Assessment of radiation safety awareness among nuclear medicine nurses: a pilot study

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Abstract. All nuclear medicine nurses need to have some knowledge and awareness on radiation safety. At present, there is no study to address this issue in Malaysia. The aims of this study were (1) to determine the level of knowledge and awareness on radiation safety among nuclear medicine nurses at Putrajaya Hospital in Malaysia and (2) to assess the effectiveness of a training program provided by the hospital to increase the knowledge and awareness of the nuclear medicine nurses. A total of 27 respondents attending a training program on radiation safety were asked to complete a questionnaire. The questionnaire consists 16 items and were categorized into two main areas, namely general radiation knowledge and radiation safety. Survey data were collected before and after the training and were analyzed using descriptive statistics and paired sample t-test. Respondents were scored out of a total of 16 marks with 8 marks for each area. The findings showed that the range of total scores obtained by the nuclear medicine nurses before and after the training were 6-14 (with a mean score of 11.19) and 13-16 marks (with a mean score of 14.85), respectively. Findings also revealed that the mean score for the area of general radiation knowledge (7.59) was higher than that of the radiation safety (7.26). Currently, the knowledge and awareness on radiation safety among the nuclear medicine nurses are at the moderate level. It is recommended that a national study be conducted to assess and increase the level of knowledge and awareness among all nuclear medicine nurses in Malaysia.

1. Introduction
Radiological imaging is an essential tool to medical staffs in diagnosing diseases. Among the common imaging modalities used in diagnostic are radiography (x-rays), fluoroscopy, mammography, computed tomography (CT) and positron emission tomography (PET). The utilization of ionizing radiation in these tools have caused potential risk to patients [1].

Ionizing radiation has hazardous effects on biological systems [2, 3]. There are two types of radiation effect on human health namely the stochastic effect and the deterministic effects. Stochastic effect is an independent-dose effect and can cause illness such as cancer [4, 5]. Dependent-dose effect are called deterministic effects and the effects are immediate such as radiation burn and acute radiation syndrome [5,6]. Despite the fact that ionizing radiation causes hazardous effects on human health,
high-energy radiation such as x-ray and gamma rays are useful in shrinking tumor and destroying cancerous cell in human body [5,7]. Any staffs if assigned to be worked in a radiological department should poses adequate knowledge on radiation safety. Continuous professional development programmes should be provided to refresh and to increase their knowledge and awareness on the safety of ionizing radiation from time to time. There are a few reported studies on the level of radiation knowledge and radiation safety awareness amongst medical staffs in other countries [1, 8, 9, 10]. However, the level of knowledge and radiation safety awareness among nuclear medicine nurses in Malaysia and the effectiveness of the training program are not known. The aims of this study were (1) to determine the level of knowledge and awareness on radiation safety among the Malaysian nuclear medicine nurses, and (2) to assess the effectiveness of a training program provided by hospital to increase the radiation knowledge and radiation safety awareness of the nuclear medicine nurses.

2. Materials and methods
The study took place at Putrajaya Hospital in Malaysia. A self-administered questionnaire was used in this study. The questionnaire was adapted from the previous studies [1, 11]. The questionnaire consists of two main areas, i.e., the general radiation knowledge (8 questions) and radiation safety (8 questions). Following the design of this questionnaire, the content was validated by medical physicists at the Nuclear Medicine Department of the hospital. The questionnaire was distributed to the nuclear medicine nurses during a one-day radiation safety training program organized by the hospital in November, 2013. The same set of questionnaire was administered twice, i.e. before and after the training program.

The completed questionnaires were assessed by one assigned researcher and scores were calculated on general radiation knowledge and radiation safety areas. Correct answers were awarded one mark, whereas an incorrect answer or omission received zero mark, hence resulting in a total score ranging from 0 to 16. Survey data were collected before and after the training and were analyzed using descriptive statistics and paired sample t-test. All the statistical analyses were performed using Statistical Package for Social Science (SPSS), version 21.0.

3. Results

3.1. Demographics
A total of 27 nurses comprising Trained Nurses and Community Nurses has responded to the questionnaire before and after attending the radiation safety training program. The general demographics of the participants for gender showed that 92.6% were female while 7.4% were male. 92.6% and 7.4% of the respondents were in the age range of 20 – 29 and 30 – 39 years old, respectively. In terms of academic qualifications, there were 14.8% of the respondents graduated with certificate level whereas 85.2% were diploma holders and 3.7% were degree holder. The respondents of this study were fresh graduates and newly joined the Ministry of Health of Malaysia. Therefore, this group of nuclear medicine nurses is identified to have very limited working experience with radiation (0 – 2 years).

3.2. Overall scores
The overall scores findings showed that the range of the total scores obtained by the nuclear medicine nurses before and after the training were 6-14 (mean score = 11.19, SD = 1.92) and 13-16 (mean score = 14.85, SD = 0.91) marks, respectively. It was found that there was a significant increase in terms of overall scores by the respondents after attending the training program (p<0.001). Based on the analysis of section scores, it was found that the respondents in general performed slightly better on the general radiation knowledge area as compared to radiation safety area. The mean scores obtained before training on general radiation knowledge area was 5.74 (SD = 1.35) and on the radiation safety area was 5.44 (SD = 1.28). The corresponding values achieved after training was 7.59 (SD = 0.57), and 7.26 (SD = 0.66), respectively. There was a significant increase in terms of participants’ scores for both sections.
after training (p<0.001). With this, the researchers have enough evidence to conclude that the radiation safety training program was effective in raising the knowledge and awareness of the respondents on radiation safety.

3.3. Items addressing the level of general radiation knowledge of respondents

Table 1 shows the percentage of the correct answers of the respondents for each general radiation knowledge item before and after training. It was found that Item No. 7 is the easiest items, all the respondents are aware that unborn child is more sensitive to radiation as compared to other groups of people such as child, adolescent, and adult. Among the eight items listed in this section, it was noticed that all the respondents were able to answer correctly four items only after training, i.e., Item No. 2, 3, 4 and 7. It was interesting to find that Item No. 5 is the most difficult item in this section for the respondents. The percentages of the respondents that gave the accurate answer (no limit) before and after the training course were 14.8% and 74.1%, respectively. The distributions of the choice of answers marked by the respondents before and after training were shown in Figure 1 and Figure 2. Based on this result, the researchers would like to highlight that quite a number of our nuclear medicine nurses still unaware that there is actually no limit to the annual whole body dose received by patient although they have attended the training program.

![Figure 1. The distribution of the choice of answers for item “What is the annual whole body dose limit for a patient?” before training.](image1)

![Figure 2. The distribution of the choice of answers for item “What is the annual whole body dose limit for a patient?” after training.](image2)

ALARA stands for “As Low as Reasonable Achievable”. The ALARA principle was asked in Item No. 6. The percentages of the respondents that were able to give the correct answer for this item before and after the training were 85.2% and 88.9%, respectively. Although, the result showed that most of the nuclear medicine nurses are well aware of the principle, but it was found that the percentage of changed of the correct answer of the respondents for this item before and after training is not high (3.7%). This result is quite unexpected.

In the field of radiation, a dosimeter is a measuring device used to measure radiation dose, and it cannot be applied as a radiation protection tool. In item No. 8, respondents were asked to decide whether a personal dosimeter can provide protection from radiation exposure. It was found that not all the respondents are aware of it. The percentages of the respondents that gave the correct answer for this item before and after the training were 92.6% and 96.3%, respectively.
Table 1. Percentage of the correct answers of the respondents for general radiation knowledge before and after training.

| Item No. | Item                                                                 | %          | Before training | After training |
|----------|----------------------------------------------------------------------|------------|-----------------|---------------|
| 1        | Radioactive radiation refers to Ionizing radiation                    | 93         | 96              |
| 2        | Which of the following radiations will be completely stopped by a piece of paper? Alpha particle | 89         | 100             |
| 3        | What is the unit of contamination? Bq/cm²                              | 40.7       | 100             |
| 4        | What is the annual whole body dose limit for radiation worker? 20 mSv | 63         | 100             |
| 5        | What is the annual whole body dose limit for a patient? No Limit      | 14.8       | 74.1            |
| 6        | Which of the following explains the ALARA principle? As Low as Reasonable Achievable | 85.2       | 88.9            |
| 7        | Which of the following is more sensitive to radiation? Unborn child    | 100        | 100             |
| 8        | A radiation dosimeter provides protection from radiation exposure? False | 92.6       | 96.3            |

3.4. Items addressing the level of radiation safety awareness of respondents

Table 2 shows the percentage of the correct answers of the respondents for each radiation safety awareness item before and after training. Among the eight items listed in this section, it was noticed that all the respondents were able to answer correctly five items only after training, i.e., Item No. 9, 12, 13, 14 and 15.

All respondents were able to give the correct dose limit for public in this item after the training compared to just 55.6% before attending the course. This showed that the respondents were well aware of the annual whole body dose limit for the public after the training. It was surprising to notice that the percentage of changed of the correct answer of the respondents for Item No. 14 before and after training is among the highest, i.e., 44.4%.

Based on the results, it was found that the two most difficult items in this section were Item No. 11 and Item No. 16. This is because the percentages of the correct answers of the respondents for these two items after training were low.

If one increases the distance of a radiation source with its target, the amount of radiation exposure will decreases. Item No. 11 was designed to test the respondents’ knowledge on this relationship. The percentage of the respondents that answered this item correctly also increased from 48.1% before the training to 77.8% after the training. It seems that there is still quite a number of respondents does not aware that this is also a way to protect them from radiation exposure.

There is a range of radiation safety items available in the hospital such as emergency tongs, radiation warning signs, survey meter, and safety manual. Among these four items, the respondents were asked in item No. 16 to choose one item that must be considered as the most important in the radiation safety. It is surprisingly to observe that only 51.9% of the respondents gave the correct answer (survey meter) to this question after the training compared to 40.7% before the training. This showed that the respondents have different point of view in terms of the priority of using a radiation safety item. The distributions of the choice of answers before and after training were shown in Figure 3 and Figure 4, respectively. Before training, it was observed that there were equal percentages (40.7%) of respondents chosen “radiation warning signs” and “survey meter” for this item, but none chosen emergency tongs. However, after the training, it was found that there was an
increase in the percentage of respondents who chosen “survey meter” as the most important radiation safety items.

Figure 3. The distribution of the choice of answers for item “Which one is the most important for the point of view of radiation safety” before training.

Figure 4. The distribution of the choice of answers for item “Which one is the most important for the point of view of radiation safety” after training.

**Table 2.** Percentage of the correct answers of the respondents for radiation safety awareness.

| Item No. | Item                                                                 | Before training | After training |
|----------|----------------------------------------------------------------------|-----------------|---------------|
| 9        | Which of the following is the basic principles of radiation safety:   |                 |               |
|          | Radiation warning signs                                              | 18.5%           |               |
|          | Survey meter                                                         | 40.7%           |               |
|          | Safety manual                                                        | 40.7%           |               |
| 10       | Medical practitioner should .................. the amount of the time in |                 |               |
|          | the room with radiation therapy patient in order to decrease radiation|                 |               |
|          | exposure. Decrease                                                   | 51.9%           |               |
| 11       | As the distance between medical staff and radiation source increases, |                 |               |
|          | the radiation exposure .......... Decreases                             | 54%             |               |
| 12       | A shield between a gamma-emitting radiation source and medical staff  |                 |               |
|          | causes the radiation exposure to ............... Decrease                | 52%             |               |
| 13       | The radiation dose may be reduced by ..................... Moving further|                 |               |
| 14       | What is the annual whole body dose limit for public?                 |                 |               |
|          | 1 mSv                                                                | 48.1            |               |
| 15       | Radiation Safety Office at respective department will be notified     |                 |               |
|          | immediately if there is a radiation incident. True                   | 55.6            |               |
| 16       | Which one of the following items is most important from the point of  |                 |               |
|          | view of radiation safety:                                             | 54%             |               |
|          | Survey meter                                                         | 46%             |               |

4. **Conclusion**

From this survey, the training program provided by the hospital to the nurses in the nuclear medicine department was effective as there is a significant increase in the score of the
respondents before and after the training. However, the knowledge and awareness on radiation safety among the nuclear medicine nurses are still at the moderate level.

It was further recommended that a national study be conducted to determine the level of knowledge about radiation and radiation safety awareness among all the medical staffs in Malaysia. Besides that future strategies to improve nuclear medicine nurses’ knowledge and radiation safety awareness also need to be investigated, developed, implemented and evaluated.

Acknowledgement
The authors would like to acknowledge the co-operation of the staffs at the National Cancer Institute, Putrajaya. This work was supported by a grant from The Ministry of Higher Education (MOHE) under the Fundamental Research Grant Scheme (FRGS) 600-RMI/ST/FRGS5/3/Fst(218/2010).

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