investigations.

Table 1: Specialty wise distribution of the physicians

Specialty	Number enrolled (total n=200)
Radiology	30
Non-radiology Departments	
Obstetrics and Gynecology	30
Surgery	30
General Medicine	30
ENT	26
Ophthalmology	26
Pulmonary Med	5
Pediatrics	8
Orthopedics	6
Urology	5
Anesthesia	4

ENT: Ear nose and throat

DISCUSSION

The study conducted by us found that physicians' knowledge about radiation dosage and risk due to radiology investigations in general, is not adequate. Compared to radiologists, the non-radiology physicians underestimated radiation dose of frequently used diagnostic procedures. 56% of radiologists and 30% of non-radiologists overestimated the radiation dose in our study. Correct estimates of the radiation dose for the chest X-ray were given by 36.7% radiologists and 26.5% non-radiologists, respectively. The highest correct mean score reported was by the radiology department participants (15.7%) while the lowest correct mean score reported was from the general medicine department participants (9.56%). This difference was found to be statistically significant ($P < 0.001$). In general, one-third of all radiologists tended to overestimate the radiation dose for all imaging techniques other than the routine chest X-ray. Importantly, most of the non-radiology physicians underestimated the radiation dose of the common routine imaging techniques such as chest, abdominal, limb X-ray, barium swallow and head, and abdominal CT as listed in Table 4. Roughly around 20% of non-radiology physicians did not know the radiation dose of routine imaging investigations. In addition, the percentages of non-radiologists associating radiation for ultrasound scanning and MRI were high, 16.4% and 19.4%, respectively.

Studies conducted in advanced countries as well as developing countries on this topic have highlighted similar findings. A study conducted at Yale University in the US,[8] found that diagnostic imaging is estimated to be responsible for more than 70% of the collective radiation dose delivered to patients. Here 47% (18 of 38), of radiologists believed that there was an increased cancer risk, whereas only 9%, (four of 45), of physicians, believed that there was an increased risk. This study concluded that most physicians and radiologists were unable to accurately estimate the dose for one CT scan compared with that for one chest X-ray. In a Hong Kong teaching hospital, a study involving 158 physicians,[9] revealed that the overall accuracy of knowledge of radiation exposure was 40% for radiologists and 16% for non-radiologists. According to the authors of this study, one-third of non-radiologists could not distinguish radiological examinations with or without ionizing radiation. Similarly, in a questionnaire study done on 130 physicians in two hospitals of London,[7] it was found that 97% of them underestimated the radiation dose of various radiological investigations. 8% did not know that MRI does not use ionizing radiation. Multiple studies conducted with a similar objective[7,9,12-19] also indicate that physicians often underestimate the radiation dose. It was

Table 2: Radiologists' Response

Imaging technique	Radiologists' response				
	Correct (%)	Underestimated (%)	Overestimated (%)	Don't Know (%)	Total
Chest X-ray	11 (36.7)	2 (6.7)	17 (56.7)	0	30
Abdominal X-ray	10 (33.3)	8 (26.7)	11 (36.7)	1 (3.3)	30
Limb X-ray	10 (33.3)	10 (33.3)	9 (30)	1 (3.3)	30
Abdominal CT	19 (63.3)	8 (26.7)	10 (33.3)	1 (3.3)	30
Head CT	14 (46.7)	4 (13.3)	10 (33.3)	2 (6.7)	30
Brain MRI	29 (96.7)	0	1 (3.3)	0	30
Abdominal USG	30 (100)	0	0	0	30
Barium Swallow	11 (36.7)	9 (30)	9 (30)	1 (3.3)	30

One benchmark unit: One chest X-ray radiation dosage, CT: Computed tomography, MRI: Magnetic resonance imaging, USG: Ultrasound, participants were instructed to estimate the radiation dose in the equivalent number of benchmark unit.[9] The typical exposure dose for an abdominal CT is 10 mSv and that for one chest radiograph is 0.02 mSv2[9]

Table 3: Mean score

Specialty	Department key	Number enrolled	Mean score %	SD	CI Range	Median
Radiology	0	30	15.70	2.32	11–20	16.00
Non-radiology Departments						
Obstetrics and Gynecology	1	30	10.63**	2.47	6–15	11.00
Surgery	2	30	10.50**	3.11	5–17	11.50
General Medicine	3	30	9.56**	2.50	5–14	10.00
ENT	4	26	11.00**	2.35	6–16	11.00
Ophthalmology	5	26	10.81**	2.91	4–15	11.00
Pulmonary Medicine	6	5	13.60$	2.96	9–17	14.00
Pediatrics	7	8	11.50*	2.00	8–15	12.00
Orthopedics	8	6	12.50$	2.34	10–16	12.50
Urology	9	5	12.80$	1.92	10–15	13.00
Anesthesia	10	4	10.75**	3.30	7–15	10.50

Using Analysis of Variance with unequal sample size and the Dunnet's Multiple Comparison Test,[11] the above results were obtained [Table 4]. $The mean scores of pulmonary medicine, orthopedics and urology did not differ significantly compared to the mean score of radiology. v/s Pulmonary Medicine: *P*=0.582, v/s Orthopedics: *P*=0.063 v/s Urology *P*=0.186. **Mean scores of all other departments, however, differed significantly. ANOVA F=10.933, *P*<0.001; the highest mean score was from the radiology department (15.7%) while the lowest mean score was from the General Medicine Department (9.56%). The maximum mean score was 20%. ENT: Ear nose and throat, SD: Standard deviation, CI: Confidence interval

Table 4: Non-radiologists' response

Imaging Technique	Non-radiologists' Response				
	Correct (%)	Underestimated (%)	Overestimated (%)	Don't Know (%)	Total
Chest X-ray	45 (26.5)	60 (35.2)	52 (30.5)	13 (7.6)	170
Abdominal X-ray	24 (14.1)	111 (65.2)	1 (0.5)	34 (20)	170
Limb X-ray	39 (22.9)	74 (43.5)	22 (12.9)	35 (20.5)	170
Abdominal CT	30 (17.6)	110 (64.7)	0	30 (17.6)	170
Head CT	44 (25.9)	74 (43.5)	15 (8.8)	37 (21.7)	170
Brain MRI	123 (72.4)	0	33 (19.4)	14 (8.2)	170
Abdominal USG	131 (77.1)	0	28 (16.4)	11 (6.4)	170
Barium Swallow	9 (5.2)	111 (65.2)	11 (6.4)	39 (22.9)	170

The mean scores of pulmonary medicine, orthopedics and urology departments did not differ significantly compared to the mean score of radiology. Mean scores of all other departments, however, differed significantly as listed in Table 4. The highest correct mean score was from the radiology department (15.7%) while the lowest correct mean score was from the general medicine department (9.56%) ANOVA F ratio=10.933, *P*<0.001

interesting to note that some physicians related ultrasound imaging with radiation exposure. According to the authors of the Queensland study, this may be of clinical importance because of the large numbers of ultrasound investigations prescribed.[9] Studies have reported that 4–11% and 8–28% of respondents have associated ultrasound scanning and MRI with radiation, respectively.[7,9,15,16] This data were similar to our results with physicians associating radiation for ultrasound scanning and MRI of 16.4% and 19.4%, respectively. The actual estimated dose for a single chest X-ray was overvalued by nearly 56% of radiologists and 30% of non-radiologists in our study. This was found similar to studies elsewhere where about two-thirds of the physicians overestimated the radiation dose.[19] This may be perhaps due to the unfamiliarity with units of radiation as was reaffirmed by authors of other studies. Under-estimation of radiation doses and the implied risks may cause physicians to over-prescribe radiology investigations. Many issues would have contributed to the non-adequate knowledge scores achieved in this study. Education about radiation dose exposure of routine imaging investigations in the undergraduate curriculum of a physician is scanty or is not given enough importance. In studies done elsewhere, around 75% of physicians reported never having been properly trained on this topic. In some studies, there was no difference in the knowledge scores between those who had received proper training and those who had not.[9] It was surprising to find that a small proportion of physicians considered that ultrasound and MRI expose patients to radiation. This seems to reflect a lack of basic knowledge of radiation physics. This knowledge gap may be further plausible because MRI is intermittently requested and is often difficult to access particularly in smaller centers. In clinical practice, a majority of radiological investigations are advised by non-radiologists. In our study, most of the non-radiologists underestimated the real radiation doses. Their knowledge of the risks was inadequate. This lack of awareness may cause them to order more radiological investigations than they would, if properly informed. Education about radiation hazards of radiological investigations should be made mandatory among all physicians. Radiologists by virtue of their specialized knowledge play a key role in educating referring physicians on the best imaging techniques and their associated hazards. However, radiologists are becoming busy with the ever-increasing need for diagnostic imaging procedures. It should be noted that India has approximately one radiologist for every 100,000 population compared to US where the corresponding ratio is 1: 10,000.[20] Perhaps considering the work-load, the radiology departments could educate point persons from other departments who can then take the lead to conduct simple inter-departmental radiation risk awareness programs. Radiology departments could also team up with the community medicine or public health department in an institution to conduct risk awareness of commonly used imaging investigations to practicing physicians not only in hospitals but also particularly in smaller clinics and primary health centers. Relevant undergraduate textbooks for medical students must provide this important information. A cursory glance of the commonly used textbook of preventive and social medicine made no mention about the radiation doses of various imaging techniques and their possible risks.[21] Such information was lacking in other undergraduate textbooks related to clinical medical subjects. Commonly, medical students are exposed in their 1st year to the topic of radiology imaging anatomy. Here the teaching incorporates either didactic lectures in a large lecture theater setting or small group interactive sessions or demonstrations in anatomy laboratory or classes. Whether these sessions provide knowledge about various radiation doses and the risks is not known. Hence, it becomes important that medical students should be educated about radiation risks during their core clinical clerkships as part of their curriculum. Finally, CIGs must be established nationally and locally to support the physicians' prescription of the most suitable imaging procedures to ensure referral compliance.

One of the strengths of our study was not only to assess the knowledge of radiation exposure among physicians but also increase awareness of the same. We found that the participants were enthusiastic in knowing the correct answer following completion of the questionnaires. The study, however, had limitations. Our questionnaire was created from questionnaires used in earlier studies.[9] We selected equal weightage for all 8 items of the score. This perhaps may limit understanding of this score, as some items may be of more importance. The use of questionnaires has inherent limitations, as some answers may reflect participative subjective opinions. Generalization of results of this study should be done judiciously given the impossibility of randomly choosing participants in such studies. One of the other limitations of the study was that it was of a small size and conducted in a single institution.

CONCLUSION

Non-radiologists underestimated the real radiation doses, and their knowledge of the risks was inadequate. It may be possible that physicians tend to order more radiological investigations due to increased patient load. Awareness of radiation dose of imaging procedures and their risk to exposure must be increased among all medical professionals. Therefore, training on radiation protection and local adoption of CIGs has become necessary. A large multi-centric nation-based study with a more clearer design will not only help in assessing the gaps in the physicians' knowledge but also help build consensus and encourage adoption of clinical imaging referring guidelines on a national level.

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