Hong Kong J Radiol. 2012;15:71-9

ORIGINAL ARTICLE

Doctors' Knowledge Regarding Radiation Dose and Its Associated Risks: Cross-sectional Study in a Tertiary Hospital in Malaysia

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ABSTRACT

Objective: *Radiological investigations that use ionising radiation pose well-established risks to patients. Doses per patient from computed tomographic examinations constitute large radiation burdens, particularly with recurrent imaging and multidetector machines. Yet, referring doctors often have a poor understanding of these risks. The objective of this study was to assess knowledge regarding medical radiation exposure and its associated risks among non-radiology doctors of all grades at the Universiti Kebangsaan Malaysia Medical Centre.*

Methods: *This was a cross-sectional study conducted by convenience sampling, using questionnaires distributed during radiology meetings. Inclusion criteria constituted: any doctor from a non-radiology specialty serving in our institution during the period between June 2006 and January 2007. Doctors affiliated to the radiology department were excluded.*

Results: *Responses from 178 doctors were analysed. Of these, 7 (4%) and 61 (34%) of the respondents were not aware that ultrasound and magnetic resonance imaging, respectively, do not emit ionising radiation. Nine (5%) respondents provided accurate dose estimates for commonly requested investigations which utilise ionising radiation, 66 (37%) believed there was an increased cancer risk in adults, whilst 41 (23%) were aware of the increased cancer risk in children.*

Conclusion: *There was a lack of awareness of radiation doses and risk of carcinogenesis, particularly that among children. There is a need to disseminate information regarding radiation dose and the possible risks to the non-radiology medical community.*

Key Words: *Medical staff, hospital; Questionnaires; Radiation dosage; Radiation, ionizing; Radiography/adverse effects*

中文摘要

一所馬來西亞提供第三層醫療轉介服務的醫院中醫生對於放射劑量的知識及其相關風險的橫向對比研究

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目的：使用電離輻射的放射性檢測會對病人構成風險這事實廣為人知。CT檢查會對病人構成巨大的輻射負擔，尤其是多次成像及多排螺旋裝置。縱然如此，把病人轉介進行放射性檢測的醫生可能對

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Submitted: 23 Feb 2012; Accepted: 27 Mar 2012.

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於此輻射風險的認識不足。本研究評估在馬來西亞國民大學醫療中心內所有職級的非放射科醫生對於醫療輻射及其相關風險的知識。

方法：本橫向對比研究在放射科會議上利用方便抽樣的方法進行問卷調查。2006年6月至2007年1月期間所有出席會議的非放射科醫生均被邀請填寫問卷。放射科醫生則不被列入研究範圍。

結果：共分析了178位醫生的問卷回應，當中7位（4%）及61位（34%）回應者分別不知道超聲及MRI不會放出電離輻射。有9位（5%）回應者能準確地評估常用放射性檢查所放出的電離輻射。66位（37%）回應者相信放射性檢查會增加成年人患癌的風險，41位（23%）回應者知道放射性檢查會增加小童患癌的風險。

結論：回應者對於放射劑量的知識及致癌的風險均欠缺認知，尤其是對於小童的相關知識。有需要向非放射科醫護人員傳遞有關放射劑量及有關風險的知識。

INTRODUCTION

Many studies corroborate the rapid increase in the use of computed tomography (CT) imaging in most countries.[1-4] In certain university departments in the US, CT scanning has grown to account for approximately 15% of the total number of examinations yet accounts for approximately 70% of the ionising radiation dosage delivered.[5] Radiation doses to patients with multidetector CT scanners are 30 to 50% greater than with older single-detector CT scanners,[3] whilst hybrid modalities like positron emission tomography / CT have also been shown to contribute significant dose burdens.[6] In the UK, it is estimated that 100 to 250 deaths per year are due to cancers directly related to such medical exposures.[7]

Widespread usage has provoked greater concerns regarding the risks of diagnostic radiation exposure. Chromosomal analyses conducted on human lymphocytes after exposure to ionising radiation often demonstrate aberrations. Stephan et al[8] reported increased frequencies of dicentric and acentric chromosomal fragments in 10 children after a CT examination. Effective doses with diagnostic CT have been shown to be similar to those delivered to Japanese survivors of atomic bombs, many of whom had a small but statistically significant increased risk of cancer as a result of their radiation.[2] The possibility that radiation exposure from diagnostic imaging increases the incidence of cancer remains controversial. The US Food and Drug Administration has stated that a CT examination with an effective dose of 10 mSv may be associated with an increase in the possibility of fatal cancer of approximately 1 in 2000.[9] This increase in the possibility of fatal cancer from radiation can be compared to the natural incidence of fatal cancer in the US population, which is about one in five. In other words, for any one person the additional risk of radiation-induced cancer is much smaller than the natural risk of cancer. Nevertheless, this small increase in radiation-associated cancer risk for an individual becomes a public health concern when large numbers of the population undergo increased numbers of CT examinations.

The issue of recurrent CT imaging has attracted increasing attention recently. Researchers have utilised different models in an attempt to describe theoretical cancer risks from low-dose radiation exposures, both from the singular acute exposures of the Life Span Study cohort of Hiroshima and Nagasaki survivors,[10] and from recurrent occupational[11] and therapeutic[12] exposures. A large multicentre trial by Cardis et al[11] conducted on 407,391 workers in the nuclear industry in 15 countries, found that the excess relative risk for leukaemia in these workers was 1.93 per Sv. They concluded that even at the low, albeit protracted, doses received by nuclear workers included in this cohort, a small excess risk of cancer development (1-2% of deaths from cancer in this cohort) may be attributable to radiation exposure. Sodickson et al[12] retrospectively reviewed 31,462 patients who had undergone 190,712 CT examinations in the 22 years prior to 2007. Of these, 33% underwent more than five CT scans, and 5% underwent more than 22 scans. The researchers used the Biological Effect of Ionizing Radiation VII methodology, which predicted a baseline cancer incidence of 42% and cancer mortality of 20% for a standardised US population.

Their estimates of CT-induced cancer incidence predict that 7% of patients exceed a lifetime attributable risk of 1% (i.e. a predicted increase in cancer incidence to 43% from the baseline rate of 42%). Of interest was the finding of no malignancy history or a cancer history without evidence of relapse in 40% of this patient subset.

Paediatric CT scans pose other concerns. The Society of Pediatric Radiology in the US recently reported that they have noted a 200% increase in paediatric CT examinations in the past few years.[5] Children are at substantially higher risk (compared to adults) with regard to radiation-induced effects due to their larger lifetime risk per unit dose of radiation and higher mitotic rates. There is a rapid increase in lifetime risk with decreasing age at exposure. A highly debated US study in 2001 estimated that 60,000 abdominal and head CT studies done annually on children aged 15 years or below could result in 500 deaths from radiation-induced cancers.[4] If adult scan parameters are used in paediatric scans, the typical radiation doses are estimated to be doubled.[3]

Despite the known health risks associated with medical radiation exposure, there is often poor dissemination of such information to the non-radiological medical community. As such, CT examinations may be requested with a poor awareness of the small but definite risks involved. A small study of 45 emergency department physicians in Yale found that only 9% believed there was an increased cancer risk associated with CT imaging.[2] In addition, 44% greatly underestimated the radiation dose of an abdominopelvic CT. In a questionnaire study of 130 doctors of all grades from two hospitals in South Wales and Oxford, 97% of the answers given with regard to dose estimation were underestimates.[7] In fact, the mean dose of radiation was six times what was estimated. Notably, 5 to 8% doctors did not realise that ultrasound and magnetic resonance imaging (MRI) do not use ionising radiation.

Thus, the objectives of this study were to determine the knowledge of non-radiology doctors of all grades in our institution with regard to radiological investigations that expose patients to ionising radiation. Through the use of questionnaires, we sought to investigate the level of knowledge regarding radiation protection of patients, i.e. the types of radiological modalities that do not utilise ionising radiation, as well as the elevated risk of cancer in those exposed.

METHODS

Study Design

This was a cross-sectional study conducted over a 7-month period from June 2006 to January 2007. Prior to starting, the study protocol was approved by the Universiti Kebangsaan Malaysia Medical Research and Ethics Committee.

Doctors from 10 specialties at the Universiti Kebangsaan Malaysia Medical Centre were invited to participate. They included: house officers, medical officers undergoing the Masters programme, trainee lecturers, and full-grade lecturers. All the doctors were serving in non-radiology specialties at our institution within the study period. Doctors in the radiology department were excluded. The Accident and Emergency, Internal Medicine, Orthopaedics, Paediatrics, and Surgery were the five specialties initially chosen for recruitment of doctors. Regular radiology conferences were conducted with these specialties in the radiology department, which facilitated convenient sampling. Five more specialties (Anaesthesiology, Family Health, Obstetrics and Gynaecology, Ophthalmology, and Radiotherapy/Oncology) were selected as we felt that the 10 resulting specialties represented a good cross-section of clinical specialties requesting regular radiological investigations for their patients.

Questionnaire Design

A written three-page questionnaire booklet was designed consisting of direct questions, mostly requiring simple tick answers or single numerical responses. The questionnaire was designed with the collaborative effort of two of the authors (TY Kew and SZ Syed Zulkifli). The contents of the questionnaire had been validated by a psychiatrist (S Hatta) with experience in questionnaire design, and were deemed valid for use among doctors for the assessment of the study objectives. The original questionnaire is reproduced in full under an Appendix (please refer to the HKJR website <www.hkjr.org>).

The questions were designed to assess the level of knowledge regarding ionising radiation in medical imaging, and divided into three sections. In Section A, participants were asked to identify, from a list of commonly requested radiological investigations, those that utilise ionising radiation. In this article, modalities which do not use ionising radiation are referred to as 'dose-saving modalities'. Respondents were then asked to estimate the radiation dose of commonly requested investigations which use ionising radiation (compared to that of one chest radiograph). Section B assessed knowledge regarding the following established facts from the literature: (a) there is a 0.01 to 0.1% increased lifetime risk of cancer in adults resulting from an exposure to a single abdominal CT scan,[1] and (b) there is an increased lifetime risk of cancer in children exposed to a single abdominal CT scan, which is at least double the risk in adults.[4] Section C was to retrieve basic demographics (gender, specialty, professional grade, and years in service). Depending on the answers given, respondents were instructed to bypass certain questions to reduce opportunities for inferred bias towards the 'correct' response.

Data Collection

The surveys were handed out during attendance at radiology conferences. Participant anonymity was assured: no names were required on the questionnaire. Participants were requested to complete the survey in one sitting without consultation, interviewer assistance, or research. Doctors working within departments that did not conduct regular radiology conferences were given the same surveys during their departmental continuing medical education (CME) conferences. This setting was chosen to ensure maximum participation, and respondents were told that the questionnaires would be collected at the end of the meeting / conference.

Statistical Analysis

We used frequencies and percentages to determine the level of knowledge of dose-saving modalities, dose estimation, and perception of cancer risk by respondents. To facilitate analysis of overall knowledge, each respondent was assigned a total score based on their responses to the questions on cancer risk and which modalities do or do not entail ionising radiation. An arbitrary score of one was given for each correct response. Dose estimation was excluded from this analysis as 78% of respondents (139 of 178) abstained in this section of the questionnaire.

We used the χ^2 test of significance with exact tests of significance to determine the associations between the results from the questionnaire and professional grade, length of work experience, and gender. The standardised adjusted residuals were also examined to assess the strength of the relationship. Fisher's exact tests were utilised if respondent numbers within an individual department were small. The level of statistical significance was set at 0.05 (two-sided). Retrospective power analyses of all significant results were also conducted.

RESULTS

Respondents' Characteristics

A total of 190 doctors completed the questionnaires, of which 12 were not analysed due to incomplete demographic data. The remaining 178 doctors whose responses were utilised comprised 34 (19%) specialists and 144 (82%) house officers / medical officers / trainee lecturers. Marginally more women responded (n = 98, 55%), compared to men (n = 80, 45%). Their years in practice ranged from one month to 29 years. All respondents were divided into two groups on the basis of years in practice: <7 years versus ≥7 years. This cut-off was used because 7 years was the median years in practice for all the respondents, drawn from all 10 specialties. The percentage and type of disciplines represented are shown in Table 1.

Awareness of Dose-saving Modalities

In all, 96% of respondents were aware of ultrasound as a primary dose-saving modality. Notably, 28% did not realise that MRI does not entail ionising radiation, while 5% were unsure. Conversely, 82% were aware that a barium swallow or enema examination exposed the patient to ionising radiation (Table 2). There was a significant difference between the level of awareness of respondents and their professional grade (Table 3). In all, 28/34 (82%) of specialists answered correctly that MRI does not use ionising radiation as compared to 62% of medical officers (89/144); $\chi^2_1 = 5.2$, $p<0.05$. Examination of the adjusted standardised residuals demonstrated a significant Z value of 2.3.

Likewise, a significant relationship was found between the respondents' years in service and their response to the same question (Table 4). Approximately 77% (60

Table 1. Specialty of respondents.

Specialty	No. (%) of respondents
Accident & Emergency	18 (10)
Anaesthesiology	37 (21)
Family Health	9 (5)
Internal Medicine	34 (19)
Obstetrics & Gynaecology	11 (6)
Ophthalmology	2 (1)
Orthopaedics	25 (14)
Paediatrics	16 (9)
Radiotherapy / Oncology	1 (1)
Surgery	25 (14)

Table 2. Questionnaire responses regarding radiation dose and associated risks.

Questionnaire response	No. (%) of respondents
1. Ultrasound uses ionising radiation?	
Yes	4 (2)
No	171 (96)
Unsure	3 (2)
2. MRI uses ionising radiation?	
Yes	49 (28)
No	117 (66)
Unsure	9 (5)
Not answered	3 (2)
3. Barium swallow uses ionising radiation?	
Yes	146 (82)
No	22 (12)
Unsure	10 (6)
4. A CT examination increases the lifetime risk of cancer in adults?	
Yes	66 (37)
No	58 (33)
Unsure	51 (29)
Not answered	3 (2)
5. A CT examination increases the lifetime risk of cancer in children?	
Yes, the lifetime risk is less than that in adults	2 (1)
Yes, the lifetime risk is equivalent to that in adults	4 (2)
Yes, the lifetime risk is higher than that in adults	35 (20)
No	64 (36)
Unsure	71 (40)
Not answered	2 (1)
6. Attitude regarding the statement “Patients referred for radiological investigations involving ionising radiation should be informed of the possible risks?”	
Strongly disagree	10 (6)
Disagree	12 (7)
Unsure	12 (7)
Agree	103 (58)
Strongly agree	35 (20)
Not answered	6 (3)
7. Practice of explaining possible risks of ionising radiation	
Never	35 (20)
Sometimes	88 (49)
Most of the time	30 (17)
Always	10 (6)
Not answered	15 (8)

Abbreviations: MRI = magnetic resonance imaging; CT = computed tomography.

Table 3. Knowledge of dose-saving property of magnetic resonance imaging (MRI) according to professional grade.*

MRI uses ionising radiation?	No. (%) of Medical Officers	No. (%) of Specialists
Yes / Unsure / Not answered	55 (38)	6 (18)
No	89 (62)	28 (82)

* χ^2_1 = 5.2, p<0.05.

Table 4. Knowledge about dose-saving property of magnetic resonance imaging (MRI) according to number of years in service.*

MRI uses ionising radiation?	Years in service, No. (%) of patients	
	<7 years	≥7 years
Yes / Unsure / Not answered	43 (43)	18 (23)
No	57 (57)	60 (77)

* χ^2_1 = 7.7, p<0.05.

of 78) of respondents with seven or more years of work experience answered correctly, as opposed to 57% (57 of 100) of respondents who had practised for less than seven years (χ^2_1 = 7.7, p<0.05).

Intriguingly, all respondents from the Department of Obstetrics & Gynaecology (n = 11) were aware of the dose-saving property of MRI and ultrasound. Significantly fewer non-obstetric doctors were aware that MRI was a dose-saving modality; χ^2_1 = 6.1; two-sided Fisher’s exact test <0.05. In an examination of the adjusted standardised residuals, obstetricians were shown to be more likely than expected to have this awareness, compared to clinicians from other disciplines (Z = 2.5). The same statistical analysis using ultrasound as a variable found no significant relationship ($\chi^2_1 = 0.62$; two-sided Fisher's exact test = 1.0). These findings are most probably related to the teaching of radiation effects on embryogenesis within the obstetric and gynaecology postgraduate curriculum.

Dose Estimation

About 3% (5/178) of respondents were able to accurately estimate the dose of standard V/Q lung scintigraphy; the dose has been reported as equivalent to 50 to 100 chest radiographs, with a median estimated dose equivalent to that of 75 chest radiographs. For an abdominal CT, 5% (9/178) of respondents provided an accurate estimate of dose. The median estimated dose was equivalent to that of 200 chest radiographs, which represents a dose underestimate of 1.5- to 2.5-fold compared to the actual reported radiation dose equivalent to 300 to 500 chest radiographs.[13] About 3% (6/178) of respondents provided an accurate dose estimate for a barium swallow. For a barium enema examination, one respondent estimated the radiation dose accurately. The median estimated dose was equivalent to 50 chest radiographs, while the actual equivalent dose is between 350 and 450 chest radiographs.[13] In other words, doctors were submitting patients to radiation doses that were up to nine times larger than they thought. Table 5 provides a list of common radiological examinations and their effective doses (with equivalent numbers of chest radiographs).[14]

Perception of Cancer Risk

In all, 37% (66/178) of respondents were aware of an increased cancer risk from an abdominal CT scan, indicating that almost two-thirds did not perceive that there was such a risk (Table 2). Only 41 (23%) of respondents were aware of the cancer risk in a child who undergoes abdominal CT. Of these, 35 (20% of total respondents) perceived the risk to be higher than that in adults (Table 2). There was no significant association between the respondents' gender ($\chi^2_1 = 0.16$, p = 0.69) or professional grade ($\chi^2_1 = 0.40$, p = 0.53) and whether or not they perceived an increased cancer risk from the abdominal CT scan. Nor was there a significant association between respondents' years in service and perceived cancer risk from an abdominal CT scan ($\chi^2_1 = 1.64$, p = 0.20).

In a comparison of respondents from the paediatric medical department (n = 16) versus elsewhere by means of the χ^2 test of independence, there was no significant association ($\chi^2_1 = 0.57$, two-sided Fisher exact = 0.74). In fact, only two (13%) respondents from paediatrics were aware of the increased cancer risk in children per unit dose of radiation, compared to that for adults.

To facilitate analysis of overall knowledge, each respondent was assigned a total score based on their responses to the questions on cancer risk and modalities

Table 5. Estimated cancer risk and radiation dose for common imaging examinations. Based on classes of risk (Bands I to IV) developed by International Commission of Radiological Protection and endorsed by European Commission referral guidelines for imaging.[14]

Risk category (Band)	Dose (mSv)	Equivalent No. of chest radiographs
0		
Magnetic resonance imaging	0	0
Ultrasonography	0	0
I		
Limb and joint radiography (except hip)	<0.01	<0.5
Chest radiography (single posteroanterior film)	0.02	1
II		
Lumbar spine radiography	1	50
Intravenous urography	2.4	120
Lung scintigraphy	1	50
Renal scintigraphy	1	50
III		
Chest computed tomography	8	400
Abdominal computed tomography	10	500
Brain positron emission tomography (with F-18 fluorodeoxyglucose)	5	250
Barium enema	7.2	360
IV		
Thallium scan	23	1150
Gallium scan	40	2000

using ionising radiation. An arbitrary score of one was given for each correct response. Dose estimation was excluded from this analysis as 78% (139/178) of respondents abstained from this section of the questionnaire. There was a significant association between the respondents' years in service and total mark (Spearman $\rho = 0.21$, $p = 0.005$). Using the same test, no significant association was demonstrated between the respondents' professional grade and their total score (Spearman $\rho = 0.14$, $p = 0.06$).

Retrospective Power Analysis

This analysis was performed on all significant results, and revealed power values ranging from 0.95 to 0.99 ($\alpha = 0.05$).

DISCUSSION

Awareness of Dose-saving Investigations

Not surprisingly, ultrasound was clearly identified by 96% of respondents as a dose-saving modality. This was comparable to the results of a survey of 130 doctors from South Wales and Oxford, where 5% did not realise that ultrasound does not use ionising radiation.[7] Awareness of MRI as a dose-saving investigation fared less well. This lack of awareness (a third of respondents) is striking when compared to the results of the aforementioned survey, where 8% did not know that MRI does not use ionising radiation. Such lack of awareness may be due to the less availability and less utilisation of MR facilities in certain centres, its relative costs also being a deterrent, which could all be linked to differences in prevailing health service infrastructure. For example, many medical officers currently practising in our centre were recently transferred from district hospitals where a single-slice CT scanner was the most sophisticated imaging modality. In which case they might not have been readily exposed to the use of MR scanners.

As demonstrated by the χ^2 test of independence, however, respondents who were specialists at the time of questioning or who had been in service longer (≥7 years in this case) were more likely to reply correctly to this question. This suggests that even if knowledge of MRI as a dose-saving modality is not attained during residency training, it may be gained later as the clinician accumulates more experience.

Interestingly, respondents from the Department of Obstetrics and Gynaecology (n = 11) gave 100% correct responses with regard to ultrasound and MRI as dose-saving modalities. These findings were consistent, regardless of the professional grade or years of clinical experience of the respondent. Statistically, obstetricians were more likely than expected to be aware that MRI does not use ionising radiation, but the small sample precludes any definitive conclusions. A postulated explanation could be the awareness of avoiding exposure to ionising radiation during the antenatal period to reduce the risk of congenital malformations. However, obstetricians were not more likely to perceive the possible increased cancer risk with diagnostic CT in children ($\chi^2_1 = 0.02$; two-sided Fisher exact = 1.0) or in adults ($\chi^2_1 = 0.003$; two-sided Fisher exact = 1.0).

Dose Estimation

For the most part, respondents were unable to provide an accurate estimate of the dose for four commonly requested radiological investigations in terms of chest radiograph equivalents. Explanation of risk related to any procedure to a patient would be incomplete, if simply the nature of the effect and not its magnitude was outlined. Somatic effects from radiation exposure are termed deterministic if the amount of radiation damage increases with the radiation dose, i.e. a threshold dose applies. In general, the radiation doses in diagnostic radiology are small and deterministic effects should not occur. However, the somatic effects of real concern remain those due to stochastic (or random) effects. Although there is no threshold dose for these, the probability of an effect (rather than its severity) increases with increasing doses.[15] As cancer induction may, in theory, occur with small doses of radiation, the magnitude of diagnostic radiation doses is an aspect to be borne in mind by the referring clinician. The concept of ALARA (as low as reasonably achievable) is familiar to many radiologists, but perhaps less so to the non-radiology community; ALARA denotes making every reasonable effort to keep patient exposures to ionising radiation as far below dose limits as practical, while maintaining diagnostic yield.

Awareness of Cancer Risk

Just as participating doctors were uninformed about radiation dose, they were also largely uninformed about the increased cancer risk associated with diagnostic radiation exposure. Almost two-thirds of respondents did not perceive a possible increased cancer risk associated with diagnostic CT scans in adults. Slightly more than three-quarters of respondents did not perceive the risk of cancer induction in children exposed to diagnostic CT scans. About 20% (35/178) of respondents were aware of the much larger lifetime risks per unit dose of radiation that apply to children. Current estimates of radiation risk for cancer induction have been mostly derived from the outcomes in survivors of nuclear catastrophes, most notably the 90,000 survivors of the atomic bomb attacks on Hiroshima and Nagasaki. The relationship of these radiation exposures to biological risk for patients has been determined by mathematical extrapolation based on changes observed after exposure to higher levels of radiation.[3,16] Linear or linear-quadratic extrapolations from the higher doses have been used to calculate the potential risk. Using these approaches, the Committee on Biological Effects of Ionizing Radiation (based in Washington, DC) estimates a 1.2 to 1.5% increase in fatal cancers for five-year-old children who receive a uniform body dose of 100 mGy.[3] As such, we cannot consider the risks of diagnostic radiation exposure to be negligible, particularly with the increasing prevalence of multi-slice CT usage. In general, radiation doses to patients from a multi-slice CT machine are approximately 30 to 50% higher primarily as a result of scan overlap, positioning of the X-ray tube closer to the patient, and possibly, increased scatter radiation with wider X-ray beams.[17]

Our findings suggest that current information regarding possible radiation-related risks needs wider dissemination among requesting clinicians in non-radiology disciplines. This issue is particularly pertinent to patients who are increasingly well-informed about diagnostic radiation exposure and its attendant risks. Education regarding radiation doses ought to be a priority to maintain public trust in the radiology community, and for practising clinicians as responsible caregivers.

Convenience Sampling of Respondents

The respondents in this study represented doctors who attended either a radiology conference in the radiology department, or, a CME conference in their own department. This constituted a form of convenience sampling. We recognise that this can introduce a degree of sampling bias. However, we utilised this form of sampling for two reasons. First, the authors felt that this method would yield a higher number of respondents compared to the traditional mailing of a questionnaire. Second, to a considerable extent conference attendance is compulsory for all doctors in a particular department, and as such we felt that the sample obtained would be quite representative of the doctors of the departments we targeted.

Limitations

The small number of respondents from individual departments might have resulted in responses which were not entirely representative of the department itself. This is especially relevant to discussions regarding respondents from the departments of Paediatrics and Obstetrics and Gynaecology.

CONCLUSION AND RECOMMENDATIONS

Patient safety is a priority in any medical investigation or intervention. There are a number of measures that radiation personnel may utilise to reduce cumulative radiation risks to patients. These include technical aspects (automated tube current modulation, beam filtration, adaptive collimation), imaging parameter selection (decreasing tube potential and current), and protocol modifications (multiple pass scanning and reduction of duplicate coverage).[12] In addition, there are calls to record patient doses, particularly after recurrent CT imaging.[18] At present, however, clear guidelines for proper implementation of this approach have yet to surface. Informed consent for every investigation requiring exposure to ionising radiation is another measure that has been suggested.[1] As doctors concerned with keeping radiation doses ALARA, we suggest that the risks of medical radiation exposure should also be borne in mind by requesting physicians. Radiologists need to ensure that investigations are justified and individual cost benefit analyses be made on the need to expose patients to ionising radiation. As partners in care, it is hoped that consideration for utilising dose-saving modalities such as MRI and ultrasound is increased among requesting physicians without necessarily compromising diagnostic yield. While ethical concerns in this study were encouraging, there was a lack of awareness of radiation dose and risk of carcinogenesis, particularly among children. The results of this study suggest that there is a need to disseminate information regarding radiation dose and its possible risks to the non-radiology medical community. Towards this end, it may well be prudent to introduce lectures regarding radiation protection into postgraduate medical programmes.

APPENDIX

Additional material related to this article can be found on the HKJR website. Please go to <http://www.hkjr.org>, search for the appropriate article, and click on **Full Article** following the title.

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APPENDIX 1: QUESTIONNAIRE BOOKLET

RADIOLOGY DEPARTMENT
UNIVERSITI KEBANGSAAN MALAYSIA
MEDICAL CENTRE

KNOWLEDGE, ATTITUDES AND PRACTICE REGARDING RADIOLOGICAL INVESTIGATIONS IN UKM MEDICAL CENTRE

The radiology department of UKM Medical Centre is conducting a survey among its own doctors regarding radiological investigations. This survey is ***completely anonymous***. Please complete it without consultation or research. Thank you for taking part in this survey!

Please leave this column blank

SECTION A

QUESTION 1

Which of the following investigations would expose a patient to ionising radiation ? (please tick the appropriate box)

Radiological investigation	Uses ionising radiation ?		
	Yes	No	Don't know
Barium swallow			
Barium enema			
Ultrasound of abdomen			
Doppler ultrasound of lower limb			
CT of abdomen			
MRI of abdomen			
MRI of knee			
MRI of brain			
V/Q scan of lung			

A1

□ □
□ □
□ □
□ □
□

QUESTION 2

Please indicate the radiation dose of the following investigations in relation to the dose of a chest x-ray (e.g. the dose of an abdominal x-ray is equivalent to that of 75 chest x-rays).
If completely unsure, tick "Don't know".

Radiological investigation	Equivalent number of chest x-rays	Don't know
Barium swallow		
Barium enema		
Ultrasound of abdomen		
Doppler ultrasound of lower limb		
CT of abdomen		
MRI of abdomen		
MRI of knee		
MRI of brain		
V/Q scan of lung		

A2

□ □
□ □
□ □
□ □
□

SECTION B

QUESTION 1

Is the lifetime risk of developing cancer increased in an adult exposed to an abdominal CT examination?

- ▯ Don't know } Please proceed to Section C
- ▯ No }
- ▯ Yes — Continue to next question

QUESTION 2

Is the lifetime risk of cancer increased in a child as a result of an exposure to a single abdominal CT examination?

- ▯ Don't know.
- ▯ No.
- ▯ Yes. The lifetime risk is less than that in adults.
- ▯ Yes. The lifetime risk is equivalent to that in adults.
- ▯ Yes. The lifetime risk is higher than that in adults.

SECTION C

QUESTION 1

"Patients referred for radiological investigations involving ionizing radiation should be informed of the possible risks."
Do you agree with this statement?

- ▯ Strongly disagree }
- ▯ Disagree } Please proceed to Section D
- ▯ Don't know }
- ▯ Agree }
- ▯ Strongly agree } Continue to next question

QUESTION 2

How often do you explain the possible risks associated with ionizing radiation to patients referred for radiological investigations?

- ▯ Never
- ▯ Sometimes
- ▯ Most of the time
- ▯ Always

Please leave this column blank

B1 ▯

B2 ▯

C1 ▯

C2 ▯

SECTION D

1. Gender
   ▯ M ▯ F

2. Professional grade (please tick the appropriate box)

House officer	
Medical officer / Trainee lecturer	
Professor / Assoc Prof / Lecturer	

3. Years in service _______________

4. Year of medical school graduation _______________

5. Specialty (please tick the appropriate box)

Accident & Emergency		Otorhinolaryngology	
Anaesthesiology		Paediatrics	
Family Health		Pathology	
Internal Medicine		Public Health	
Maxillofacial Surgery		Psychiatry	
Microbiology		Radiotherapy & Oncology	
Obstetrics & Gynaecology		Surgery	
Ophthalmology		Others ______________	
Orthopaedics			

6. Subspecialty _____________________________

Please direct any inquiries towards:
Dr. Kew Thean Yean
Jabatan Pengimejan Diagnostik
Fakulti Perubatan Universiti Kebangsaan Malaysia
Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras, Kuala Lumpur.
Tel: (HP) 012-3509538 E-mail: tykew@email.com

Thank you for your time!

Please leave this column blank

D1 ▯

D2 ▯

D3 ▯

D4 ▯

D5/6 ▯