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RADIATION PROTECTION LITERACY AND ITS ASSOCIATED FACTORS AMONG HEALTHCARE WORKERS IN NEGERI SEMBILAN

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ABSTRACT

Background: Ionizing radiation can be an occupational hazard that need protection when in the form of particle which can produce biological changes to cells, tissues or organs. About 19.7% of worldwide average radiation dose is due to the medical use of radiation. In Malaysia, about 700,000 X-ray examinations were performed in 2014. The objective of this study is to assess the level and predictors for radiation protection literacy among healthcare workers in Negeri Sembilan.

Materials and Methods: A cross-sectional study was conducted in health facilities in Negeri Sembilan from April 2018 to June 2018 among 151 healthcare workers. Respondents were selected based on their workplace using proportionate stratified random sampling method and data was obtained using validated self-administered questionnaire that focused on knowledge, attitude and practices on radiation protection. Data were analyzed using IBM SPSS version 23.0.

Result: 52.3% of respondents had high knowledge, 80.8% had positive attitude and 56.3 % had good practice on radiation protection. Significant predictors for high knowledge were the use of radiation hazard monitoring device and being a radiation worker meanwhile for positive attitude was received medical surveillance. Significant predictors for good practice were the use of radiation hazard monitoring, being a radiation worker, being a health professional and being a health associate professional.

Conclusion: Attitude on radiation protection among healthcare workers in Negeri Sembilan was still positive despite knowledge and practice was marginal. Future radiation protection awareness programme, education and training should be strengthen in order to improve radiation protection literacy among healthcare worker in Negeri Sembilan.

Keywords: radiation protection literacy, healthcare worker, knowledge, attitude, practice,

1.0 Introduction

World Health Organization define ionizing radiation as a type of energy released by atoms that travel in the form of particles (neutrons, beta or alpha) or electromagnetic waves (gamma or X-rays) (WHO, 2016). Based on worldwide average radiation exposure, it is about 41.7 % of radiation exposure due to radon, 38.3 % due to other naturally-occurring radiation sources, 19.7 % due to the medical use of radiation and 0.3 % due to other sources of human-made radiation (UNSCEAR, 2010; WHO, 2016). Radiation can be classified into ionizing and non-ionizing radiation whereby ionizing radiation is a major public health significance that was produced by high-energy particles which can produce ionization or biological changes when introduced into cells, tissues or organs (Brody, Frush, Huda, & Brent, 2007). Medical exposure is the most artificial source of exposure to ionizing radiation which is about 98 % from all artificial sources and 20 % of the total population dose worldwide (UNSCEAR, 2010).

Radiology service is one the most important diagnostic service in the Ministry of Health Malaysia and chest X-ray remains the commonest radiological procedure especially in primary health care. In Malaysia, about 700,000 X-ray examinations were performed in 2014 and healthcare workers are potentially at risk for occupational radiation hazard (MOH, 2014). Radiation arising from the medical imaging procedure has the potential to bring effect to human health. It is concluded that there is a high risk of cancer concomitant with increasing radiation exposure even in the lowest dose which is approximately 10 to 50 millisievert (mSv) for an acute exposure and approximately 50 to 100 mSv for a protracted exposure (Linet et al., 2012). In one retrospective analysis performed in Malaysia, the result showed cumulative dose to the lens for interventional cardiologist ranged from 0.01 Gy to 43 Gy had strong dose and response relationship between occupational radiation exposure and the incidence of posterior lens changes (Ciraj-Bjelac et al., 2010).

General literacy is the capacity to read, write and have basic numerical skills (Kickbusch, 2001). National Assessment of Adult Literacy defines literacy as both task-based and skills -based. The task-based focuses on the everyday literacy task an adult can and cannot perform meanwhile skills – based focuses on the knowledge and skills an adult must possess in order to perform these task (White et al., 2003). United Nations Educational, Scientific and Cultural Organization (UNESCO) defined literacy as the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve his or her goals, develop his or her knowledge and potential and participate fully in community and wider society (UNESCO, 2013). International Atomic Energy Agency (IAEA) define radiation protection as the protection of people and the environment from the harmful effects of ionizing radiation (IAEA, 2014).

Radiation protection literacy has been defined in many ways by different belief, people, agencies, and organization. However, radiation protection literacy can be defined based on the definition of health literacy which is a cognitive and social skill that determines the motivation and ability of individuals to gain access, understand, and use information in ways that promote and maintain good health (Kindig et al., 2004). Therefore, radiation protection literacy can be defined as a cognitive and social skill that determines the motivation and ability of individuals to gain access, understand, and use information in ways that promote and maintain good radiation protection. Radiation protection literacy on radiation protection among healthcare workers has been studied in several countries in term of knowledge, attitude and practice. There is study which concluded that the level of KAP regarding radiation protection among healthcare worker was inadequate (Moshfegh et al., 2017). Simultaneously, a study by Sharma et al., (2016) concluded that there is 'knowledge-practice gap' on the use of personal protective devices among radiographers. Another study by Awosan et al., (2016) also concluded that there are poor radiation protection practices despite a good knowledge of radiation hazards among the healthcare workers.

2.0 Materials and Methods

A cross-sectional study was conducted in health facilities in Negeri Sembilan from April 2018 to June 2018 among 151 healthcare workers. Respondents were selected based on their workplace using proportionate stratified random sampling method and data was obtained using validated self-administered questionnaire that focused on knowledge, attitude and practice on radiation protection. Inclusion criteria for participation were age more than 18 years old, having a minimum 1-year working experience in health services and working in the workplace which provides radiology services under the State Department of Health, Negeri Sembilan facilities.

A standardized, semi-structured, and self - administered questionnaires were prepared, validated and used to obtain information on socio-demographic characteristics, employment characteristics, knowledge, attitude and practice of radiation protection among participants. The questionnaires were divided into 4 sections which was section A: sociodemographic data, section B: knowledge on radiation protection, section C: attitude on radiation protection and section D: practice on radiation protection. Likert scale was used to measure attitude and practice. Knowledge was obtained by categorizing the total knowledge score for the respondents into two categories: 'high knowledge = more than mid-range score' and 'low knowledge = less than mid-range score'. The attitude was obtained by categorizing the total attitude score for the respondents into two categories: 'positive attitude = more than mid-range score' and 'negative attitude = more than a mid-range score'. The practice was obtained by categorizing the total practice score for the respondents into two categories: 'good practice = more than mid-range score' and 'poor practice = less than mid-range score'.

Evaluation of the content validity of the questionnaires was done by a team of experts that comprised of 2 Public Health Specialists from Universiti Putra Malaysia, 1 Public Health Specialist and 1 Radiation Protection Officer (RPO) from Department of Health, Negeri Sembilan. Evaluation of face validity of the questionnaires was done during a pre-testing of the questionnaires involving 30 healthcare workers from 6 government health clinics in Melaka Tengah District, Melaka. Reliability of the 12 items on knowledge, 8 items on attitude and 5 items on practice were measured using Cronbach's alpha coefficient. The Cohen's Kappa for all items were 0.78. The Cronbach's alpha for knowledge was 0.719, attitude 0.956 and practice 0.949 respectively. Data were analyzed using IBM SPSS version 23.0 with the chi-square test to determine the association between categorical variables while multiple logistic regression used to identify significant predictors. Ethical approval was granted by the Ethics Committee for Research Involving Human Subjects, Universiti Putra Malaysia (Reference No.: UPM/TNCPI/RMC/1.4.18.2 (MREC-JKEUPM)). Also, the researchers gained approval from the Medical Research and Ethics Committee, Ministry of Health

Malaysia (Reference No.: NMRR-17-3275-39503 (IIR)) prior to the commencement of the study.

3.0 Result

3.1 *Sociodemographic and Employment Characteristics*

A total of 151 healthcare workers from 6 hospitals and 13 health clinics were approached and 151 of them agreed to participate in the study. Therefore, the overall response rate in this study was 100%. Table 1 shows the socio-demographic characteristics of the respondents. The median age of the respondents was 31 years (IQR = 7). The mean age was 32.5 (SD = 6.96). The youngest respondent was 23 years old while the oldest was 59 years old. An 84.1% of the respondents were less than 40 years old and 41.1 % of the respondents were between the ages of 20 to 29 years old which show that they have the greatest risk of constantly being exposed to radiation hazard as early as possible through their working period till retirement phase. There were more female than male respondents, with a total of 98 and 53 respectively and the majority of respondents (77.5%) were married. In view of the level of education, most of the respondents were Diploma holders (60.9%), followed by a Bachelor's degree and higher holders (26.5%). Only a very small percentage of the respondents had obtained a secondary school certificate (12.6%). In a conclusion, the multilevel of education background were involved in this research which represents the population of healthcare worker in Negeri Sembilan.

Table 1: Socio-demographic characteristics of respondents

Socio-demographic characteristics (*n*=151)	Frequency (*n*)	Percentage (%)
Age (years)		
20 – 29	62	41.1
30 – 39	65	43.0
≥ 40	24	15.9
Gender		
Male	53	35.1
Female	98	64.9
Marital status		
Single	34	22.5
Married	117	77.5
Level of education		
Secondary	19	12.6
Diploma	92	60.9
Degree and higher	40	26.5

The employment characteristics of the respondents were illustrated in table 2. More than half (56.3%) of the respondents were radiographers, followed by doctors (21.2%) and only a small percentage (7.9%) of the respondents was a staff nurse. The remaining 14.6% were personal care workers in health services which were healthcare assistants. The majority (84.1%) of respondents worked in hospitals while the remaining 15.9% of them were worked in health clinics, respectively. The median duration of service was 2 years (IQR = 2.00). Half of the respondents (47.5%) had less than 9 years of working duration. Although all of the respondents had exposed with radiation in the workplace, only 73.5% of respondent were radiation worker as defined by Law of Malaysia, Act 304 under section 5. In term of training in radiation hazard, only half of the respondents (57.0%) had attended the training which shows inadequate coverage for radiation protection training among respondent. About less than three-quarter of the respondent (58.9%), received medical surveillance pertaining to radiation hazard. This shows an evidence of lack of enforcement in radiation protection among healthcare worker even though Ministry of Health had developed guideline and manual for radiation protection in 2017. In view of radiation exposure monitoring, less than three-fourths of the respondent (68.9%) used or aware about radiation exposure monitoring device. This reflex the knowledge on radiation monitoring programme is alarmingly critical. However, most of the respondents (84.1%), believed that they had sufficient knowledge in radiation protection literacy which shows that respondent had good insight regarding radiation protection.

Table 2: Employment characteristics of respondents

Employment characteristics (*n* = 151)	Frequency (*n*)	Percentage (%)
Job		
Medical doctor	32	21.2
Staff nurse	12	7.9
Radiographer	85	56.3
Healthcare assistant	22	14.6
Workplace		
Hospital	127	84.1
Health clinic	24	15.9
Service duration (years)		
Less 10 years	102	67.5
≥ 10 years	49	32.5
Radiation Worker		
Yes	111	73.5
No	40	26.5
Training in Radiation Hazard		
Yes	86	57.0
No	65	43.0
Received medical surveillance		
Yes	89	58.9
No	62	41.1
Radiation exposure monitoring		
Yes	104	68.9
No	47	31.1
Belief in Radiation protection literacy		
Insufficient	24	15.9
Sufficient	60	39.7
Good	53	35.1
Excellent	14	9.3

3.2 Level of Knowledge on Radiation Protection

In this study population, only 52.3% of respondents possess high levels of knowledge on radiation protection. Majority of respondents (95.4%) were able to answer correctly regarding lead apron as a personal protective device which can reduce radiation exposure. However, less than half (42.4%) of respondents were able to answer SI unit for radiation measurement of the absorbed dose which indicated that there was lack of basic knowledge in radiation protection. In relation to knowledge on diseases caused by radiation exposure, not much respondent able to answer correctly regarding bone marrow depression and anemia which were 24.5% and 25.2 % respectively. Moreover, about 7.3% and 0.7% of respondent had wrongly answered gastritis and diabetes mellitus as diseases that can cause by radiation exposure.

Among the respondents with a high knowledge, 51.9% (n = 41) were between the ages of 30 to 39, 64.6% (n = 51) were female, 82.3% (n = 65) were married, 70.9% (n = 56) were Diploma holders, 78.5% (n = 62) were radiographer, 75.9% (n = 60) worked in hospitals, 64.6% (n = 51) had working experience of less than 10 years, 98.7% (n = 78) were radiation worker, 79.7% (n = 63) had undergone training in radiation hazard, 83.5% (n = 66) had received medical surveillance, 94.9% (n = 75) had use radiation exposure monitoring and 45.6% (n = 36) good belief in radiation protection literacy respectively. A chi-square test was conducted between the level of knowledge and age and between the level of knowledge and the level of education. There was a statistically significant but small association (Cohen, 1988) between the level of knowledge and age ($\chi 2 = 7.967$, df = 2, $p < 0.05$, Cramer's V = 0.23) as well as between the level of knowledge and the level of education ($\chi 2 = 16.00$, df = 2, $p < 0.001$, Cramer's V = 0.326). However, there were no significant associations between the level of knowledge and gender as well as between level of knowledge and marital status.

A chi-square test showed significant but moderate and weak associations (Cohen, 1988) between level of knowledge with job ($\chi 2 = 41.219$, df = 3, $p < 0.001$, Cramer's V = 0.52), radiation worker ($\chi 2 = 54.135$, df = 1, $p < 0.001$, Phi = 0.60), received medical surveillance ($\chi 2 = 41.443$, df = 1, $p < 0.001$, Phi = 0.52), use radiation exposure monitoring ($\chi 2 = 52.496$, df = 1, $p < 0.001$, Phi = 0.59), workplace ($\chi 2 = 8.246$, df = 1, p = 0.004, Phi = 0.23), belief in radiation protection literacy ($\chi 2 = 19.834$, df = 3, $p < 0.001$, Cramer's V = 0.36) as well as undergone training in radiation hazard ($\chi 2 = 35.109$, df = 1, $p < 0.001$, Phi = 0.48). However, there were no significant associations between the level of knowledge and service duration.

The final model for high knowledge containing all nine factors was statistically significant (Omnibus $\chi 2 = 93.05$, df = 5, $p < 0.001$), indicating that the model was able to distinguish between respondents who had high knowledge and low knowledge. The model as a whole explained between 46.0% (Cox and Snell R squared) and 61.4% (Nagelkerke R squared) of the variance in the level of knowledge is explained by this logistic model. Hosmer - Lemeshow Goodness of Fit Test showed that there was a non-significant small discrepancy between the observed probability and the expected probability ($\chi 2 = 0.54$, df = 5, p = 0.991), indicating that the model fits.

However, only four variables made a unique statistically significant contribution to the model which are level of education, workplace, received medical surveillance, radiation exposure monitoring and a radiation worker. The strongest predictor of having a high level of knowledge on radiation protection literacy is had a diploma or higher, recording an adjusted odds ratio of 12.99 (95% CI [2.37, 71.07], p = 0.003). This indicates that respondents who had a diploma or higher had almost thirteen times higher odds to have a high level of knowledge than a respondent who had a certificate or less. Healthcare worker working in health clinic increases the odds of having high knowledge by almost six times compared to healthcare worker working in a hospital (AOR = 5.77, 95% CI [0.97, 34.34], p = 0.035). Being a radiation worker increases the odds of having high knowledge by almost twenty-seven times compared to the non-radiation worker (AOR = 27.43, 95% CI [2.58, 291.81], p = 0.006). Healthcare worker undergone medical surveillance increases the odds of having high knowledge by almost three times compared to healthcare worker not undergone medical surveillance (AOR = 2.97, 95% CI [1.08, 8.15], p = 0.035). A healthcare worker uses radiation exposure monitoring increases the odds of having high knowledge by almost four times compared to healthcare worker not use radiation exposure monitoring (AOR = 4.05, 95% CI [1.01, 16.2], p = 0.048).

3.3 Level of Attitude on Radiation Protection

In this study population, 80.8% of respondents' showed a positive level of attitude on radiation protection. Most of the respondents (82.1%, n = 124), agreed with the attitude statement regarding workplace policies and procedures are based on current regulations. However, about 31.1% (n = 47) of respondent disagreed with attitude statement regarding working in radiation service area will not affect my ability to have a child which determine their basic knowledge regarding radiation protection were inadequate.

Among the respondents who had positive attitude, 44.3% (n = 54) were between the ages of 30 to 39, 65.6% (n = 80) were female workers, 78.7% (n = 96) were married, 61.5% (n = 75) were Diploma holders, 61.5% (n = 75) were radiographer, 81.1% (n = 99) worked in hospitals, 64.8% (n = 79) had working experience of less than 10 years, 80.3% (n = 98) were radiation worker, 63.1% (n = 77) had undergone training in radiation hazard, 67.2% (n = 82) had received medical surveillance, 76.2% (n = 93) had use radiation exposure monitoring and 41.0% (n = 50) sufficient belief in radiation protection literacy respectively.

A chi-square test showed significant associations (Cohen, 1988) between job ($\chi2$ = 12.626, df = 3, p = 0.006, Cramer's V = 0.29), radiation worker ($\chi2$ = 15.164, df = 1, $p < 0.001$, Phi = 0.32), received medical surveillance ($\chi2$ = 17.964, df = 1, $p < 0.001$, Phi = 0.35), use radiation exposure monitoring ($\chi2$ = 16.031, df = 1, $p < 0.001$, Phi = 0.33), workplace (p = 0.047), belief in radiation protection literacy (p = 0.003) as well as undergone training in radiation hazard ($\chi2$ = 9.836, df = 1, p = 0.003, Phi = 0.26). However, there were no significant associations between the level of attitude with service duration, age, gender, marital status and the level of education.

The final model for positive attitude containing all eight factors was statistically significant (Omnibus $\chi2$ = 31.48, df = 9, $p < 0.001$), indicating that the model was able to distinguish between respondents who had a positive attitude and negative attitude. The model as a whole explained between 18.8% (Cox and Snell R squared) and 30.2% (Nagelkerke R squared) of the variance in the level of attitude is explained by this logistic model. Hosmer-Lemeshow Goodness of Fit Test showed that there was a non-significant small discrepancy between the observed probability and the expected probability ($\chi2$ = 5.85, df = 8, p = 0.664), indicating that the model fits. However, only one out of the eight predictor variables made a statistically significant contribution to the multivariable model, which was received medical surveillance. The odds of having a positive attitude on radiation protection for respondents who received medical surveillance were six times higher compared to those who did not receive medical surveillance, after controlling for all other factors in the model (AOR = 5.52, 95% CI [2.14, 14.25], $p < 0.001$).

3.4 Level of Practice on Radiation Protection

In this study population, only 56.3% of respondent have good practices on radiation protection. About 69.5% (n= 105) of respondents claimed that they very often wear a lead apron to protect their self from radiation exposure while on duty. Surprisingly, 70.2% (n = 106) of respondent do not wear lead goggle and 76.2% (n = 115) of respondent did not wear lead gloves while working in the radiation area. This study also revealed that more than half (52.3%, n = 95) of respondent very often did not use of thyroid shield while working. Therefore, their practice on radiation protection was very unsatisfactory.

Among the respondents who had good level of practice, 50.6% (n = 43) were between the ages of 30 to 39, 65.9% (n = 56) were female workers, 81.2% (n = 69) were married, 75.3 % (n = 64) were Diploma holders, 78.8% (n = 67) were radiographer, 83.5% (n = 71) worked in hospitals, 65.9% (n = 56) had working experience of less than 10 years, 97.6% (n = 83) were radiation worker, 74.1% (n = 63) had undergone training in radiation hazard, 81.2% (n = 69) had received medical surveillance, 97.6% (n = 83) had use radiation exposure monitoring and 40.0% (n = 34) good belief in radiation protection literacy respectively.

A chi-square test showed significant associations (Cohen, 1988) between level of practice with level of education ($\chi 2 = 24.019$, df = 2, $p < 0.001$, Cramer's V = 0.40), job ($\chi 2 = 50.293$, df = 3, $p < 0.001$, Cramer's V = 0.58), radiation worker ($\chi 2 = 58.183$, df = 1, $p < 0.001$, Phi = 0.62), received medical surveillance ($\chi 2 = 39.732$, df = 1, $p < 0.001$, Phi = 0.51), use radiation exposure monitoring ($\chi 2 = 75.10$, df = 1, $p < 0.001$, Phi = 0.71), belief in radiation protection literacy ($\chi 2 = 24.679$, df = 3, $p < 0.001$, Cramer's V = 0.40) as well as undergone training in radiation hazard ($\chi 2 = 23.369$, df = 1, $p < 0.001$, Phi = 0.39). However, there were no significant associations between the level of practice with age, gender, marital status, workplace and service duration.

The final model for good practice containing all ten factors was statistically significant (Omnibus $\chi 2 = 116.98$, df = 5, $p < 0.001$), indicating that the model was able to distinguish between respondents who had a good practice and poor practice. The model as a whole explained between 53.9% (Cox and Snell R squared) and 72.3% (Nagelkerke R squared) of the variance in the level of practice is explained by this logistic model. Hosmer-Lemeshow Goodness of Fit Test showed that there was a non-significant small discrepancy between the observed probability and the expected probability ($\chi 2 = 1.72$, df = 5, $p = 0.887$), indicating that the model fits.

However, only three out of the ten predictor variables made a statistically significant contribution to the multivariable model, which was a job, radiation worker and use of radiation exposure monitoring. The odds of having a good practice on radiation protection for respondents being health professional were seventy one times higher compared to personal care workers in health service, after controlling for all other factors in the model (AOR = 70.58, 95% CI [4.26, 1170.03], p = 0.003). The odds of having a good practice on radiation protection for respondents being health associate professional were thirty-nine times higher compared to personal care workers in health service, after controlling for all other factors in the model (AOR = 38.72, 95% CI [4.01, 373.85], p = 0.002). The odds of having a good practice on radiation protection for respondents being radiation worker were nineteen times higher compared to those who not being radiation worker, after controlling for all other factors in the model (AOR = 19.39, 95% CI [1.70, 220.78], p = 0.017). The odds of having a good practice on radiation protection for respondents who use radiation exposure monitoring were six times higher compared to those who did not use radiation exposure monitoring, after controlling for all other factors in the model (AOR = 46.46, 95% CI [8.23, 262.53], p < 0.001).

4.0 Discussion

Almost half (52.3%, n = 79) of respondents in this study had fairly high knowledge on radiation protection as opposed to a study from India involving group of the general dental practitioner, which reported that only 2.45% had thorough knowledge about radiation protection (B. Agrawal et al., 2015). These findings are better than another study in Tehran province, Iran involving medical radiation worker which reported 2.7% (n = 11) of respondent having high knowledge on radiation protection (Alavi et al., 2017). However, finding in this study is almost similar with that from the study in Nigeria which reported that 59.1% (n = 65) of respondent have good knowledge on radiation hazard and radiation protection (Awosan et al., 2016). Findings in this study also supported by another study by Samuel et al. (2016) involving a group of medical student in Malaysia which reported 48.3% of respondent had high knowledge of radiation protection. There is another study in Egypt involving physician which reported that 76.3% (n=61) of respondent have high knowledge of radiation protection (R. Abdellah et al., 2015). The finding in this study was better than another study because Negeri Sembilan is a developing state with easy access to infrastructure which influence respondent to attend a training to gain knowledge.

Most (93.4%, n = 141) of the respondent in this study knew about radiation hazard. These findings are better than another study in Northen Nigeria which reported only 77.3% (n=85) of respondent knew about radiation hazard (Awosan et al., 2016). Almost more than three quarter (81.5%, n = 123) of respondents from this study knew that infertility can cause by radiation hazard, as opposed to a study from Nigeria involving a group of health workers working in teaching hospital, which reported that only (67.3%) of the respondents know that radiation hazard can cause infertility in men and women (Awosan et al., 2016). Yurt et al., (2014) conducted a study among healthcare professional in turkey and found that 79.3% of respondent knew that infertility can cause by radiation hazard. The findings between this study and other study were similar due to same sociodemographic especially education background and job.

About 72.8% (n = 110) of respondent in this study knew that thyroid cancer is caused by radiation hazard as opposed to study in turkey involving healthcare professionals who use ionizing radiation at work which reported that majority of respondent (93.5%) knew that radiation hazard can cause thyroid cancer (Yurt et. al., 2014). A study by Awosan et al., (2016) also found that 63.6% of respondent knew that radiation hazard can cause cancer especially skin cancer and leukemia. In our study, 73.5% (n = 111) of respondent knew that radiation hazard can cause skin injuries such as erythema, skin pigmentation, dermatitis, hair loss and skin desquamation. Our result is better than another study conducted in Northen Nigeria which reported that only 64.5% (n = 71) of health worker knew that radiation hazard can cause skin injuries (Awosan et. al., 2016). However, only half (51%, n = 77) of the respondent in our study knew that radiation hazard can cause leukemia. Our study had better

findings due to all respondent were healthcare worker which give them advantages of knowing a disease especially cause by radiation hazard.
Almost one quarter, 24.5% (n = 37) of respondent in this study knew that radiation hazard can cause bone marrow depression as opposed to study in Nigeria involving health worker which reported 60.9% (n = 67) of respondent knew radiation hazard can cause bone marrow depression (Awosan et al., 2016). Another disease caused by radiation hazard is congenital malformation which 68.9% (n = 104) of the respondent in this study knew about it as similar to another study in Northern Nigeria which founded that 68.2% of respondent knew that radiation hazard can cause congenital malformation in babies delivered by pregnant women exposed to ionizing radiations.

In this study, most of the respondent knew about symptoms of acute radiation syndrome such as nausea (88.7%, n = 134), vomiting (84.8%, n = 128) and headache (69.5%, n = 105). This finding is better than findings from another study in Northen Nigeria which only 56.4% (n = 62) of respondent knew about symptoms of acute radiation syndrome such as nausea and vomiting. This is because most of the respondent had undergone training in radiation hazard which knowledge update regarding radiation syndrome. However, there is also few respondents wrongly answered about symptoms of acute radiation syndrome such as a sore throat (2%, n = 3) and flu (11.3%, n = 17).

Most of respondent in this study (94%, n = 142) knew that personal protective devices can reduce exposure to radiation such as lead goggles (78.11%, n = 118), lead apron (95.4%, n = 144), lead gloves (72.2%, n = 109), thyroid shield (86.1%, n = 130) and gonad shield (76.2%, n = 115). These findings are better compared to other study in Nigeria which found only 78.2% (n = 86) of respondent knew that personal protective devices can reduce exposure to radiation such as lead goggles (51.8%, n = 57), lead apron (71.8%, n = 79), lead gloves (51.8%, n = 57), thyroid shield (43.6%, n = 48) and gonad shield (46.4%, n = 51) (Awosan et. al., 2016). However, findings in this study was similar with other study in Hamadan, Iran which reported on respondents' knowledge on personal protective devices that can reduce exposure to radiation such as lead goggles (28.2%, n = 20), lead apron (98.6%, n = 70), lead gloves (35.2%, n = 25), thyroid shield (67.6%, n = 48) and gonad shield (78.9%, n = 56) (M. Mojiri et al., 2011). This finding is better than finding in Nigeria because the Ministry of Health Malaysia had actively promotes radiation protection among healthcare worker whereby they just developed a guideline on radiation protection in 2017.

Less than half (41.1%, n = 62) of respondents in this study knew about Atomic Energy Licensing act (Basic Safety Radiation Protection) Regulation 2010 as opposed to study in Malaysia involving radiology personnel which reported 68% (n = 60) of respondents study knew about Atomic Energy Licensing act (Basic Safety Radiation Protection) Regulation 2010 (Karim et al., 2016). In this study more than half (65.6%, n = 99) of respondent knew that sievert is the SI unit for radiation measurement of equivalent dose which is better than another study in India involving urology resident which reported that only 57.6% of respondent knew that sievert is the SI unit for radiation measurement of equivalent dose (T. Jindal et al., 2015). Finding in our study was poor compared with another study because most of the respondent did not be emphasize regarding Law of Malaysia, Act 304, AELB Act (Basic Safety Radiation Protection) regulation 2010 which is important for them to know their right.

About 15.9% (n = 24) of the respondent in this study felt that they have insufficient literacy on radiation protection which is better than another study by T. Jindal et al., (2015) among urology resident in India which reported that 82.6% of respondents felt that they have insufficient literacy on radiation protection. Another study by Ariella A. et al., (2013) in Canada involving urology resident which reported 53% of respondents felt sufficient literacy in radiation protection whereby in our study about 84.1% (n = 127) felt sufficient literacy in radiation protection. The overall level of knowledge for the respondents in this study is satisfactory, with 52.3% (n = 79) in the high-level category and only 147.7% (n = 72) in the low-level category. Surprisingly, among those with a low level of knowledge, more than one quarter (31.9%, n = 23) were radiographer even though their main job scope involving radiation services (Public Services Commission of Malaysia, 2017). This evidence shows that they did not have enough training pertaining to radiation protection even though they deal with radiation hazard every day in their job scope.

Another significant finding is that more than two-thirds (73.3%, n = 63) of those who had gone for training in radiation hazard had a high level of knowledge and this can be taken as evidence for the effectiveness of such training. This study also identified that most of the respondents were young; 84.1% (n = 127) were below the age of 40 and would have at least another 20 or more years in the service which possibly had a greater chance of getting health effect from radiation hazard. Although half (51.2%) of those under the age of 40 had the high knowledge, from the perspective of occupational health, it is still important to provide them with accurate knowledge regarding the issues related to radiation hazard and radiation protection.

In this study, majority (80.8%, n = 122) of respondent have positive attitude meanwhile 19.2% (n = 29) of respondent have negative attitude on radiation protection as similar with another study in Northern Nigeria which reported 88.2% of respondents demonstrated positive attitude on radiation protection (Awosan et al., 2016). However, findings in this study are better than another study in Tehran province, Iran involving medical radiation worker which reported only 2.2% (n = 9) of respondent having a positive attitude on radiation protection (Alavi et al., 2017). Finding in this study also contradict with another study in Egypt involving physician which reported that only 23.7% (n = 19) of respondent have a positive attitude on radiation protection (R. Abdellah et al., 2015). This findings showed that the respondents had good insight and with constant training and continuous medical education on radiation protection, this may cultivate a good work practice among them.

About 82.1% (n = 124) of respondents in this study either strongly agreed or agreed with attitude statement which their workplace policies and procedures are based on current regulations as opposed with another study in Egypt involving physician which reported that only 35% (n = 28) of respondent agree with this attitude statement (R. Abdellah et al., 2015). This indicates that the top management has successfully played their role in establishing and implementing safety culture towards radiation hazard among healthcare worker. In this study, 70.9% (n = 107) of respondent either strongly agreed or agreed with the attitude statement which they know whom to contact if they have questions about radiation protection. This finding is better compared with another study in Egypt involving physician which reported that only 58.8% (n = 47) of respondent agreed with this attitude statement (R. Abdellah et al., 2015). Finding in this study shows that the respondents know about their workplace policies and procedure which is up to date with current law of Malaysia.

About 78.8% (n = 119) of respondents in this study either strongly agreed or agreed with attitude statement which they can clearly explain the radiation protection needed to the patients and their visitors as opposed with another study in Egypt involving physician which reported that only 50% (n = 40) of respondent agree with this attitude statement (R. Abdellah et al., 2015). Findings on this study (80.8%, n = 122) were better than another study in Egypt (61.3%, n = 49) on attitude statement which they feel confident about steps needed when handling patient to undergo radiology procedure (R. Abdellah et al., 2015). This finding showed that the respondent had high level of confident pertaining to radiation protection which can change their practice towards radiation hazard.

About 68.9% (n = 104) of respondents in this study either strongly agreed or agreed with attitude statement which they feel that working in radiation service area will not affect their ability to have a child as opposed with another study in Egypt involving physician which reported that only 15% (n = 12) of respondent agreed with this attitude statement (R. Abdellah et al., 2015). Findings on this study (76.2%, n = 115) were better than another study in Egypt (27.5%, n = 22) on attitude statement which they feel safe when handling patient to undergo radiology procedure (R. Abdellah et al., 2015). This showed that the respondents in this study have more positive attitude compared to respondents in another study as they are confident that working in a radiation area will not affect their ability to have a child.

In this study, 56.3% (n = 85) of respondents have a good practice on radiation protection which is better than another study in Tehran province, Iran involving medical radiation worker which reported 29.3% (n = 121) of respondent having a good practice on radiation protection (Alavi et al., 2017). In this study, 68.9% (n = 104) of respondent used dosimeter as radiation exposure monitoring which is better than other study in Canada which reported almost 70% of respondents never used dosimeters as radiation exposure monitoring (Ariella A. et al., 2013) and finding in Tehran province which reported 55% of respondent did not use dosimeter as radiation exposure monitoring (Alavi et al., 2017). However, findings in another study in Dublin, Ireland and Hamadan, Iran reported that almost 93.6% and 94.4% of respondent used dosimeter as radiation exposure monitoring (Bahari et al., 2006; M. Mojiri et al., 2011). The findings in this study are better compared to another study in Tehran and Canada because of the effectiveness of enforcement using dosimeter by the law of Malaysia, Atomic Energy Licensing Act 1984.

About 58.9% (n = 89) of the respondents in this study perform medical surveillance as opposed to another study in Kermanshah, Iran involving radiographer which reported less than half of the radiographers regularly performed medical surveillance (Rostamzadeh et al., 2015). However, finding in this study is similar to a study in Kerman University of Medical Sciences hospitals, Iran which reported 60% of radiographers performed regular medical surveillance (Borhani et al., 2003). A study by M. Mojiri et al., (2011) found that 77.5% of respondents perform medical surveillance which findings are higher than the current study. This findings showed that inadequate of medical surveillance coverage related to radiation hazard among healthcare worker. This issues must be highlighted to the top level in the Ministry of Health so that necessary action can be taken accordingly.

Most of the respondents in this study (80.1%, n = 115), used personal protective device to reduce radiation exposure while on duty which is similar to other study by Awosan et al., (2016) in Northern Nigeria which reported 75.5% of respondent used personal protective device to reduce radiation exposure while on duty. In our study, 45% (n = 68) of respondents always used lead aprons, 3.3% (n = 5) used lead goggles, 29.1% (n = 44) used thyroid shield, 2% (n = 3) used lead gloves and 21.2% (n = 32) used gonad shield as opposed with another study in Eastern Province, Saudi Arabia involving medical staff in health care facilities which reported 99% of medical staff always used lead aprons, 60% used a lead shield, 37% used lead glasses, and 42% used thyroid shield (K. Salama et al., 2016). However, findings in our study is better than other study in Northern Nigeria which reported 10.9% (n = 12) of respondent always used lead aprons, 4.5% (n = 5) used lead goggles, 2.7% (n = 3) used thyroid shield, 4.5% (n = 5) used lead gloves and 4.5% (n = 5) used gonad shield (Awosan et al., 2016). Findings in our study showed an evidence of adequate personal protective device provided by the Ministry of Health to reduce radiation exposure among their healthcare workers. Our study also revealed that more than half (52.3%, n = 95) of respondents do not use very often the thyroid shield while working. This poor practice of the respondent can possess a greater risk of getting thyroid cancer.

5.0 Conclusions and recommendations

This study found that the knowledge and practice of radiation protection among healthcare workers in Negeri Sembilan were poor despite positive attitude. Poor in knowledge on radiation protection could affect their risk perception of radiation hazards and by extension their compliance with radiation protection practices. Health professionals were found to have better knowledge regarding radiation protection than personal care workers in health services. Therefore, it is imperative that future radiation protection awareness programme, education and training be conducted on other healthcare workers besides health professional with more focus on the importance of radiation protection and behaviourally-relevant knowledge. Even though healthcare worker in Negeri Sembilan had poor knowledge and practice on radiation protection, they had a positive attitude that represents their culture of self - care which is a key factor to ensure higher performance in knowledge and practice.

It is recommended that this study should be extended to other states, healthcare workers based in private facilities and other medical institutions in order to determine the overall level of knowledge, attitude and practice on radiation protection among all healthcare workers in Malaysia. Education and awareness on radiation protection should also focus on healthcare workers who are involved directly or indirectly with a radiological procedure regardless of their job category. Medical surveillance session can help healthcare worker increase their knowledge and change their attitude regarding radiation hazard and protection especially on individual consultation with occupational health physician. Therefore, local authority and ministry of health should enforce medical surveillance towards healthcare worker, who are exposed to radiation as its one of the component in the Law of Malaysia, Act 304, Atomic Energy Licensing Act, 1984. Enforcement of using dosimeter among health care worker exposed to radiation is very important. When healthcare workers complied with the usage of the dosimeter, they also increased their knowledge regarding radiation dosage that their body received every month. Therefore, this may change their attitude and practice towards radiation protection when they know the level of radiation hazard exposure to their body.

It is recommended that knowledge and practical experience pertaining to the effective management of radiation protection be included early in healthcare workers' professional training curriculum. Guidelines on the proper management of radiation protection should be developed and displayed clearly at the workplace and regular practical training should be conducted for all healthcare workers. The implementation of public policies to use personal protective device specific on radiation protection such as lead apron, lead goggles, thyroid shield, lead gloves and gonad shield while on radiation procedure in the health sector is necessary to reduce the effect of radiation hazard to the healthcare worker. Knowledge about the potential threats of radiation hazard to human and the environment should be imparted to all healthcare workers and the public in general through occupational safety and health activities as well as awareness programmes.

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Declaration

Authors declare that there is no conflict of interest regarding publication of this article.

Author’s contribution

The 1st author carried out the research, analyzed the data and prepared draft of the manuscript while the 2nd, 3rd and 4th author supervised the research and data analysis. The 2nd and 3rd author edited the final manuscript.

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