



UNIVERSITI PUTRA MALAYSIA

***KNOWLEDGE OF RADIATION EXPOSURE IN COMMON
RADIOLOGICAL INVESTIGATIONS AMONG HPUPM MEDICAL
PRACTITIONERS***

GROUP 5

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KNOWLEDGE OF RADIATION EXPOSURE IN COMMON RADIOLOGICAL INVESTIGATIONS AMONG HPUPM MEDICAL PRACTITIONERS

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ABSTRACT

Introduction: Radiological examinations play an important role in the management of patients in the hospital setting. However, radiological investigations are associated with radiation exposure. Therefore our challenge is to use radiography mindfully to avoid unnecessary radiation-related investigations from being carried out for the patients. **Materials and Methods:** A cross-sectional study was conducted among the clinical specialists and medical officers of 'Hospital Pengajar Universiti Putra Malaysia' (HPUPM) in 2021. The data of the study was analysed with IBM Statistical Package for the Social Science (SPSS) version 26.0. The data was analysed based on descriptive and analytical analyses. **Results:** Majority of respondents were medical practitioners who had four to ten years of experience and claimed to have sufficient knowledge on radiation exposure in common radiological investigations. Majority of them had never been to any sessions of practical training regarding ionizing radiation. It was found that the level of knowledge on radiation exposure among HPUPM medical practitioners was average. There were a statistically significant association between all the factors (level of experience, perceived knowledge level, practical training) and knowledge of radiation exposure in common radiological investigations. **Conclusion:** The respondents (37.3%) had average knowledge on radiation exposure in common radiological investigations. Knowledge of radiation exposure was found to be significantly associated with all the factors such as level of experience, perceived knowledge level and practical training.

Keywords: Knowledge; Radiation exposure; Medical Practitioner

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Chapter 1

1.1 Background

Radiological investigations are widely used to visualise organs or body spaces to diagnose and treat certain illnesses. Some of the common radiological investigations include computed tomography, fluoroscopy, magnetic resonance imaging and ultrasonography. The concern of harmful consequences or side effects of the radiation exposure during radiological investigations is widely known. However, knowledge of radiation exposure in common radiological investigations among healthcare practitioners is certainly crucial to prevent health related complications. According to a study by Lee et al (2011) on Knowledge of radiation exposure in common radiological investigations: a comparison between radiologists and non-radiologists, it was concluded that knowledge of radiation doses of investigation is generally inadequate among radiologists, and particularly poor in non-radiologists. Thus, investigating the medical practitioners' knowledge level on radiation exposure would be a great way to assess whether our health care practitioners are well equipped in terms of knowledge.

Besides, based on a study done by Shafiee et al (2020), working experience was a factor that affected the knowledge of radiation exposure among medical practitioners. Hence, from here we can deduce that the knowledge of radiation exposure can be affected by healthcare practitioners' level of working experience in the medical field. In another study by Szarmach et al (2018), the highest rates of correct answers to questions related to the issue of radiation protection were provided by the staff of radiology facilities and emergency departments with one to five years of professional experience. This is a finding that definitely needs to be investigated further since most of us usually assume that medical practitioners with longer experience in the medical field would have a higher score. However, the researchers in this study finally concluded that periodic training of medical practitioners regardless of position and length of service should be practised in the field of radiological protection knowledge. Thus, we decided to study further on other factors similar like level of experience and find their association with knowledge of radiation exposure during common radiological investigations. We can definitely use studies like the one by Szarmach et al (2018) as a strong support that not all these factors might be significantly associated with the medical practitioners' knowledge and tally with our general

assumptions. Thus, the main goal of our study was to identify the factors that can affect a healthcare practitioner's knowledge on radiation exposure together with their association.



1.2 Problem Statement

Nowadays, it is undeniably true that various radiological procedures in all kinds of healthcare establishments are often carried out. However, these radiological procedures are a great source of artificial radiation. Hence, it is certainly advisable to use these radiological procedures to aid diagnosis only when necessary. The knowledge of radiation exposure in common radiological investigations among healthcare practitioners is an important measure to prevent unnecessary radiation-related investigations and radiation exposure to the patients.

Moreover, according to a study conducted by Bonsanquet et al in 2011, it was significantly proven that the doctor's knowledge regarding radiation exposure was seriously lacking and insufficient. Ever since 2003, various publications and studies conducted have demonstrated inadequate knowledge of radiation exposure among medical professionals. Through these studies, it is clear and worrying to be considered in all aspects that doctors have no real knowledge of radiation doses as well as the exposure of radiation that their patients will receive. This may eventually result in getting the risk of injury associated with long-term exposure to radiation.

There are fewer studies about knowledge on radiation exposure in common radiological investigations being done in Malaysia. Therefore, there is a need to look more in-depth on the knowledge of radiation exposure in common radiological investigations and their associated factors especially among medical practitioners who are involved in performing and requesting radiological investigations.

Therefore, the purpose of this study is to determine the knowledge of radiation exposure in common radiological investigations and the HPUPM medical practitioners were chosen to be the respondents as they are considered as a group of people who should be knowledgeable regarding radiation exposure thus, they play an important role in protecting their patients from unnecessary radiation.

1.3 Significance of study

The significance of this study was to obtain the exact data and baseline information regarding the knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners. This is because, we all know that the higher the doses and exposure of the radiation, the greater the chance of developing side effects from the radiation exposure. The findings obtained from this study were used to develop a strategy in order to find significant ways to create awareness of radiation safety and avoid unnecessary exposure to medical radiation to the patients and staff involved.

In this study, we were also devoted to determining factors that are associated with the knowledge of radiation exposure. It was significantly proven by previous studies that the knowledge of radiation exposure among medical practitioners from different departments were still considered as poor and insufficient. Therefore, this study functioned as a reference in the future to create awareness regarding radiation exposure and the risk of side effects due to the radiation exposure.

1.4 Research question

- I. What is the level of knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners?
- II. Do the factors (perceived knowledge level, work experience, practical training) affect knowledge of radiation exposure among HPUPM medical practitioners?

1.5 Study objectives

1.5.1 General objective

To determine the knowledge of radiation exposure in common radiological investigations and its associated factors for HPUPM medical practitioners.

1.5.2 Specific objective

- I. To determine the level of knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners.
- II. To study the association between factors (perceived knowledge level, work experience, practical training) and knowledge of radiation exposure.

1.6 Hypothesis

- I. There is a significant association between level of experience and knowledge of radiation exposure.
- II. There is a significant association between perceived knowledge level and knowledge of radiation exposure.
- III. There is a significant association between practical training and knowledge of radiation exposure.

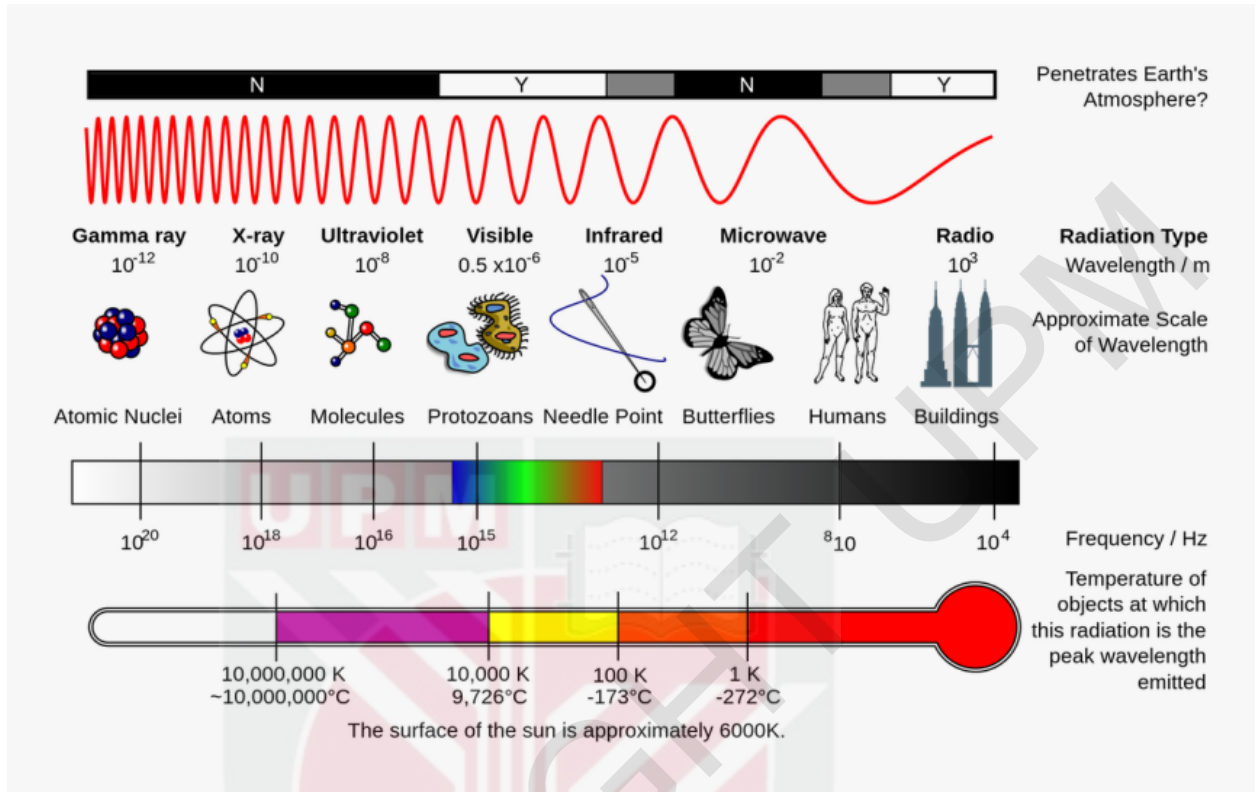
Chapter 2

Literature Review

2. 1 Radiation Exposure

2.1.1 Definition

Radiation, according to the World Health Organization (WHO) can be defined as a type of energy that travels in the form of waves or particles and it is included in our everyday environment. It is a complete process in which the energy is emitted from one substance through a medium and will be absorbed by another body. It can be subdivided into two which includes ionizing and non-ionizing radiation. The major types of ionizing radiation emitted include alpha particles, beta particles and gamma rays. Commonly, it is undeniably true that during an interventional radiological procedure, some of this radiation might be transmitted and exposed but the level or risk depends on the type of procedure. In general, the risk that results from the use of interventional radiological procedures does not pose a major concern when compared to the benefits of the procedure itself. Most radiation exposure resulting from medical procedures comes from the use of standard X-rays and CT scans which act as an important tool in helping medical professionals to diagnose injuries and diseases in patients.



2.1.2 Impact of Radiation Exposure

Numerous interventional medical imaging procedures used in daily life especially in the medical field consist of low or high levels of radiation exposure which causes cancers and genetic disorders. The most common example is seen in complications on the Japanese atomic bomb survivors who were exposed to high dose rates. There were also some studies carried out to assess the occupational exposure-induced cancer rate and mortality among radiation workers. The health impacts of radiation can be manifested in various ways according to different doses and characteristics of the irradiated body parts.

According to study which aimed to investigate the level of knowledge about radiation safety, Kurtul et al (2018) claimed that low doses of radiation exposure can cause cellular and chromosomal damage besides carcinogenic effects to different parts of body such as skin, eyes, gonads and blood cells and even lead to a detrimental effect in a severe extent. It was also noted that chronic and intermittent exposure to a low level of radiation over a prolonged period can emerge years later.

Most of the common symptoms of radiation exposure found are very acute such as nausea and vomiting. Some radiation workers might also suffer from varieties of diseases and abnormalities. For example, skin disorder, cataract, bone marrow suppression, infertility, congenital malformations and secondary cancer. In some cases, organ sensitivity to radiation damage can also occur which will eventually lead to susceptible reproductive organs and resisted nerve tissue. All of these will result in radiation-related death.

2.1.3 Prevalence of radiation exposure in common radiological investigation

Based on a study conducted by Lee et. al (2012), on thyroid cancer risks among medical radiation workers in South Korea between 1996–2015, Korean medical radiation workers had a higher incidence of thyroid cancer than those in the general population and there was no increase associated with occupational radiation dose. The study shows that 827 thyroid cancer cases were reported among 93,922 medical radiation workers. The Standardized incidence ratios (SIRs) were significantly higher than expected for both men (SIR 1.72, 95% confidence interval [CI] 1.53 to 1.91) and women (SIR 1.18, 95% CI 1.08 to 1.28).

In another study on projected lifetime cancer risks from occupational radiation exposure among diagnostic medical radiation workers in South Korea, Lee et al has provided an assessment of the potential cancer risk from occupational radiation exposure. The highest lifetime attributable risk (LAR) was observed in male and female radiologic technologists who started work in 1991 (264.4/100,000 and 391.2/100,000, respectively). A higher risk of radiation-related excess cancer was seen in females even though they were exposed to lower radiation doses than male workers.

In the Asia Pacific region that covers the East Asia, South-East Asia, Australia, New Zealand and the Pacific Islands, the medical radiation exposure due to the use of interventional radiological procedure has been on the rise with 39% of the Asia-Pacific countries in healthcare level I, 27% in level II, 29% in level III and 5% in level IV. According to the 2008 UNSCEAR report, it was clearly stated that the number of radiological examinations and the risk of radiation exposure through this medical examination is closely related to the healthcare level of the countries. Therefore, the higher usage of these medical interventional procedures leads to a higher risk of radiation exposure.

2.2 Factors associated with the knowledge on radiation exposure

2.2.1 Level of experience

Based on a previous study done by Shafiee et. al (2020), a study to assess the knowledge of medical professionals on radiation in interventional radiology was done in order to determine the association between working experience and the knowledge of radiation exposure among medical personnel. The result of the study clearly stated that participants with low level of working experience with only one to four years before had lesser knowledge about radiation as compared to the more experienced participants (> 20 years) ($P = 0.043$). The knowledge of radiation exposure was assessed based on the knowledge on the staff positioning, leakage of radiation from the tube X-ray as well as the awareness of the radiation scattered from the body of the patient. It had been proven that 25.5% of health workers were aware of the staff positioning that induces their occupational exposure to the radiation while less than one third of the physicians and nurses barely knew about the radiation leaked from the tube X-ray. 17.2% of the participants were aware of the radiation exposure scattered from the patient's body.

Another study by Luke et al. (2011) also found that participants who had more years of experience answered the questions more correctly and accurately compared to those with lesser experience. However, study done by Lee et al (2012) claimed that senior radiologists were observed to have a poorer performance than junior radiologists, which proved there was no significant relationship between radiologist years in practice and dose estimates Thomas el al also noted that there was no significant performance difference between those who had years of clinical experience and those who did not have experience. In the study about radiation safety awareness among medical staff by Szarmach et al, working experience was not significantly important as the study showed participants with 1 - 5 years of experience achieved the highest percentage of correct answers (73%). Whereas, those who had 11 - 15 years of experience scored the lowest percentage of correct answers (14%).

2.2.2 Perceived knowledge level

Based on the study conducted by Faggioni et al (2017) to assess the awareness of radiation exposure and dose level imaging procedures among medical students, it was proven that there is a significant association between perceived knowledge level and the knowledge of radiation exposure. According to Sundaran et al (2017), there was no significant association between confidence in knowledge and knowledge of radiation exposure.

There was also a study conducted by Awadghem et al (2020) in a study on medical student's proficiency regarding hazards of radiological examination that significantly reported students who perceived as having excellent radiological knowledge achieve lower knowledge scores as compared to the other students who perceived their knowledge as average. In another study conducted by Zhou et al (2010) and Dellie et al (2015), it was found that students who reported to have moderate confidence in their knowledge on radiation scored better than those who were not confident with their own knowledge. According to Sripusanapan et al (2020) in a study of assessment of awareness of radiation protection and knowledge of radiation dose among 5th year medical students and radiology at Maharaj Nakorn Chiang Mai Hospital, in self rating their knowledge level related to ionizing radiation related risk, 12 (25.5%) rated their knowledge as insufficient, 11 (23.4%) rated it as good and only one (2.13%) rated their knowledge as excellent. It was proven that there was inadequate awareness of radiation protection and knowledge of radiation dose among the respondents.

2.2.3 Practical training

In a study done by Kurtul et al to determine the level of knowledge about radiation safety among healthcare workers (2018), it was proven that most of the participants learned about the knowledge of radiation protection through in-service training and self- teaching (41.5%).

Kurtul et al also noted results gained from other researchers in the study. For example, it was stated that Jacob et al (2006) claimed that practitioners who practiced under radiation protection regulations such as IR(ME)R had a better overall performance than physicians who had more experience and those who had undergone a radiation safety course. McCusker et al (2009) also proved that interns and practising doctors performed significantly better than medical students. The study by Soye and Paterson (2008) showed that respondents with more training had better knowledge in comparison with those with less practice training. Zhou et al (2010) noted that interns performed significantly better than the medical students who had never attended practical training. However, Thomas et al (2006) found out that there was no better performance for those who had practiced paediatricians.

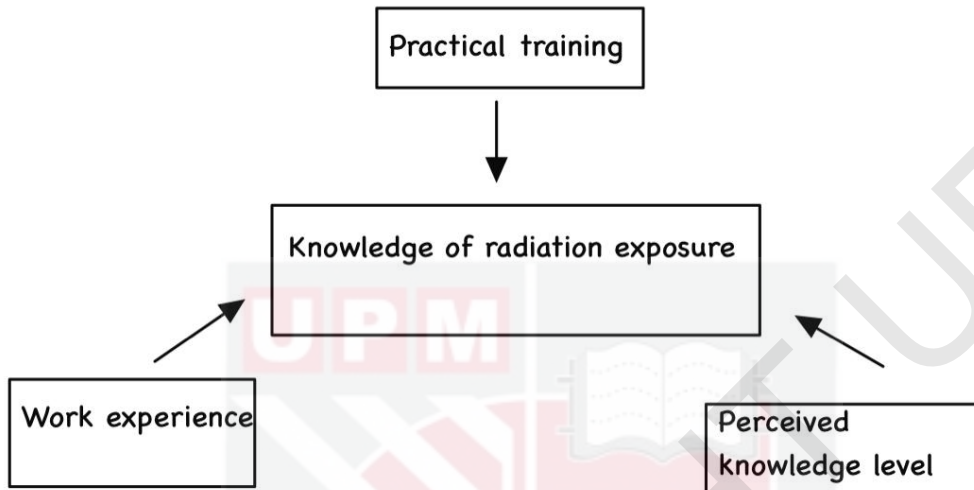
The evidence of no better performance for medical staff who attended practical training was also further supported by a study conducted by Barnawi et al that significantly proven the fact that doctors who had formal practical training on radiation exposure and protection before is more knowledgeable regarding ionizing radiation that could indicate a potential lifetime risk of developing cancer ($p=0.028$) and the risk of imaging on fetus ($p=0.024$). In the same study, the result also surprisingly indicated the fact that 55% of its respondents were unaware that ultrasound had no ionizing radiation and 67% of its respondents were also unaware that MRI has no ionizing radiation and this is said to be highly associated with practical training as 80% of the participants in the study had no training before. It was also found that doctors who had radiation protection training in the past few years answered three of four questions that are related with the risk of radiation exposure more correctly than other doctors who did not undergo any practical training.

2.3 Ways to assess the knowledge on radiation exposure

In a past survey on Radiologists' Knowledge and Attitudes towards CT Radiation Dose and Exposure in Saudi Arabia (2020) by Almohiy et al, the radiologists' knowledge was assessed based on a survey. A questionnaire was designed on primary aspects of CT scan, hence allowing them to evaluate the potential radiation risk knowledge collectively. The survey was divided into three parts, mainly the participant's background followed by respondent's knowledge regarding CT protocols and participant's knowledge regarding CT doses in paediatric patients. The section regarding the participant's background consists of questions such as academic qualification, CT experience and training. The frequency of updating CT scan protocols, the confidence of the radiologist regarding the correct modulation of the CT parameters and basic questions relating to CT scan procedures were included in respondent's knowledge regarding CT protocols. Finally, for participant's knowledge regarding CT doses in paediatric patients, survey questions such as the relationship between cancer and CT dose, alternative medical imaging techniques and organisational policy for explaining the effects of CT radiation on the child were asked.

Besides, in another survey by Lee et al on knowledge of radiation exposure in common radiological investigations: a comparison between radiologists and non-radiologists (2011), a survey using questionnaires was conducted too. The survey was done by asking participants to indicate the average dose of radiation (in mSv) for a standard chest x-ray exposure and estimate the doses of radiation (measured in chest x-ray equivalents) for various radiological procedures. Nicholas et al had also conducted a similar study on knowledge of medical imaging radiation dose and risk among doctors (2012) and distributed an online survey to all doctors at 14 major Queensland public hospitals, Queensland fellows and trainees in radiology, emergency medicine and general practice. In this survey, respondents were asked to estimate the individual radiation doses of different radiological instruments besides being assessed on knowledge of, and attitudes towards, potential health risks and medicolegal considerations of ionising radiation scans.

2.4 Conceptual framework



Chapter 3

METHODOLOGY

3.1 Study location

This study was conducted at Hospital Pengajar Universiti Putra Malaysia (HPUPM).

3.2 Study design

The study design that was used is a cross sectional study.

3.3 Study duration

The study duration was separated into two phases. The data collection started in the second phase which was from the 1st of March to May 2021.

3.4 Sampling

3.4.1 Study population

The study population is the medical practitioners who are currently working in HPUPM whom include the clinical specialists and medical officers.

3.4.1.1 Inclusion Criteria

- Medical practitioners from all the clinical departments in HPUPM who agreed to participate in the study.

3.4.1.2 Exclusion Criteria

- Medical practitioners who are currently not in HPUPM eg. sabbatical leave, study leave etc.
- Medical practitioners who got transferred, resigned or retired from HPUPM
- Medical practitioners who disagreed to participate in the study.

3.4.2 Sampling frame

All medical practitioners of Hospital Pengajar Universiti Putra Malaysia (HPUPM) in 2021.

3.4.3 Sampling unit

All medical practitioners who fulfilled the inclusion and exclusion criteria.

3.4.4 Sampling size estimation

Formula to estimate two sample proportions by Lwanga S.K. and Lemeshow S.

$$n = \frac{\{[z_{(1-\alpha/2)} \cdot \sqrt{2\bar{P}(1-\bar{P})}] + [z_{(1-\beta)} \cdot \sqrt{P_1(1-P_1) + P_2(1-P_2)}]\}^2}{(P_1 - P_2)^2}$$

n = sample size

$z(1 - \alpha/2)$ = Z statistic for level of confidence of 95%

$z(1-\beta)$ = Z statistic for 80% power

P1 = overall knowledge accuracy of radiologists (larger)

P2 = overall knowledge accuracy of non-radiologists (smaller)

E = $(P_1 + P_2)/2$

Calculations

$z(1 - \alpha/2)$ = level of confidence = 95%

Hence, $Z_{1-\alpha} = 1.96$

$z(1-\beta)$ = Z statistic for 80% power

= 0.842

P1 = overall knowledge accuracy of radiologists = 40% = 0.4

(Lee et al, 2012)

P2 = overall knowledge accuracy of non-radiologists = 16% = 0.16

(Lee et al, 2012)

E = $(0.4 + 0.16)/2 = 0.28$

Hence,

$$n = \frac{\{[(1.96)\sqrt{2(0.28)(1-0.28)}] + [(0.842)\sqrt{0.4(1-0.4) + 0.16(1-0.16)}]\}^2}{(0.4 - 0.16)^2}$$

$$(0.4 - 0.16)^2$$

= 54 samples

$54 \times 2 = 108$ samples

Adjusting for 20% non- response rate / drop out rate.

$$\begin{aligned}n &= (108 \times 20\%) + 108 \\ &= 130 \text{ samples}\end{aligned}$$

Thus, a total of 130 HPUPM practitioners are needed to estimate the population with 20% drop out rate.

3.4.5 Sampling method

The simple random sampling technique was used in this study. The access for the email was obtained from the administrative office of the HPUPM. All the medical practitioners were given a number according to the list obtained. Thus, 130 numbers were chosen randomly using a number generator and the medical practitioners to each number specifically was chosen. The online questionnaire was delivered to the chosen medical practitioners' email through a UPM staff based email platform. The link for the data collection is https://docs.google.com/forms/d/e/1FAIpQLSdgmWprBvfLHXl3Fyycd8jAl57w7vTxuL62Vj3TcHs0p9_Eg/viewform?usp=sf_link

3.5 Data collection

3.5.1 Instruments of study

The questionnaire which was taken from a past research on Awareness of radiation protection and dose levels of imaging procedures among medical students, radiography students, and radiology residents at an academic hospital: Results of a comprehensive survey (2016) was used in the study. The questionnaire consisted of 15 multiple choice questions which were divided into three separate sections (i.e., personal details, awareness about radiation protection issues, and knowledge about radiation dose levels of common radiological examinations).

The questionnaire in the format of Google form was distributed to the participants via email. The Google form were created using UPM student emails : 200723@student.upm.edu.my owned by Soo Jing Xuan and 200306@student.upm.edu.my (Farah Husna Binti Muliadi), 200795@student.upm.edu.my (Jahnnavii Shakti A/P Srithar) were added as editor. The data were only accessible by the owner and editors and the results were kept confidential. There were three main sections which included personal details, radiation protection knowledge and radiation dose assessment.

Section 1	Personal details	<ul style="list-style-type: none">• In this section, the participant's details were being questioned which include their gender, age, level of experience, perceived knowledge level regarding ionizing radiation related risk and their experiences of attending any training courses beforehand• There were a total of five questions in this section
Section 2	Radiation protection knowledge	<ul style="list-style-type: none">• In this section, the questions were related to the level of knowledge on the effects of radiation exposure and the need for radiation protection knowledge. The format of the questions were

		<p>similar to multiple choice questions (MCQ) where the participants were allowed to choose only one answer.</p> <ul style="list-style-type: none"> • There were a total of seven related questions.
Section 3	Radiation dose assessment	<ul style="list-style-type: none"> • In this section, participants were assessed on their knowledge of radiation dose in common radiological investigations. The format of the questions were similar to multiple choice questions (MCQ). • There were eight questions in this section.

The knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners was assessed based on the scoring of their radiation protection knowledge and radiation dose assessment. The radiation protection knowledge section consisted of seven questions whereas the radiation dose assessment section consisted of eight questions respectively. The questionnaire consisted of 15 questions each contributing one mark which made up of a total 15 marks. The scoring was converted into percentage to ease the data analysis process.

3.5.2 Validity and reliability

Content validity and reliability: The questionnaire was taken from a previous study by Faggioni et al in 2016: Awareness of radiation protection dose levels of imaging procedures among medical students, radiography students and radiology residents at an academic hospital. According to the journal, the questionnaire was assessed by the members of supervisory teams and its reliability was assessed in terms of internal consistency by means of the Cronbach's alpha (α) coefficient [mean and 95% confidence intervals (CI95)]. The questionnaire was found to have an acceptable internal reliability ($\alpha = 0.780$; CI, $0.762 \div 0.852$) as a measure of knowledge of essential radiation protection and radiation dose assessment. The internal consistency of the questionnaire was also assessed separately among radiology residents, medical students and radiography students. Cronbach's α coefficients were 0.760, 0.727 and 0.797 respectively.

3.6 Data Analysis

In this study, the data was analysed with IBM Statistical Package for the Social Science (SPSS) version 26.0. The data was analysed based on descriptive and analytical analysis. In the descriptive analysis, the frequency, mean and standard deviation were determined for normally distributed data, while the median and interquartile range (IQR) were presented for not normally distributed data. The Fisher's Exact test was used in order to determine the association between dependent and independent variables and the level of significance was set at $\alpha = 0.05$.

3.7 Variables

3.7.1 Dependent variables

The dependent variable is knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners.

3.7.2 Independent variables

The independent variables are:

- Level of experience
- Perceived knowledge level
- Practical training among medical practitioners in HPUPM.

3.8 Expected outcome

The association between all the factors of level of experience, perceived knowledge level, practical training and knowledge of radiation exposure were determined in this study. Based on the study design that was conducted, we expected that there were associations between all these factors and the knowledge of radiation exposure among medical practitioners in HPUPM.

3.9 Operational Definition

Term	Definition
Medical practitioners	In our study, the term medical practitioners refers to the clinical specialists and medical officers from all departments of HPUPM
Knowledge of radiation exposure	Knowledge is a condition of knowing or understanding information that is obtained through experiences or study. In this study, the knowledge of radiation exposure was assessed based on a published study on the awareness of radiation protection and dose level among medical students: radiography students and radiology residents at an academic hospital(2). The respondents' knowledge was assessed based on section 2 and section 3 in the questionnaire which consisted of radiation protection knowledge and radiation dose assessment respectively.
Radiation exposure	It is the exposure of energy that travels in the form of waves or particles and is part of our everyday environment (WHO). A device called a dosimeter can be used to measure the absorbed dose of radiation.
Radiological investigations	It is the use of medical imaging to help in the diagnosing and treatment of diseases. In this study, common radiological investigations that are included are PA chest radiograph, mammography, CT examination, MRI examination, abdominal ultrasound and myocardial scintigraphy.
Practical training	It is the duration of time in which the respondents take the opportunity to learn and apply the knowledge regarding radiation exposure.
Work Experience	It is the duration of all the medical professionals working in their specific field of medicine. In this study, the working experience was also assessed by the study published previously on the awareness of radiation protection and dose level among medical students: radiography students and radiology residents at an academic hospital. (2)
Perceived knowledge level	It is the respondent's confidence level in their knowledge on radiation exposure.

3.10 Study ethics

We obtained the ethics approval in conducting this study from Jawatankuasa Etika Universiti Penyelidikan Melibatkan Manusia (JKEUPM) and consent from the participants before conducting this study

3.11 Anticipate difficulties/ limitation

The study only focused on the medical practitioners of HPUPM. Therefore, the result of the study on the knowledge of radiation exposure in common radiological investigation was only based on the specialists and medical officers of HPUPM. The result presented may not be representative of the whole population of Malaysia and may also be different from other hospitals and institutions. The causal relationship was not obtained through cross-sectional study.

Chapter 4

Data Analysis

4.1 Response rate

Among the 108 calculated sample sizes, all respondents were able to participate in this study. The response rate were calculated by using the formula below:

$$\text{Response rate} = \frac{\text{Eligible}}{\text{Consented}} \times 100\%$$

$$\text{Response rate} = \frac{108}{108} \times 100\%$$

Response rate = 100%. The final response rate of our study was equivalent to 100%

4.2 Normality Assessment and Statistical Testing

Table 4.1 shows the Test of normality

Kolmogorov-Smirnov test	p<0.001
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The Statistical Package for the Social Science (SPSS) version 26.0 had been used for data analysis, data entry, clean data, and normality testing. Kolmogorov-Smirnov test of normality was implemented to determine the normality (i.e. data distribution) of the numerical data for the dependent variable namely 'knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners'. Table 4.1 showed the normality testing using the Kolmogorov-Smirnov test, it was found that knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners was not normally distributed and skewed as the $p < 0.001$. For descriptive statistics, we categorized our numerical variables for the ease of description. The variable was categorised into low, average and high. For statistical analysis, the relationship between the factors (level of experience, perceived knowledge level and practical training) and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners was analysed by using the Fisher's Exact Test.

4.3 Descriptive statistics

4.3.1 Frequency and percentage distribution of the characteristics of HPUPM medical practitioners (N=110)

Table 4.2 The distribution and frequency percentage of personal details and the characteristics of HPUPM medical practitioners.

Characteristics	Mean (SD)	N	%
Age	40 (7.83)		
Gender			
Male		28	25.5
Female		82	74.5
Level of experience			
Less than 3 years		10	9.1
4 to 10 years		47	42.7
11 to 20 years		39	35.5
More than 20 years		14	12.7
Perceived knowledge level			
Excellent		6	5.5
Good		11	10
Sufficient		67	61.8
Insufficient		26	22.7
Practical training			
Yes, frequently		12	10.9
Yes, seldom		26	23.6
No, never		72	65.5

The first section of our questionnaire required the respondents to give answers regarding their personal details. Table 4.2 showed the distribution of HPUPM medical practitioners according to their characteristics. From the responses, the calculated mean for age was equivalent to 40 (7.83). The respondents were 28 (25.5%) male and 82 (74.5%) female. For the level of experience, ten (9.1%) of the respondents claimed that they had an experience of less than three years while 47 (42.7%) claimed that they had the experience of four to ten years. Thirty-nine (35.5%) of the respondents had 11 to 20 years of experience and lastly 14 (12.7%) had the experience of more than 20 years of working. As observed in this study, the majority of the medical practitioners had four to

ten years of working experience and the reason for this could be because of HPUPM which was a newly established teaching hospital for the faculty of medicine and health sciences in UPM. From the questionnaire, there were also questions on the level of knowledge about ionizing radiation related risk and six (5.5%) of the respondents perceived their knowledge to be excellent, 11 (10%) claimed to have their knowledge as good, 67 (60.9%) perceived their knowledge on ionizing radiation related risk to be sufficient and 26 (23.6%) of the respondents claimed to have insufficient knowledge. For practical training, there were 12 (10.9%) of the respondents that attended practical training frequently, 26 (23.6%) who attended practical training but seldom and 72 (65.5%) respondents have never attended any practical training on knowledge of radiation.

4.3.2 Frequency and percentage distribution of radiation protection knowledge among HPUPM medical practitioners

Table 4.3: The frequency and correct percentage distribution of correct and incorrect answers based on the radiation protection knowledge question. (N=110)

Questions	Correct		Incorrect	
	N	n (%)	N	n (%)
According to current Malaysian legislation, is it necessary to advice patient about the risks related to the use of ionizing radiation for medical purpose?	105	95.5	5	4.5
Which of the following patients is the most sensitive to ionizing radiation?	14	12.7	96	87.3
Which one of the following professionals is considered legally responsible (in Malaysia) for unnecessary exposure to ionizing radiation and/or improperly performed radiological examinations?	82	74.5	28	25.5
Which one of the following professionals are more likely to be exposed to ionising radiation because of their job?	68	61.8	42	38.2
Which of the following tissues is more susceptible to ionising radiation-related damage?	44	40.0	66	60.0
Which of the following diseases may be a result of stochastic radiation damage?	47	42.7	63	57.3
Which of the following best describes the concept of “dose optimisation”?	79	71.8	31	28.2

The second section of the questionnaire was regarding radiation protection knowledge of the respondents. For the first question, 105 (95.5%) respondents agreed that it was necessary to advise patients about the risks related to the use of ionizing radiation which answered correctly and 5 (4.5%) respondents were incorrect. Next for the second question, only 14 (95.8%) respondents agreed that a one-year old female is the most sensitive to ionizing radiation which was correct and 96 (87.3%) incorrect. For the third question 82 (74.5%) respondents agreed that all referring physicians, radiologist, medical specialist and radiographer are considered legally responsible (in Malaysia) for

unnecessary exposure to ionizing radiation and/or improperly performed radiological examinations which was correct answer and 28 (25.5%) respondents answered this question wrongly. Next, 68 (61.8%) respondents agreed that interventional cardiologists and radiologists are more likely to be exposed to ionising radiation which was the correct answer while 42 (38.2%) respondents answered incorrectly. 44 (40.0%) respondents agreed that breast tissue tissues are more susceptible to ionising radiation-related damage which was correctly answered while 66 (60.0%) respondents answered incorrectly. Moreover, 47 (42.7%) respondents agreed that leukemia diseases may be a result of stochastic radiation damage which was correctly answered, while 63 (57.3%) respondents answered incorrectly. Lastly, 79 (71.8%) respondents were able to correctly describe the concept of “dose optimisation” while 31 (28.2%) respondents were incorrect.

Table 4.4 Mean of radiation protection knowledge based on respondent answers. (N=110)

	Mean Knowledge (SD)
Radiation protection knowledge	56.11 (20.43)

Based on table 4.4, it was stated that the mean knowledge of radiation protection among the respondents was 56.11 (20.43).

4.3.3 Frequency and percentage distribution of radiation dose assessment among HPUPM medical practitioners

Table 4.5 The frequency and percentage distribution of correct and incorrect answers based on radiation dose assessment questions. (N=110)

Questions	Correct		Incorrect	
	N	n (%)	N	n (%)
Which is the average radiation dose of a PA chest radiograph?	44	40	66	60
If a PA chest radiograph counts as 1 unit, how much is the average dose due to natural background radiation in Malaysia?	5	4.5	105	95.5
If a PA chest radiograph counts as 1 unit, how much is the average dose due to a lumbar x-ray examination?	14	12.7	96	87.3
If a PA chest radiograph counts as 1 unit, how much is the average dose due to mammography (bilateral, two projections each, i.e. four images in total)?	49	44.5	61	55.5
If a PA chest radiograph counts as 1 unit, how much is the average dose due to a non-contrast chest CT examination?	19	17.3	91	82.7
If a PA chest radiograph counts as 1 unit, how much is the average dose due to a pelvis MRI examination?	60	54.5	50	45.5
If a PA chest radiograph counts as 1 unit, how much is the average dose due to a whole body PET-CT examination?	15	13.6	95	86.4
If a PA chest radiograph counts as 1 unit, how much is the average dose due to an abdominal ultrasound examination?	81	73.6	29	26.4

The third section of the questionnaire was regarding the knowledge of respondents on radiation dose assessment. For the first question, 44 (40%) of the respondents agreed that 0.01 – 0.1 mSv is the average radiation dose of a PA chest radiograph which was correct while 66 (60%) of the respondents were incorrect. Next, for the second question, only 5 (4.5%) of the respondents agreed that 100 – 500 is the average dose due to natural background radiation in Malaysia if a PA chest radiograph counts as 1 unit which was the correct answer while 105 (95.5%) of them answered wrongly. For the third question, 14 (12.7%) of the respondents agreed that 50-100 is the average dose due to a lumbar x-ray examination if a PA chest radiograph counts as 1 unit which was the correct answer while 96 (87.3%) of the respondents answered wrongly. For the fourth question, 49 (44.5%) of respondents agreed that 10-50 is the average dose due to mammography (bilateral, two projections each, i.e. four images in total) if a PA chest radiograph counts as 1 unit which was the correct answer while 61 (55.5%) of them answered wrongly. For the fifth question, 19 (17.3%) of the respondents agreed to the correct answer that 100-500 is the average dose due to a non-contrast chest CT examination if a PA chest radiograph counts as 1 unit while 91 (82.7%) of the respondents answered wrongly. For the sixth question, 60 (54.5%) of the respondents agreed that 0 is the average dose due to a pelvis MRI examination if a PA chest radiograph counts as 1 unit which was the correct answer while 50 (45.5%) of the respondents answered wrongly. In the seventh question, only 15 (13.6%) of the respondents agreed that more than 500 is the average dose due to a whole body PET-CT examination if a PA chest radiograph counts as 1 unit which is the correct answer while 95 (96.4%) of the respondents answered wrongly. For the last question, 81 (73.6%) of the respondents agreed that 0 is the average dose due to an abdominal ultrasound examination if a PA chest radiograph counts as 1 unit which is the correct answer while 29 (26.4%) of the respondents answered wrongly.

Table 4.6 Mean of radiation dose assessment knowledge based on respondents' answers.

	Mean knowledge (SD)
Radiation dose assessment knowledge	32.61 (19.68)

Based on table 4.6, the mean radiation assessment knowledge of the respondents was stated to be 32.61 (19.68).



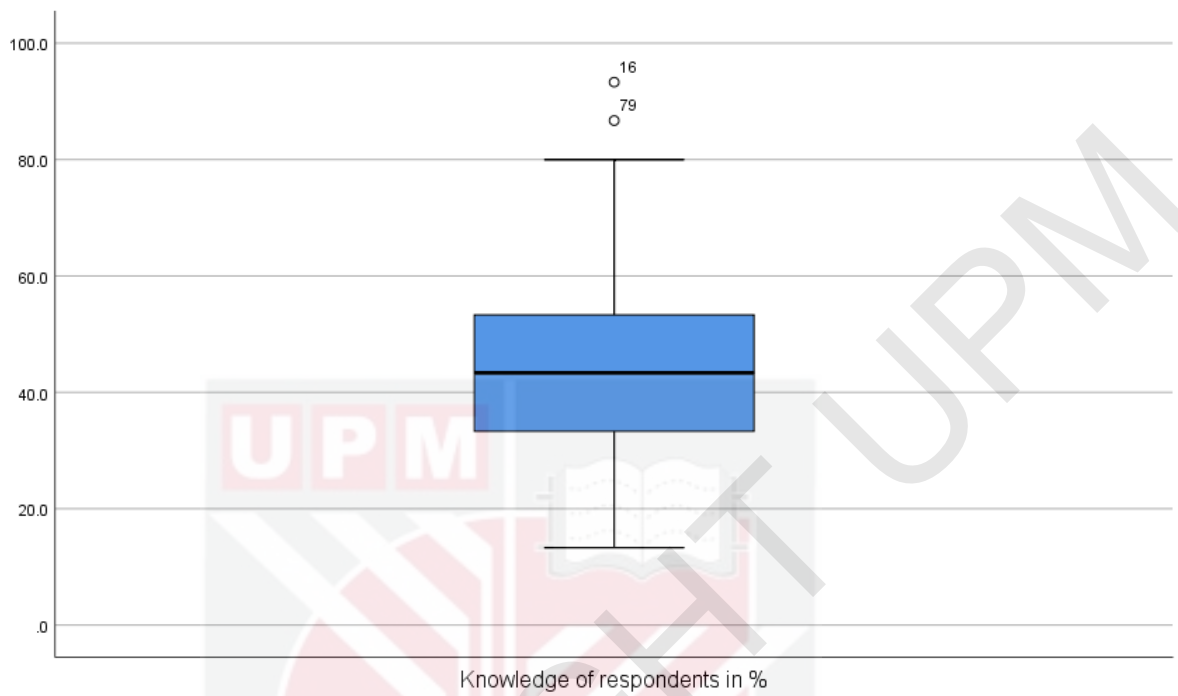
4.3.4 Knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners

Table 4.7 Median and IQR of knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners based on respondents' answers.

Variable	Lowest mark (%)	Highest mark (%)	Median	Interquartile range (IQR)
Knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners	13.3	93.3	43.35	20.00

The knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners was assessed based on the scoring of their radiation protection knowledge and radiation dose assessment. The radiation protection knowledge section consisted of 7 questions whereas the radiation dose assessment section consisted of 8 questions respectively. The questionnaire consisted of 15 questions each contributing one mark which made up of a total 15 marks. The scoring was converted into percentage to ease the data analysis process. As depicted in Table 4.7 above, the median and interquartile range of the knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners were 43.35 and 20.00, respectively. The highest mark obtained from the study was 93.3% and the minimum mark obtained was 13.3%.

From the normality testing using the Kolmogorov-Smirnov test, it was found that knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners was not normally distributed and skewed as the $p < 0.001$.



The numerical part for the knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners was then categorized into 3 groups which were low, average, and high. These categories were made based on the marks obtained by the medical practitioners. The mark range for each of the mentioned categories were made using the the quartiles of the marks obtained by the respondents with 25 quartiles of an assessment mark of 33.3% and 75 quartiles of an assessment mark of 53.33%. Therefore, knowledge of radiation exposure for those who obtained less than 33.3% will be considered low, average in between, and high if more than 53.33%. From the data obtained, most of the respondents i.e. 41 of them (37.27%) had average knowledge of radiation exposure. This was followed by 38 respondents having low knowledge (34.55%) and the remaining 31 having high knowledge (28.18%). The summarized grouping of the knowledge of radiation exposure in common lab investigations among HPUPM medical practitioners based on these 3 categories is depicted in table 4.8 below.

Table 4.8 Percentage and frequency of each categories of knowledge of radiation exposure

	Frequency	Percentage (%)
Low	38	34.55
Average	41	37.27
High	31	28.18

4.4 Analytical statistics

4.4.1 Association between level of experience and knowledge of radiation exposure

Table 4.9: Association between level of experience and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners (N=110)

Level of Experience	Knowledge of radiation exposure					
	High		Average		Low	
	N	%	N	%	N	%
Less than 3 years	5	50	4	40	1	10
4 to 10 years	14	29.8	13	27.7	20	42.6
11 to 20 years	6	15.4	21	53.8	12	30.8
More than 20 years	6	42.9	3	21.4	5	35.7

Table 4.10: Association between level of experience and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners

Variables	Knowledge of radiation exposure result
Level of Experience Pearson's Chi Square Fisher's Exact Test	Significance 0.043 0.041

5 cells (41.7%) have expected count less than 5

The tables above (table 4.9 and 4.10) showed the result for Fisher's Exact test that was used to investigate the association between level of experience with knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners. The result showed that there was a significant association between the level of experience of the medical practitioners and their knowledge on radiation exposure as the P value is less than 0.05 (0.041). Thus, the null hypothesis was rejected. We used Fisher's Exact test as the assumption of Chi-square test was not met. 5 cells (41.7%) have an expected count less than 5. From the result,

50% of medical practitioners with experience of less than three years had high knowledge of radiation exposure, 40% of them had average knowledge on radiation exposure and 10% of medical practitioners with experience of less than three years showed that they were still having low knowledge level on radiation exposure. In another group of medical practitioners with the experience of four to ten years, 29.8% of them had significantly high knowledge on radiation exposure, 27.7% of them had average knowledge while there were 42.6% of them with low level of knowledge of radiation exposure in common radiological investigations. Moreover, the studies showed that medical practitioners with 11 to 20 years of working experience had 15.4% of them with high knowledge, 53.8% with average knowledge of radiation exposure and 30.8% of them still showed lower level of knowledge regarding radiation exposure. Lastly, medical practitioners with more than 20 years of experience showed a result of 42.9% having a high knowledge level on radiation exposure. There were also 21.4 % of medical practitioners from more than 20 years of experience who had average knowledge of radiation exposure and 35.7% of them that are still currently having low knowledge level of radiation exposure in common radiological investigations.

4.4.2 Association between perceived knowledge level by HPUPM medical practitioners and knowledge of radiation exposure

Table 4.11 Association between perceived knowledge level and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners (N=110)

Perceived knowledge level	Knowledge of radiation exposure					
	High		Average		Low	
	N	%	N	%	N	%
Excellent	6	100	0	0	0	0
Good	6	54.5	3	27.3	18.2	2
Sufficient	17	25.0	25	36.8	38.2	26
Insufficient	2	8.0	13	52.0	40.0	10

Table 4.12 Association between perceived knowledge level and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners

Variables	Knowledge of radiation exposure result
Perceived knowledge level	Significance
Pearson's Chi Square	0.000
Fisher's Exact Test	0.001

6 cells (50.0%) have expected count less than 5.

Table 4.11 and 4.12 show the result of the Fisher's Exact test that was used to determine the association between perceived knowledge level with knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners. As both perceived knowledge level and knowledge of radiation exposure in common radiological investigations were categorical variables, either Pearson's Chi Square or Fisher's Exact test can be used based on the percentage of cells having expected count of less than 5 ($E < 5$). As shown in Table 4.12, the expected count less than 5 ($E < 5$) was more than 20% which was 50.0% therefore, Fisher's Exact test was chosen. The p-value of Fisher's Exact is less than 0.05 (0.001), therefore it is statistically significant. Thus, the null hypothesis was rejected. Hence, there was an association

between the knowledge and perceived knowledge level of medical practitioners. As to the perceived knowledge of radiation exposure, all respondents (100%) who claimed to have excellent knowledge showed high knowledge on radiation exposure. In fact, 54.5% of respondents who claimed to have at least a good knowledge showed high level of knowledge, 27.3% showed average level of knowledge whereas 18.2% showed low knowledge level. Moreover, 36.8% of the respondents who claimed to have sufficient knowledge showed average knowledge level. 25.0% and 32.8% showing high and average knowledge level respectively. 52.0% of the respondents who opted for insufficient knowledge level showed average radiation exposure knowledge level. Another eight percent showed high knowledge level and 40.0% with low knowledge level.

4.4.3 Association between knowledge and practical training

Table 4.13 Association between practical training and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners

Practical training	Knowledge of radiation exposure (%)						Total
	High		Average		Low		
	N	%	N	%	N	%	
Yes, frequently	8	66.7	2	16.7	2	16.7	100
Yes, seldom	11	42.3	9	34.6	6	23.1	100
No, never	12	16.7	30	41.7	30	41.7	100

Table 4.14 Association between practical training and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners

Variables	Knowledge of radiation exposure result
Practical training	Significance
Pearson's Chi Square	0.002
Fisher's Exact Test	0.003

3 cells (33.3%) have expected count less than 5.

Table 4.13 and 4.14 showed the result of the Fisher's Exact test to determine the association between practical training and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners. Based on Table 4.13, 3 cells (33.3%) have an expected count less than 5. Thus, Fisher's Exact test was chosen. The P value in the Fisher's Exact test is 0.003 which was less than 0.05. Hence, it was statistically significant and the null hypothesis was rejected. Therefore, there was a significant association between practical training and knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners. 66.7% of the medical practitioners that frequently attended practical training had high knowledge of radiation exposure while 16.7% of them had average and low knowledge of radiation exposure respectively. Next, 42.3% of the respondents that seldom attended practical training had high level knowledge of radiation exposure followed by 34.6% having average level and 23.1% with low level of knowledge of radiation exposure. Finally, 16.7% of respondents that have never attended practical training had a high level of

knowledge regarding radiation exposure whereas, 41.7% of them had average and low knowledge of radiation exposure respectively.



Chapter 5

Discussion

5.1 Knowledge of radiation exposure

In this study, it was proven that the knowledge level of radiation exposure among medical practitioners in HPUPM were on the average level. This could be due to the medical practitioners who had a high level of experience, excellent knowledge on ionizing radiation and had attended practical training sessions on radiation beforehand. This finding was strongly supported by Shafiee et al (2020) that significantly proved there were still many medical professionals who were not aware of the necessary radiation protection concept and practices. Furthermore, this finding was also similar with a study conducted by Lee et al (2012) that concluded the knowledge of radiation in common radiological tests among radiologists and non radiologists were still poor and this was said to be risky as it may put patients at risk of undergoing unnecessary radiological investigations. In comparison with a study conducted by Bonsanquet et al in 2011, it was significantly proven that the doctor's knowledge regarding radiation exposure was seriously lacking and insufficient.

Medical practitioners including specialists and medical officers could improve their knowledge level on ionizing radiation by developing and implementing a radiation protection program managed by the qualified experts. Apart from that, the implementation of radiation protection curriculum early in medical school should also be mandatory. According to a study done by Bonsanquest et al (2011), due to the overwhelming evidence that the knowledge of ionizing radiation is still inadequate among physicians, the World Health Organization (WHO) has made some suggestions that the clinical behaviour of established clinicians could be improved through audit, educational outreach and individual guideline-based feedback messages embedded into x-ray reports which have been proven to decrease unnecessary use of diagnostic imaging by 20%.

5.2 Association between factors and knowledge of radiation exposure

5.2.1 Association between level of experience of medical practitioners in HPUPM and the knowledge of radiation exposure in common radiological investigations

Based on a previous study done by Lee et al (2012), it was proven that there was no association between level of experience with knowledge of radiation exposure as senior radiologists were observed to have a poorer performance than junior radiologists. Another study by Thomas et al also noted that there was no significant performance difference between those who had years of clinical experience and those who did not have experience. In a study about radiation safety awareness among medical staff by Szarmach et al (2015), working experience was not significantly important as the study showed participants with one to five years of experience achieved the highest percentage of correct answers (73%). Whereas, those who had 11 - 15 years of experience scored the lowest percentage of correct answers (14%).

In contrast, our study proved that there was a significant association between medical practitioners with high levels of experience and their knowledge on radiation exposure. This was proven as the P value is less than 0.05 (0.041) and the second highest knowledge level was among the medical practitioners who had more than 20 years of working experience (42.9%). Fifty percent of medical practitioners who had level of experience of less than three years showed the highest results of knowledge level and this could be due to reasons such as the medical practitioners with less than 3 years of working who answered questionnaire in our study had recently attended a practical training session on radiation protection knowledge and radiation dose assessment, or are from the radiological department in HPUPM. Therefore, they are able to answer the questions correctly and obtain high marks in the questionnaire. From our study, it was also shown that the majority of HPUPM medical practitioners with 11 to 20 years level of experience had average knowledge level on radiation exposure (53.8%). Therefore, this result showed a significant association between level of experience and knowledge level of radiation exposure. Our findings were also supported by another study that was done by Shafiee et. al (2020) to assess the knowledge of medical professionals on radiation in interventional radiology

which clearly stated the fact that participants with low level of working experience with only one to four years before had lesser knowledge about radiation as compared to the more experienced participants (> 20 years) ($P = 0.043$). Another study by Luke et al. (2011) also found that participants who had more years of experience answered the questions more correctly and accurately compared to those with lesser experience.

Therefore from our study, we concluded that there were definitely associations between level of experience and knowledge of radiation exposure. This is because medical practitioners with high levels of experience were already exposed to radiation protection safety and radiation dose in common radiological investigations throughout their working experience. Through this, they were able to know and make judgments whether or not patients are in need of necessary radiological investigations that could be of help in the aid of diagnosis. In comparison with the medical practitioners who had just started working, they were not yet exposed or had the opportunity to learn in more details regarding radiation exposure in common radiological investigations used in HPUPM. This shows that the more experienced the medical practitioners, the more knowledge they have gained

5.2.2 Association between perceived knowledge level of medical practitioners in HPUPM and the knowledge of radiation exposure in common radiological investigations

According to our study, we found that there was a significant association between perceived knowledge level and knowledge of radiation exposure among medical practitioners as the significant value of Fisher's Exact test was $p < 0.05$. Medical practitioners who claimed to have excellent (100%) and good (54.5%) knowledge showed high levels of results. This result was also proven by a study which showed significant association between perceived knowledge level and knowledge on radiation protection (Faggioni et al, 2017).

Apart from that, the results from our study were in contrast to a study done by Sundaran et al.(2017) who concluded that perceived knowledge level was not found to be statistically significantly associated with knowledge of radiation exposure ($p > 0.05$). On the other hand, contrast of our study result was also seen in a study done on medical students' proficiency regarding hazards of radiological examination that significantly reported students who perceived as having excellent radiological knowledge achieved lower knowledge scores as compared to the other students who perceived their knowledge as average (Awadghem et al, 2020). Contrary to our results, two other researchers found that students who reported having moderate confidence in their knowledge on radiation scored better than those who were not confident with their own knowledge (Zhou et al, 2010) and (Dellie et al, 2015). Study of assessment of awareness of radiation protection and knowledge of radiation dose among 5th year medical students and radiology at Maharaj Nakorn Chiang Mai Hospital, in self rating their knowledge level related to ionizing radiation related risk, 12 (25.5%) rated their knowledge as insufficient, 11 (23.4%) rated it as good and only one (2.13%) rated their knowledge as excellent. However, there was inadequate awareness of radiation protection among the respondents. Thus, it was proven that there was no significant association between perceived knowledge level and knowledge of radiation dose. (Sripusanapan et al, 2020) .

Therefore, as study done by Faggioni et al. (2017) showed different outcome from other researches which were done by Sundaran et al.(2017) and others, we would like to use the perceived knowledge level as our variable to find the apparent association of perceived knowledge level of medical practitioners in HPUPM and the knowledge of radiation exposure in common radiological investigations. Thus, from the result that we obtained we concluded that there was an actual association of perceived knowledge level and the knowledge of radiation exposure in common radiological investigations among medical practitioners in HPUPM.

We obtained such results from our study was probably due to the medical practitioners in HPUPM know their level of knowledge on radiation exposure in common radiological investigations well. Those who assume to have adequate knowledge level will normally carry out their radiation related work with more confidence, therefore causing lesser error that may boost their confidence of having high knowledge in their medical field . On the other hand, for those who perceive to have insufficient knowledge, they often know their limitation in knowledge of radiation exposure and will try to catch up with medical practitioners who are equipped with adequate knowledge on radiation exposure in common radiological investigations. Besides that, previously made errors in the medical practice related to radiation due to low knowledge on radiation exposure might also give the medical practitioners the feeling that they are not well trained or not well equipped with adequate knowledge related to their medical career.

5.2.3 Association between practical training among medical practitioners in HPUPM and the knowledge of radiation exposure in common radiological investigations

Based on a previous study to assess the knowledge and practice of medical professionals on radiation protection in interventional radiology(2020) by Mohsen Shafiee, the difference between radiation protection knowledge and practice between the physicians who received more practical training courses in the workplace or their educational curriculum and nurses was statistically significant ($P = 0.041$). In another study by Barnawi et al, it was again proven significantly that doctors who had formal practical training on radiation exposure and protection before were more knowledgeable regarding ionizing radiation that indicate a potential lifetime risk of developing cancer ($p=0.028$) and the risk of imaging on fetus ($p=0.024$). Doctors with formal training answered three out of four questions more correctly than doctors without formal training too.

Similarly, there was a significant association between practical training and knowledge of radiation exposure among HPUPM medical practitioners ($p<0.05$). The medical practitioners who frequently attended practical training had the highest level of radiation exposure knowledge (66.7%) among all categories. This proved that practical training does significantly affect the medical practitioners' knowledge on radiation exposure. On the other hand, 41.7% of medical practitioners that never attended any practical training had the average and lowest level of knowledge on radiation exposure which was the highest percentage. This value can be relied on even more since the total number of medical practitioners who never attended any practical training was the most ($N= 72$). A study done by McCusker et al (2009) also proved that interns and practising doctors performed significantly better than medical students. Zhou et al (2010) noted that interns performed significantly better than the medical students who had never attended practical training. Besides, Soye and Paterson (2008) also said that the 52 doctors who had received formal training about ionizing radiation scored higher than those with no previous training in this area ($p = 0.003$). In other words, agreeing that there was a significant association between formal training and awareness of radiation dose.

Based on this, most previous research obtained a similar significant association between practical training and knowledge of radiation exposure among medical practitioners. This indicates that knowledge on radiation exposure needs to be refreshed from time to time. Hence, it is advisable for HPUPM to focus on developing the skills of its medical practitioners to be well equipped with the best and latest knowledge on radiation exposure. This way, they can produce well trained medical practitioners that can avoid making unnecessary errors.



Chapter 6

Conclusions and Recommendations

6.1 Conclusion

Generally, the respondents (37.3%) had average knowledge on radiation exposure in common radiological investigations. Knowledge of radiation exposure was found to be significantly associated with all the factors such as level of experience, perceived knowledge level and practical training.

6.2 Limitations

Our study only focused on the medical practitioners of Hospital Pengajar Universiti Putra Malaysia (HPUPM), hence the validity of this study was limited only to the medical practitioners of HPUPM. Therefore, the outcome of this research cannot be generalised to represent the medical practitioners of other universities and hospitals in Malaysia. This factor influences the result obtained in this study as the findings cannot be generalised to represent the public. Other than that, our study was a cross-sectional study. The limitation of this type of study is that we were not able to determine the causal relationship. Lastly, we only found the association between knowledge of radiation exposure in common radiological investigations with only three factors such as level of experience, perceived knowledge level and practical training.

6.3 Study Strengths

The strength of this study was to avoid bias in the data by doing the random sampling method in choosing participants of this study. Moreover, this study had a representation of mixed specialities and occupation, thus it represented the population of study well in hospital.

6.4 Recommendation

6.4.1 Recommendations for future researcher

For future studies, we would like to recommend a conduction of a study that does not only involve medical practitioners from HPUPM but to involve other hospitals in Malaysia. This will allow an increased number of the respondents and are able to determine the knowledge of radiation exposure in common radiological investigations among Malaysian medical practitioners.

Furthermore, other factors that were not yet studied in this research such as educational level and occupations should also be included. This will allow the future researchers to determine the association between knowledge of radiation exposure to not only for perceived knowledge level, level of experience and practical training but for other factors as well.

Lastly, other types of study designs like cohort study or interventional study could also be carried out and are recommended for future research as cross sectional study could not determine the cause and effect relationship.

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Appendices

Appendix A - Work Plan Gantt Chart

No.	Activities	Time (2021)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec (2020)
1.	Preparation of proposal	✓											✓
2.	Submission of proposal	✓											
3.	Proposal presentation	✓											
4.	Preparation of ethical approval/ Letters to respective organization		✓	✓									
5.	Data Collection and Analysis				✓	✓							
6.	Submission of data analysis report					✓							
7.	Report writing and poster preparation						✓						
8.	Submission of final report and scientific articles						✓						
9.	Poster presentation						✓						
10.	Preparation for final presentation						✓						
11.	Final presentation						✓						
12.	Submission of logbook							✓					

Appendix B: Milestone

DATE	RESEARCH PROJECT ACTIVITY	CUMULATIVE COMPLETION (%)
20/12/20-14/01/21	Proposal Preparation and Meeting with Supervisors	100
15/01/21	Submission of Proposal to Module Coordinator (2 copies before 9 a.m)	100
16/01/21-20/01/21	Preparation for Proposal Presentation	100
21/01/21	Proposal Presentation (2-5 p.m)	100
29/01/21	Submit Documents for JKEUPM (NMRR submission done earlier)	100
01/03/21-15/03/21	Commencement of Semester II and Data Collection	100
31/05/21	Submission of Final Report to Module Coordinator (2 copies before 3 p.m)	100
14/06/21	Final Report Presentation	100
21/06/21	Submission of Poster and Scientific Article (Before 3.pm)	100
28/06/21	Poster Competition	100
05/07/21	Submission of Log Book and Hard Bound Copies of Final Report (Before 12 a.m)	100

Appendix C: Budget Planning

No	Items	Estimated cost
1	Printing	RM60.00
2	Hand Cover and Binding Thesis	RM100.00
TOTAL		RM160.00



Appendix D - Questionnaires

KNOWLEDGE OF RADIATION EXPOSURE IN COMMON RADIOLOGICAL INVESTIGATIONS AMONG HPUPM MEDICAL PRACTITIONERS

Researchers:

FARAH HUSNA BINTI MULIADI

011-23099249

SOO JING XUAN

011-20730509

JAHNAVII SHAKTI A/P SRITHAR

012-2201906

Section 1 - Personal details

1. Your gender:

- Male
- Female

2. Your age: _____

3. What is your level of experience?

- Less than 3 years
- 4 to 10 years
- 11 to 20 years
- More than 20 years

4. Which is your knowledge level about ionising radiation-related risks?

- Excellent
- Good
- Sufficient
- Insufficient

5. Have you ever attended training events and/or refresher courses on radiation protection?

- Yes, frequently
- Yes, seldom
- No, never

Section 2 - Radiation protection knowledge

1. According to current Malaysian legislation, is it necessary to advise patients about the risks related to the use of ionising radiation for medical purposes?

- Yes, always
- Yes, but only for patients younger than 18 years old
- Yes, but only for patients who are going to have a CT scan
- Yes, but only for patients younger than 65 years old
- No, never

2. Which of the following patients is the most sensitive to ionising radiation?

- 1-year-old male
- 1-year-old female
- 20-year-old female
- 40-year-old male
- ionising radiation damage risk is unrelated to patient's age and sex

3. Which one of the following professionals is considered legally responsible (in Malaysia) for unnecessary exposure to ionising radiation and/or improperly performed radiological examinations?

- Only the referring physician
- Only the radiologist
- Only the medical specialist (other than radiologist) performing interventional radiology procedures
- Only the radiographer
- All answers are correct

4. Which one of the following professionals are more likely to be exposed to ionising radiation because of their job?

- Nuclear medicine physicians
- Radiographers
- Interventional cardiologists and radiologists
- Non-interventional radiologists
- Surgeons

5. Which of the following tissues is more susceptible to ionising radiation-related damage?

- Kidney
- Breast
- Bone
- Liver
- Muscle

6. Which of the following diseases may be a result of stochastic radiation damage?

- Dermatitis
- Leukaemia
- Alopecia
- Cataract
- All answers are correct

7. Which of the following best describes the concept of “dose optimisation”?

- Ionising radiation-based examinations should be prescribed and performed only when indispensable
- The dose delivered by ionising radiation-based examinations must be kept as low as reasonably achievable, consistent with obtaining the required diagnostic information
- The scan volume for ionising radiation-based examinations should be as large as possible, so as to maximise diagnostic information from a single acquisition
- An ionising radiation-based examination is optimised when spatial and contrast resolution are maximised to assess even the finest image details
- All answers are correct

Section 3 - Radiation dose assessment

(For each question, dose refers to an examination performed with state-of-the-art equipment)

1. Which is the average radiation dose of a PA chest radiograph?

- Less than 0.01 mSv
- 0.01 – 0.1 mSv
- 0.1 – 1 mSv
- 1 – 10 mSv
- 10 – 100 mSv
- More than 100 mSv

2. If a PA chest radiograph counts as 1 unit, how much is the average dose due to natural background radiation in Malaysia?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

3. If a PA chest radiograph counts as 1 unit, how much is the average dose due to a lumbar x-ray examination?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

4. If a PA chest radiograph counts as 1 unit, how much is the average dose due to mammography (bilateral, two projections each, i.e. four images in total)?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

5. If a PA chest radiograph counts as 1 unit, how much is the average dose due to a non-contrast chest CT examination?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

6. If a PA chest radiograph counts as 1 unit, how much is the average dose due to a pelvis MRI examination?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

7. If a PA chest radiograph counts as 1 unit, how much is the average dose due to a whole body PET-CT examination?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

8. If a PA chest radiograph counts as 1 unit, how much is the average dose due to an abdominal ultrasound examination?

- 0
- 1 – 10
- 10 – 50
- 50 – 100
- 100 – 500
- more than 500

Appendix E: Respondent Information Sheet and Consent Form



UPM
UNIVERSITI PUTRA MALAYSIA

**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

FORM

2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE:

Knowledge of radiation exposure in common radiological investigations among HPUPM Medical Practitioners

2. INTRODUCTION:

This study is an undergraduate research project that will be conducted from the 20th of December 2020 to 5th July 2021. It involves all medical practitioners from HPUPM which includes specialists and medical officers. The number of respondents needed in this study are approximately 130. This study will be carried out in order to determine the knowledge of radiation exposure in common radiological investigations among all medical practitioners in HPUPM

3. WHAT WILL YOU HAVE TO DO?

Respondents will be asked to fill up the questionnaire that has 3 main sections. This includes section 1 which is regarding the personal details of the respondents, Section 2 which is regarding the knowledge on radiation protection, and Section 3 which is regarding the radiation dose assessment. Respondents are allowed to stop answering the questionnaire at any point of time. **The respondents have the right to decline participation and this would not jeopardize their work/ethics.**

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Respondents who do not fulfil the criteria needed to participate in this study will not be participating in this study.

- Medical practitioners who are currently not in HPUPM eg. sabbatical leave, study leave etc.
- Medical practitioners who got transferred, resigned or retired from HPUPM
- Medical practitioners who disagree to participate in the study.

5. WHAT WILL BE THE BENEFITS OF THE STUDY?

(a) TO YOU AS THE SUBJECT?

The respondent's participation will help the researchers to investigate the knowledge of radiation exposure in common radiological investigations among medical practitioners in HPUPM. Through this, respondents will be able to be more aware of the appropriate steps that can be taken in minimizing the amount of radiation exposure from common radiological investigations. Through the findings of this study, respondents may also be able to develop a new strategy to reduce the unnecessary radiation exposure. Respondents will not be charged with any expenses regarding the participation in this study.

(b) TO THE INVESTIGATOR?

Data that will be collected in this study will help the researchers to study the factors associated with the knowledge of radiation exposure in common radiological investigations. The investigators will not be participating in this study and will only act as the investigator.

6. WHAT ARE THE POSSIBLE RISKS?

There will be no possible risks towards the respondents who had decided to participate in this study. This study will be conducted online without any face to face interaction. The data collected from the respondents in this study will strictly remain confidential.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

Any information or data given by the respondents will be kept private and confidential. Study monitor(s), auditor(s), the JKEUPM Ethics Review Panel, and regulatory authorities will be granted direct access to your data **ONLY** for verification of clinical trial procedures and data purposes. This study had been approved by the JKEUPM ethics review panel.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

Any information regarding this study, the respondents may contact any of the number below:

- | | |
|--------------------------------|--------------|
| ● Dr Suzana binti Ab Hamid | 019-6156079 |
| ● Dr Norafida binti Bahari | 019-3225254 |
| ● Farah Husna Binti Muliadi | 011-23099249 |
| ● Soo Jing Xuan | 011-20730509 |
| ● Jahnnavii Shakti A/P Srithar | 012-2201906 |

Please initial here if you have read and understood the contents of this page_____

9. CONSENT

I Identity Card No.
address.....
.....hereby voluntarily agree to take part in the research stated
above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature Signature
(Respondent) (Witness)

Date : Name :
I/C No. :

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date Signature
(Researcher)

Appendix F: Approval Letter

Ref. no: UPM/TNCPI/RMC/JKEUPM/1.4.18.2 (JKEUPM)

Date: 4 April 2021

Dear Prof./Dr./Mr./Ms.,

APPLICATION FOR JKEUPM ETHICAL CLEARANCE: APPROVED

With reference to the above, I am pleased to inform you that your application for ethical clearance for the research project entitled 'Knowledge of Radiation Exposure in Common Radiological Investigations among HPUPM Medical Personnel' has been approved.

Please note that the official letter of approval will be issued as soon as possible. However, the ethical clearance is considered effective from the date of this email, and you may now proceed with your research.

Kindly remind the ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.

Researchers should also complete a Study Final Report upon study completion. The form can be obtained from the Ethics Committee for Research Involving Human Subjects (JKEUPM) website (<http://www.tncpi.upm.edu.my/faildokumen>).

If you have any enquiries, please contact Ms. Nurulhasanah Ishak (03-97691605) or Ms. Nor Ellia Abd Ajis (03-97691244).

Note: Please use this reference number for any transaction.

- JKEUPM-2021-113

Thank you.

Yours faithfully,

Prof. Dr. Zamberi Sekawi
Chair
Ethics Committee for Research Involving Human Subjects
Universiti Putra Malaysia

Appendix G: Study Final Report Form



**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

FORM 3.2 STUDY FINAL REPORT

1.	JKEUPM Ref. No.	JKEUPM-2021-113
2.	Study Title	Knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners
3.	i. Principal investigator a. Name b. Address c. Tel.No d. Email ii. List of co-investigators	I. Principal Investigator a. Dr. Suzana Ab Hamid b. Department of Imaging, Faculty of Medicine and Health Sciences, University Putra Malaysia c. Tel: 03-89472511/12 Fax: 03-89426957 d. suzana@upm.edu.my II. List of co-investigators 1. Dr. Norafida Bahari 2. Farah Husna Binti Muliadi 3. Soo Jing Xuan 4. Jahnnavii Shakti A/P Srithar
4.	Name Of Funding Agency	-
5.	Study Site	Hospital Pengajar Universiti Putra Malaysia (HPUPM)
6.	Total number of eligible subjects in study site	368

7.	<p>Recruitment of subjects in study site</p> <p>i. Number of participants recruited:</p> <p>ii. Number of participants completing trial/ study:</p> <p>iii. Proposed in original application:</p> <p>iv. Number of withdrawals from trial to date due to:</p> <p style="padding-left: 20px;">a) withdrawal of consent</p> <p style="padding-left: 20px;">b) no response from participants</p> <p style="padding-left: 20px;">c) loss to follow-up</p> <p style="padding-left: 20px;">d) death (not the primary outcome)</p> <p>Total study withdrawals:</p> <p>v. Number of treatment failures to date (Prior to reaching primary outcome) due to:</p> <p style="padding-left: 20px;">a) adverse events</p> <p style="padding-left: 20px;">b) lack of efficacy</p> <p>Total treatment failures:</p>	<p>i.130</p> <p>ii.110</p> <p>Iii.130</p> <p>Iv:</p> <p style="padding-left: 20px;">a) 0</p> <p style="padding-left: 20px;">b) 20</p> <p style="padding-left: 20px;">c) 0</p> <p style="padding-left: 20px;">d) 0</p> <p>20</p> <p>V. 0</p> <p>0</p>
8.	Duration of study	<p>The study duration was separated into two phases. The first phase was from 20th of December 2020 to 25th January 2021 where proposal preparation, proposal presentation and submission of documents for JKEUPM took place. The data collection started in the second phase of conducting this study which was from 1st March to May 2021</p>
9.	Protocol Violation or Deviation	-

<p>10.</p>	<p>Executive summary (Summary of research background, objectives, methodology, findings and conclusion of the research project) - maximum 500 words)</p> <p>*Committee may request additional information if required.</p>	<p>Summary of research background: Radiation is one of the mostly investigated causes of diseases around the world. Radiography has changed over the years. However, our challenge is to use radiography mindfully to avoid unnecessary radiation-related investigations from being carried out for the patients. Hence, many studies have been done in the past to assess the level of knowledge on radiation exposure among medical practitioners who are involved in requesting and performing radiological investigations.</p> <p>Objective: This study aimed to determine the relationship between the level of experience, perceived knowledge level and practical training with knowledge of radiation exposure in common radiological investigations among HPUPM medical practitioners.</p> <p>Materials and Methods: A cross-sectional study was conducted among the clinical specialists and medical officers of ‘Hospital Pengajar Universiti Putra Malaysia’ (HPUPM) in 2021. The data of the study was analysed with IBM Statistical Package for the Social Science (SPSS) version 26.0. The data was analysed based on descriptive and analytical analyses.</p> <p>Results: Majority of respondents were medical practitioners who had four to ten years of experience and claimed to have sufficient knowledge on radiation exposure in common radiological investigations. Majority of them had never been to any sessions of practical training regarding ionizing radiation. It was found that the level of knowledge on radiation exposure among HPUPM medical practitioners was average. There were a statistically significant association between all the factors (level of experience, perceived knowledge level, practical training) and knowledge of radiation exposure in common radiological investigations.</p> <p>Conclusion: The respondents (37.3%) had average knowledge on radiation exposure in common radiological investigations. Knowledge of radiation exposure was found to be significantly associated with all the factors such as level of experience, perceived knowledge level and practical training.</p>
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