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RADIATION RISK ESTIMATION FROM OCCUPATIONAL MEDICAL IMAGING EXPOSURE IN MALAYSIA

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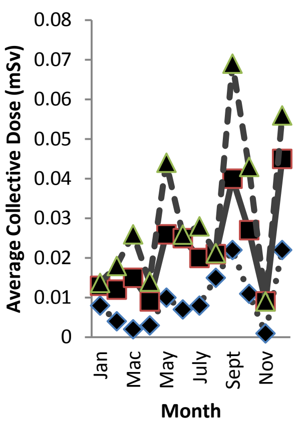
Graphical abstract



Abstract

Ionizing radiation has been increasingly applied in medicine and firmly established as an essential tool for diagnosis. There is high possibility for medical radiation workers to receive doses that are considerably higher than recorded by their dosimeters due to lack of knowledge about ionizing radiation, lack of training in radiation protection, and attitude of the workers themselves toward radiation protection. The purpose of this study is to estimate the radiation risk due to occupational exposure to ionizing radiation among medical diagnostic workers at hospitals in Malaysia. Also the objective is to determine the knowledge of occupational radiation exposure and radiation safety among the workers. The assessment was made based on the collective doses collected from film badge of the workers. The results of risk assessment show the mean annual collective effective dose based on type of X-ray procedure in this study was 5.445mSv, which is much lower compared to the whole body exposure dose limit, set by the ICRP Publication 60. A survey on knowledge of occupational radiation exposure and radiation safety was conducted using questionnaire and it was found that vast majority of respondents were aware of radiation safety with 91.3% answered the specific questions regarding radiation protection at workplace correctly. Unfortunately only 30.4% of the respondents fully understand the hazard they are exposed to. The study reveals that there is a critical need to educate not only medical radiation workers but also medical doctors and nurses to decrease unnecessary occupational exposure to radiation hazard.

Keywords: Ionizing radiation, occupational radiation exposure, film badge

Abstrak

Penggunaan sinaran mengion dalam perubatan semakin meningkat dan menjadi peralatan penting dalam bidang pengimejan. Terdapat kebarangkalian bagi pekerja sinaran perubatan menerima dos yang tinggi dari nilai yang direkodkan oleh dosimeter kerana kurangnya pengetahuan berkaitan sinaran mengion, kurang latihan dalam perlindungan sinaran serta sikap pekerja itu sendiri terhadap perlindungan sinaran. Tujuan kajian ini adalah untuk menganggar risiko sinaran akibat dari pendedahan sinaran pekerjaan terhadap sinaran mengion dikalangan pekerja perubatan di beberapa hospital di Malaysia. Selain itu, objektif kajian ini juga adalah untuk menentukan tahap pengetahuan pendedahan sinaran pekerjaan serta keselamatan sinaran dikalangan pekerja. Penilaian risiko dibuat berdasarkan kutipan dos dari lencana filem pekerja. Keputusan penilaian risiko menunjukkan purata tahunan bagi dos efektif terhadap prosedur penggunaan sinar-X adalah 5.445mSv, yakni lebih rendah berbanding dengan had dos pendedahan terhadap seluruh badan, yang telah ditetapkan oleh Penerbitan 60, ICRP. Kaji selidik berkaitan pengetahuan pendedahan sinaran pekerjaan dan keselamatan sinaran telah dijalankan menggunakan soal selidik dan mendapati hampir kesemua pekerja yang terlibat sedar akan keselamatan sinaran dimana 91.3% menjawab dengan betul bagi soalan berkaitan perlindungan sinaran di tempat kerja. Walaubagaimana pun, hanya 30.4% pekerja yang terlibat faham mengenai bahaya yang mereka hadapi. Kajian ini membuktikan terdapat keperluan yang kritikal untuk meningkatkan pengetahuan bukan sahaja pekerja sinaran malah doktor perubatan dan jururawat bagi mengurangkan pendedahan pekerjaan terhadapa bahaya sinaran.

Kata kunci: Sinaran mengion, pendedahan sinaran pekerjaan, lencana filem

1.0 INTRODUCTION

Ionizing radiation has been increasingly applied in medicine as essential tool for diagnostic and therapy [1]. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [2], based on physician densities, Malaysia was classified as a level II country where the population to physician ratio was 1402:1 in year 2004 [3]. In 1994, a total of 3.6 million X-ray examinations were performed in Malaysia and 63% of the total was contributed by chest examinations [3]. Medical radiation was the largest man-made source of public exposure to ionizing radiation. Even though the doses from diagnostic radiology examinations are generally low, but the exposures of workers to the doses are continuous due to the continuing needs for radiological based procedures in hospitals.

Since it is was first discovered, the fact that ionizing radiation offers tremendous benefits to human population are widely accepted especially in medical field [4]. However as ionizing radiation may cause adverse impacts to health, it is therefore necessary to consider additional protection for workers from the potential harm. The most common health problem related to radiation exposure is cancer, where it has been widely studied and documented by other researchers [2-4]. In a report by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [5], regarding biological effects at low radiation doses, UNSCEAR have classified ionizing radiation as carcinogenic.

Aside from the exposure risk, another issued commonly debated is the level of knowledge in radiation protection among the associated workers. Several studies have been conducted on radiation risk estimation for example estimation of radiation exposure and radiation risk from film badge wore by employees at interventional radiological procedures at public hospital in German [6]. The result calculated for effective dose among physicians wearing lead apron was 1.7mSv per year. While the effective dose received by physicians without lead apron was 3.5mSv per year. From the estimated annual effective dose, a lifetime dose of 68mSv was estimated for a 40 years of working career. While the corresponding lifetime risk for induced cancer due to radiation exposure was determined to 0.3% by applying the risk factor by ICRP.

Meanwhile a study on awareness of radiation safety among medical radiation workers had been conducted for example at Mulago Hospital, Kampala, Uganda [7]. The study was done through interviews using questionnaires to the radiation workers. The result reported, around 68.2% from the total respondents have a basic knowledge about radiation safety before they started working with radiation. It was noted that radiation workers that participated in the study were well informed about radiation hazard and its safety. Another relevant study conducted was to assess the radiation protection awareness among medical radiation technologists at three major hospitals in Peshawar, Pakistan. The result found that about 20-35% from the total of participants has better knowledge in radiation awareness at workplace. While about 50% from the total participants have no knowledge on radiation safety [8]. Study on medical radiation exposure in Malaysia has been conducted by the Ministry of Health (MOH) at 437 public and private hospitals, medical centers and also 329 public and private dental clinics in Malaysia [9]. A questionnaire was designed for use in a survey which consists of questions related to the application of radiological procedures and practices, radiation safety at workplace and doses received by a patient during treatment. The typical doses received by patient also were measured using thermo-luminescent dosimeter (TLD) and the effective doses were then calculated accordingly using mathematical formula. Unfortunately, the study did not focus on occupational radiation exposure received by the workers. Such study is still lacking for Malaysian scenarios but very much in need in order to serve as input when decisions are to be made in selecting the type and level of counter measures to be taken for radiation safety.

Therefore the purpose of this study is to estimate the radiation risk due to the occupational exposure to ionizing radiation based on the collective dose data collected from workers' film badge. Besides that, this study aims to determine the level of knowledge on occupational radiation exposure and radiation safety among medical diagnostic workers at hospitals in Malaysia. Due to the difficulties in getting permission from hospitals to conduct the study, the study involved three major government hospitals only - two main state hospitals (Hospital Sungai Petani and Hospital Sultan Ismail) and one suburban hospital (Hospital Kulim). The study involved radiation workers at the Radiology Department of each hospital.

2.0 METHODOLOGY OF THE STUDY

The methodology for this study is divided into two sections: first is the methodology for estimating the occupational radiation exposure risk received by participants. Meanwhile the second section is the methodology for identifying the knowledge of ionizing radiation hazard and radiation safety among the participants.

2.1 Estimation of Occupational Radiation Risk

Data for this study were collected from three government hospitals,in Malaysia which are Hospital Sungai Petani, Kedah, Hospital Kulim, Kedah and Hospital Sultan Ismail, Johor. Two of them are located in urban area (Hospital Sungai Petani and Hospital Sultan Ismail) whereas the other one (Hospital Kulim) is in suburban area. The hospitals were selected because they are among those very minor ones that gave permission for the study. Also it is possible to compare the results between urban and suburban-located hospitals.

It is well-known that in medical practice, X-ray is frequently used for diagnostic purposes. The wide range of medical X-ray equipments in modern diagnostic radiology has led to faster and better diagnoses of large proportion of diseases. Since X-ray examinations are the most frequently used ionizing radiation in medicine, they become the most significant source of medical radiation exposure globally [9]. Therefore, medical diagnostic using X-ray has been chosen as the radiation source in this study. Medical diagnostic using X-ray commonly consists of activities such as general/plain X-ray, mammography, fluoroscopy, computed tomography (CT) and dental radiography.

The data on the annual dose received by workers participated in this study in all the three hospitals is based on that recorded using film-badge reading between January to December 2012 (the only data available for all the three hospitals). Film badge is an economic method to measure the whole body exposure, which offers a very good feature for research and monitoring purposes, that is the provision of permanent record of the doses in the form of processed film. All the registered radiation workers were assigned a code number, which were punched on their films as shown in Figure 1. The code number provides information on the duration of use of the badge, user establishment and identity of the worker personnel (e.g. the worker's staff number). It is a globally accepted practices to ensure all workers are wearing the film badge at the chest level under the lead apron they are wearing to estimate the actual whole-body dose. The worn/used films are dispatched from the user (hospital) to the Secondary Standard Dosimetry Laboratory (SSDL) at the Agency Nuclear Malaysia (MINT) by registered postal service on regular interval for film processing to measure the monthly dose received by workers.

Figure 1 Film badge holder.

In Malaysia, the Agency Nuclear Malaysia or previously known as MINT is responsible for the provision of personal dosimeter service at both local and national level for the measurement of occupational exposure to radiation hazard among workers and subsequently risk assessment. About 75% of the personnel dosimeter processing services done by SSDL involved film badge (FB) dosimeter and the remaining are by thermo luminescent dosimeters (TLD). However this study covers the workers' exposure measurement by film badge only because almost all of the participants are wearing film badge as personnel monitoring equipment instead of the TLD.

The measurement records available for all the three hospitals for the same period of time is only for year 2012 (12 months data). The data involved a total of 46 workers - 22 workers from Hospital Kulim, 10 workers from Hospital Sungai Petani and 14 workers from Hospital Sultan Ismail. The doses recorded on the film badges of each wearer were transcribed from the dose report cards and compiled into Excel spread sheets for analysis.

2.2 Survey on Radiation Knowledge and Radiation Safety

In order to assess knowledge of the workers who are dealing with radiation hazards, a survey was conducted using a set of carefully designed questionnaire. The questionnaire is divided into four parts with the first part requires information on the workers' demographic data. The second part mainly examines the general understanding of workers on ionizing radiation hazard, the third part evaluates workers' knowledge on the potential adverse health effects due to the exposures whereas the last part is on radiation safety. The questionnaire were distributed to the workers in each hospital by hand to ensure high return rate of respondents, and this process alone took almost four months to complete. Workers were not allowed to refer to any reading materials or information sources when completing the questionnaire. The collected data from the survey were analyzed using the statistical package for social sciences (SPSS) version 21.00.

3.0 RESULTS AND DISCUSSIONS

Similar to the Methodology as presented in Section 2, the result and discussion of this paper are also divided into two sections. The first section presents the result of the collective dose received by workers as well as the associated risk of exposure. Meanwhile the second part presents the result of the survey conducted on radiation safety.

3.1 Radiation Exposure Risk Estimation

Basically this sub-section presents and discusses the risk assessment due to radiation exposure under study. However in order to reach to that, the collective doses received by the workers first need to be determined. Figure 2 presents the monthly average collective dose of radiation exposure received by workers in all the three hospitals for year 2012. From here, the annual average collective dose for each hospital can be calculated which are 0.207mSv, 0.087mSv and 0.172mSv for Hospital Kulim, Hospital Sungai Petani and Hospital Sultan Ismail respectively. The dosage may be contributed by various activities in those hospitals involving ionizing radiation such as computed tomography, education and research, mammography, fluoroscopy, dental, plain radiography etc. From all of the activities using X-ray in medical diagnosis, 66% of activities involved with plain radiography.

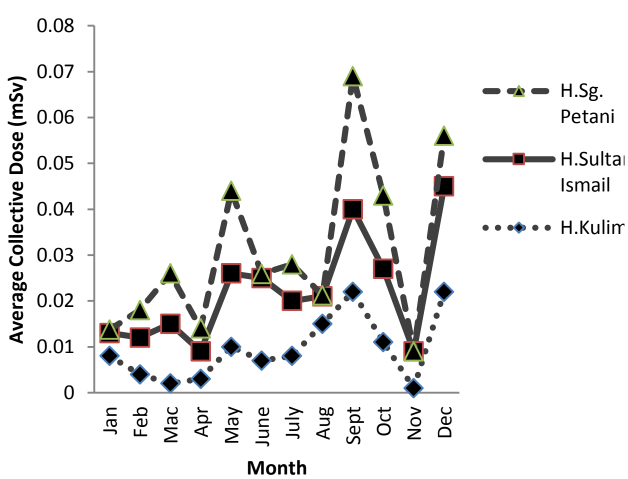


Figure 2 Distribution of the monthly average collective dose received by workers for each hospital in year 2012.

In practice, single film badge is normally placed outside the apron of the wearer at collar level. This is to monitor exposure to head, lens of the eye and neck. The second function of film badge is to monitor the effectiveness of lead apron. The value recorded from film badge was used to calculate the value for equivalent dose (H) using Equation 1. Unit for the equivalent dose is mSv. The International Commission on Radiation Units and Measurements (ICRU) defines equivalent dose as *"an amount of radiation dose that takes the damaging properties of different types of radiation into account"*[10]. Equivalent dose is an expression used to assess how much biological damage is expected from the absorbed dose (D) received by a person. The value of absorbed dose is not calculated but instead, provided by the SSDL following their analysis on the film badge. Generally ionizing radiation consists of different types of radiation source such as photon, electron, neutron, proton, alpha particle and heavy nucleus. In order to calculate the value of equivalent dose (H), the ICRU has set specific score for different types of ionizing radiation which is known as radiation weighting factors, W_R[10]. This is to acknowledge the fact that different types of radiation have different damaging properties when being absorbed by human tissue.

$$H = D \times W_R \qquad (1)$$

where H is the equivalent dose (mSv), D is the absorbed dose from the analysis of the film badge reading (mSv) andW_R is the radiation weighting factors provided by the ICRU.

The value of the equivalent dose is then used to calculate the Effective Dose (E) using Equation 2. Unit for effective dose is mSv. Effective dose was introduced by ICRP to provide a summation of radiation doses to tissues and organs for radiological protection. Effective dose is an expression to assess the potential for long-term effects that might occur in the future due to radiation exposure.

$$E = \sum W_T H_T \qquad (2)$$

where E is the effective dose (mSv), W_T is the tissue weighting factors provided by the ICRP report 60 and H_T is thetotal of the equivalent dose (H) for all radiation types (i.e. photon, electron etc.)

W_T are dimensionless tissue weighting factors that characterize the relative sensitivity of various tissues with respect to the endpoints, such as cancer induction. Twelve tissues and organs are specified in the ICRP report 60 [11].

For this particular study, the calculated values for the effective dose (E) and equivalent dose (H) are presented in Table 1. The average annual effective dose received from diagnostic radiology procedure in year 2012 for the three hospitals is 1.815 mSv. The average effective dose received per person is 0.118 mSv. The total collective radiation dose received by workers at Hospital Kulim is 2.329 mSv, which is the highest compared to the other two major hospitals. This is due to the fact that the number of workers involved is the highest (22 out of total 46 workers from all the three hospitals).

Table 1 Value for effective dose (E) and equivalent dose (H) received by respondents for each hospitals in year 2012.

	Effective Dose, (E) (mSv)	Equivalent Dose, (H) (mSv)			
		Photon	Electron	Proton	Alpha
HK	2.329	2.329	2.329	11.645	46.580
HSP	1.048	1.048	1.048	5.240	20.960
HSI	2.068	2.068	2.068	10.340	41.360

*HK-Hospital Kulim
HSP-Hospital Sungai Petani
HSI-Hospital Sultan Ismail

For Malaysia, the Basic Safety Radiation Protection (BSRP) Regulation 2010 in Atomic Energy Licensing Act 1984 [18,19] has established the dose limit for whole body exposure for occupational application which is based on the recommendation of the ICRP 60, 1990. The limit has been set as 20 mSv/year with averaged over a defined period of 5 years. Mind that the effective dose shall not exceed 50 mSv/year in any single year. From the result of this study, the dose received by the respondents is well below the annual dose limit.

Meanwhile for the differences types of X-ray diagnosis examination, plain radiography has recorded as the highest value of dose received by workers. The average dose recorded is 0.225 mSv in year 2012. The reason is among the examinations performed in the hospitals, around 66% of the activities involved plain radiography (the most frequent procedure conducted almost daily in hospitals). Among the activities that require the application of plain radiography are examination of skull, abdomen, chest poster-anterior and chest lateral. Such situation is also mirrored in other countries e.g. in Ethiopia where almost 54% of the examinations done in hospitals involve plain radiography [14].

Now the probability of cancer induced due to radiation exposure received by the respondents in this study can further be calculated using Equation 3 [12]. The ICRP proposes a value of 5% per Sv of the standard population to estimate fatal cancer risk from the effective dose calculated for the workers.

$$\text{Probability of Fatal Cancer Risk} = 0.05 \times E \qquad (3)$$

where E is the effective dose (mSv).

Table 2 The estimated cancer risk based on the ICRP fatality risk for each hospital.

Type of examination	Weighting factor, W_R	Total collective effective dose (mSv)	Estimated cancer risk in 2012 (%)
		HK	
Photon	1	2.33	0.12
Electron	1	2.33	0.12
Proton	5	11.65	0.58
Alpha	20	46.58	2.33
Total	27	62.89	3.15
		HSP	
Photon	1	1.05	0.05
Electron	1	1.05	0.05
Proton	5	5.24	0.26
Alpha	20	20.96	1.05
Total	27	28.3	1.41
		HSI	
Photon	1	2.07	0.10
Electron	1	2.07	0.10
Proton	5	10.34	0.51
Alpha	20	41.36	2.07
Total	27	55.84	2.78

*HK-Hospital Kulim
HSP-Hospital Sungai Petani
HSI-Hospital Sultan Ismail

Table 3 The estimated cancer risk based on the ICRP fatality risk based on type of examination.

Type of examination	Total collective effective dose in 2012 (mSv)	Estimated cancer risk in 2012 (%)
Education/research	0.009	0.00045
Mammography	0.018	0.0009
Computed tomography	0.034	0.0017
Fluoroscopy	0.031	0.00155
Dental	0.0015	0
Plain radiography	0.225	0.001125
Others	0.012	0.0006
Total	0.33	0.006

There are various types of radiation sources used in medical imaging including photon (γ-ray), electron (X-ray), proton (heavy particle radiation) and alpha. However, at the moment, alpha is the only source used in radiation therapy. Therefore, the estimation of fatality cancer risk in this study only involves photon, electron and proton. Based on the fatality cancer risk of 5% per Sv in the three hospitals under study (Table 2), approximately there is a possibility of one fatal case of cancer (11.65man.Sv × 5% perSv) for Hospital Kulim and one fatal case of cancer (10.34man.Sv × 5% perSv) for Hospital Sultan Ismail. This estimation may be attributable to the diagnostic X-rays in year 2012 thatused proton as their source of radiation such as Proton Computed Tomography. While for the common radiological diagnostic such as mammography, plain radiography, Positron Emission Tomography (PET), Computed Tomography (CT) and fluoroscopy which use electron (X-ray beam) and photon (Gamma) as the sources of radiation(see Table 3), the estimation of fatality due to cancer does not show any significant risk value.

This study does only cover a one year period of duration (2012); therefore the calculated cancer risk estimation is negligible. If the duration of the study is prolonged, the probability of the risk value might increase. Such study involving the estimation of the extent of risk on the basis of the annual number of diagnostic X-rays undertaken in the UK and 14 other developed countries was done for a period of 15 years. The result indicated that in the UK alone, about 0.6% of cumulative risk of cancer may occur among the workers, which could be attributable to diagnostic X-rays [22]. This percentage is equivalent to about 70 cases of cancer per year among radiation workers in the UK.

3.2 Awareness on Radiation Safety

For this study, the sample size was 80. A total of 46 questionnaires (76.7%) were returned from 60 questionnaires sent out, with a response rate of 36.7%, 16.7% and 23.3% for Hospital Kulim, Hospital Sungai Petani and Hospital Sultan Ismail respectively. The respondents from the three hospitals are either attendance hospital (*n*=1), medical officer (*n*=2), medical physicist (*n*=1), nurse (*n*=3), physics officer (*n*=2), physiotherapist (*n*=2), radiographer (*n*=6), student (*n*=2), x-ray technician (*n*=17), x-ray therapist (*n*=6) and included with missing data (*n*=4). The demographic characteristics of respondents who participated in the survey are summarized in Table 4.

Table 4 Demographic characteristics of the respondents.

		Gender			
		Male		Female	
		N	N %	N	N %
Education background	Science	4	36.4%	7	63.6%
	Arts	0	0.0%	0	0.0%
	Engineering	0	0.0%	0	0.0%
	Medical science	13	46.4%	15	53.6%
	Others	6	85.7%	1	14.3%
Level of education	Primary/Secondary school	5	100.0%	0	0.0%
	Diploma/Degree	18	46.2%	21	53.8%
	Master/PhD	0	0.0%	2	100.0%
Working experience	0-5 years	13	46.4%	15	53.6%
	5-10 years	7	58.3%	5	41.7%
	10-15 years	1	33.3%	2	66.7%
	15 years and above	2	66.7%	1	33.3%

Each question is assigned with its own coding such as Q1, Q2 and Q3 and each of this code has its own mark that has been set using the SPSS tool. In analyzing the questionnaires, a correct answer was given one mark and for an incorrect answer no mark was given. If a question was left blank (not answered), the coding will be 99, and meaning that it is a missing case and therefore, no mark was given.

Figure 3 shows the score received by respondents for each hospital. The mean score achieved in this study was 16.67 out of 22. This indicate that the respondents capable to answer correctly half of the questions given. One of the respondents (male) who work as radiographer with working experience more than 15 years scored 22 – which mean he answered all the questions correctly.All the answers have been reviewed and verified by two professional volunteers from a private hospital who work as Senior Medical Physicists.

On the other hand, one of the respondents (female nurse) scored the lowest mark which is 8 out of 22. Based on the analysis of the questionnaire answered by the nurse, she failed to answer most of the questions related to basic knowledge of ionizing radiation, health effects of occupational radiation exposure and awareness on radiation safety. Although the respondent has basic educational background in science but she never attended any training related to radiation safety throughout her career. The respondent also stated that she never wear film badge during working in exposure room but does put on the lead gown. For some nurses, they are not regularly stay inside the exposure room during X-ray examination. They are only in the exposure room to help patients with disabilities during the X-ray examination. This shows that those who had gone through formal training on ionizing radiation have greater awareness of the risks involved, compared to those who have had never took any training.

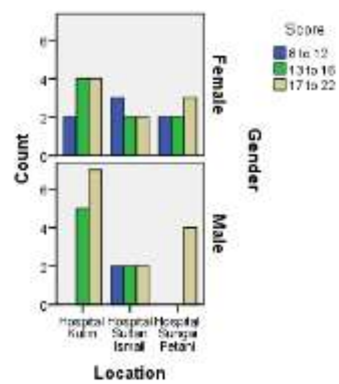


Figure 3 Score received by respondents based on the survey conducted.

Around 21.7% of the respondents correctly identified the types of ionizing radiation and majority of them are physics officer and X-ray technician. Meanwhile for question regarding the knowledge of radiation hazard, forty two of the respondents (91.3%) correctly answered the questions. However regarding the questions related to radiation safety, on average only 10 of the respondents (21.7%) correctly answered the questions and most of them are radiographers, X-ray technicians and medical physics officers.

Thirty out of forty six of the respondents (65.2%) had received some kind of formal training about ionizing radiation. Twenty two of respondents with formal training (73.3%) achieved a score of 50% or more in answering all the questions. Sixteen of respondents that never attend any formal training, included of 43.7% (*n*=7) X-ray technician, 18.8% (*n*=3) are nurses, 6.3% (*n*=1) are attendance hospital, 12.5% (*n*=2) are students, 12.5% (*n*=2) are physiotherapies and 6.3% (*n*=1). Eight respondents that never attend any formal training achieved a score of 50% or above, with a mean score of 10 out of 22.

Pearson's correlation statistical analysis using two-tailed statistical significant correlation between two groups of variables have been chose. This is because Pearson's correlation can be used to measure the linear relationship between two continuous random variables. The value of Pearson correlation of close to 1 indicates there is strong relationship between the two variables examine, meanwhile if the value is close to 0, the relationship between them is weak [11].

For correlation analysis between score received from questionnaire and attending a formal radiation training, the Pearson's correlation value is 0.243. This indicated that the relation between the scores received by the respondents and their participation in formal training is weak. Nevertheless, the Pearson's correlation value obtained is a positive number. This indicated that the more training attend by respondents, the scores received by the respondents should also by right, increases.

The probability to determine if the correlation is real or not is expressed by *p* value, which is obtained from the hypothesis. If the p value is less than 0.05, the correlation is significant. For the two variables studied, the p value calculated was 0.004 (< 0.05). This reflects that the Pearson correlation calculated between the two variables of score and training is statistically significant with the distribution of scores showing that training led to a greater proportion of higher score. For example, most of the X-ray technicians who had received formal training in ionizing radiation were able to answer the question regarding methods for minimizing radiation exposure correctly compared to those technicians who have never attended any formal training (21.7% vs. 13% of them gave correct answer on that particular question).

Out of the seventeen X-ray technicians who responded to this question, eleven of them have 5 years professional experience and six of them have more than 5 years experience working with ionizing radiation. As a summary, the X-ray technicians in this study have a good knowledge regarding ionizing hazard and radiation safety during common diagnostic imaging procedures. However the other worker i.e. nurses and medical officers have poorer knowledge and awareness regarding this subject matter.

From 28 of the respondents who had received formal training related to radiation safety, only eleven of them scored 50% or more (correct answers), with the average score of 16.3 out of 22. Almost 61% of the participants who had received formal training failed to score more than 50% of the questions given which is unacceptable. Again this study shows that those who had formal training about ionizing radiation have higher knowledge and greater awareness of the risks involved, compared to those who have had no training. The groups of workers who identified as more knowledgeable on this issue are X-ray technician and physics officer compared to nurse and medical officer. This is more or less contributed by the trainings underwent by these groups of workers as well as their better accessibility to the related information (from the equipment manual, operating procedure etc.).The correlation study also shows that work experience does has significant correlation with the level of knowledge among workers, again primarily as a result of not attending relevant courses e.g. on radiation protection safety among those workers with shorter working experiences

4.0 CONCLUSION

Protection of workers against radiation exposure is necessary to reduce the level of occupational cancer risk among workers. From this study, it can be concluded that the level of occupational radiation exposure in Malaysian hospitals is at acceptable risk. Also the level of knowledge among workers on radiation hazards and safety in the associated facilities under study varies depending on the job scope as well as working experience. Even though the status of radiation protection in hospitals at Malaysia can be considered as adequate at the moment based on the average risk value calculated, still tremendous works need to be done further to reduce the occupational radiation exposure among workers especially considering the fact that the study was not comprehensively covered all hospitals but only several due to difficulties in getting permission. Also more concerns should be put on the potentiality for inappropriate use and unnecessary exposure of workers to radiation doses. Therefore, each request for radiography procedure in all hospitals must be justified.

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