Radioprotection 2022, 57(1), 27–31

https://doi.org/10.1051/radiopro/2021024

Available online at:
www.radioprotection.org

ARTICLE

Knowledge on radiation emergency preparedness among nuclear medicine technologists

N.A. Shubayr[1,2,a,*] and Y.I. Alashban[3,a]

[1] Diagnostic Radiography Technology Department, College of Applied Medical Sciences, Jazan University, Jazan, Saudi Arabia.
[2] Medical Research Center, Jazan University, Jazan, Saudi Arabia.
[3] Radiological Sciences Department, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia.

Received: 14 May 2021 / Accepted: 13 July 2021

Abstract – This study aimed to assess the knowledge of nuclear medicine technologists (NMTs) in radiation emergency preparedness and response operations and their willingness to participate in such operations. A survey was developed for this purpose and distributed to NMTs in Saudi Arabia. Sixty participants responded with a response rate of 63.31%. Based on the overall radiation protection knowledge related to emergency response, NMTs can perform radiation detection, population monitoring, patient decontamination, and assist with radiological dose assessments during radiation emergencies. There were no significant differences in the knowledge on the use of scintillation gamma camera ($P = 0.314$), well counter ($P = 0.744$), Geiger counter ($P = 0.935$), thyroid probes ($P = 0.980$), portable monitor ($P = 0.830$), or portable multichannel analyzer ($P = 0.413$) and years of experience. Approximately 44% of the respondents reported receiving emergency preparedness training in the last 5 years. Respondents who reported receiving training were significantly more familiar with the emergency preparedness resources ($P = 0.031$) and more willing to assist with radiation detection or monitoring in the event of nuclear reactor accident ($P = 0.016$), nuclear weapon detonation ($P = 0.002$), and dirty bomb detonation ($P = 0.003$). These findings indicate the importance of training and continuing education in radiological emergency preparedness and response, which increase the willingness to respond to radiological accidents and fill the gaps in NMTs' knowledge and familiarity with response resources.

Keywords: radiation protection / nuclear medicine / technologist / radiological accident / emergency

1 Introduction

Radiation emergencies are non-routine situations that can be intentional acts intended to hurt others or can be accidental when using radioactive materials. They can be an isolated event or a large-scale catastrophe, which can seriously impact life, property, and the environment. Radiation emergencies include nuclear weapon detonation, dirty bomb detonation, radiological exposure devices, nuclear reactor accidents, transportation accidents, and occupational accidents (IAEA, 2018). Radiation emergencies have been gaining increased attention because of their impact on public health (Coleman *et al.*, 2015; Carr *et al.*, 2016; Veenema *et al.*, 2019). Preparedness and response to radiation emergencies are vital in reducing the risk and mitigating the consequences to prevent deterministic health effects and reduce stochastic health effects (IAEA, 1998).

The type of the radiation emergency and the appropriate preparedness and response vary according to the magnitude of the accident and the nature of radiation exposure and contamination. Some of the radiation emergencies such as nuclear weapon detonation induce a massive influx of victims to hospitals soon after the accident, which requires a sufficient number of trained medical staff to assist in the medical response. Other emergencies such as nuclear reactor accidents have large consequences but may not induce mass casualty inflowing to the hospital. Although, population monitoring is warranted soon after the accident to evaluate contamination and the medical attention needs. Therefore, planning and preparedness for radiation emergencies should be based on several scenarios with different magnitudes taking into consideration the first priorities during the response and the associated challenges. The need for more experts in the radiation field during radiation emergencies is widely emphasized as one of the challenges, especially for medical response (Miller *et al.*, 2005; Tsubokura *et al.*, 2012).

*Corresponding author: nshubayr@jazanu.edu.sa
[a] Both authors contributed equally to this work.

Medical response during radiological accidents requires knowledge on casualty triage, decontamination, radiation protection, and treatment (Hrdina *et al.*, 2009; Lim *et al.*, 2011). Hospitals need to be prepared to respond to radiological accidents and receive causalities. These require special emergency room layouts and qualified medical staff. Emergency room layouts should have two entrances and three zones: hot, warm, and cold (Davari and Zahed, 2015; Ghaedi *et al.*, 2020). Medical staff should have the knowledge to deal with causalities.

Nuclear medicine technologists (NMTs) have the expertise because of their daily work with radioactive materials (Pomerleau *et al.*, 2013). Moreover, NMTs' education in health physics, radiation biology, radiation safety, decontamination, and patient care can be helpful during a radiation emergency (Miller *et al.*, 2007; SNMMI, 2017). Therefore, their expertise can be utilized during radiological accidents.

NMTs can participate in responding to a radiation emergency. They can be part of the response team and provide assistance with radiological dose assessments, population monitoring, development of radiation emergency response plans, and determination of contamination extent (Miller *et al.*, 2007). Furthermore, NMTs can assist in planning and developing training and informational resources tailored to a hospital setting (Becker, 2011) and training hospital staff.

In Saudi Arabia, the Ministry of Health (MOH) is responsible for medical response to radiological accidents. Recently, the MOH developed a plan to prepare NMTs to assist in the medical response during public health crises involving radioactive materials. The plan includes preparing a medical response team, including personnel in the nuclear medicine departments, in each region in Saudi Arabia. It is important to have insight into the NMTs' existing status pertaining to knowledge, preparedness, and willingness to participate. Therefore, this study aimed to assess the knowledge of NMTs in radiation emergency preparedness and response operations and their willingness to participate in such operations.

2 Material and methods

A cross-sectional survey was used, in which data were simultaneously collected from NMTs working in 16 nuclear medicine departments in the MOH hospitals from different regions in Saudi Arabia. There are only 130 NMTs with qualifications and certifications in nuclear medicine.

The original proposal was developed to be a face-to-face interview, however, due to the COVID-19 pandemic, the protocol changed to a web-based survey. Therefore, an online database that has valid contact information of 95 NMTs in Saudi Arabia was used. All the 95 NMTs were invited to participate in the study by email. All data were collected through SurveyMonkey, which participants could access *via* a link in the e-mail. Participate consent form was sent in the same web link before beginning the survey. Participants were informed that their contribution is voluntary, and data will only be used for research purpose and treated in a confidential manner. Invitations and questionnaires were sent to the NMTs at the end of February of 2020. The initial email was followed by three monthly reminders to increase the response rate. A response rate greater than 60% may be considered sufficient for the majority of research purposes (Polit and Beck, 2004). Sixty questionnaires, with a 63.31% response rate, were completed. Participants' responses were anonymous and processed following published principles of good research practice.

To achieve the study objectives, the 26-items self-administered questionnaire was built based on previously published study (Van Dyke *et al.*, 2013) and items related to the country. The first section was dedicated to background questions that covered regional location, work experience, radiation emergency preparedness training. The second section was dedicated to assessing the NMTs' knowledge of radiation protection and the characteristics specific to α-, β-, and γ-emitting radionuclides. The third section evaluated access to equipment that is useful in a response to radiological accidents. The fourth section includes questions about NMTs' familiarity with preparedness resources such as the online resources and the Saudi Center for Disease Prevention and Control (Weqaya) and other online resources. The fifth section was dedicated to continuing education and training on radiological emergency preparedness and response.

The analysis was performed using a Statistical Package for the Social Sciences (version 20, IBM Inc., Chicago, IL). Background data were analyzed with descriptive statistics and presented as percentages, means, and standard deviations. To assess the overall knowledge of the NMTs, we constructed a total knowledge score for the 9 radiation protection questions related to emergency response. A correct answer gave 1 point, yielding a maximum of 9 points. Descriptive analysis was performed, and Chi-square, Fisher's exact, and one-way ANOVA tests were used to determine differences between the knowledge and willingness of NMTs with various levels of experience and training. The results were investigated and presented with confidence intervals of 95%. An α-value of 0.05 was used to determine statistical significance.

Research permission was granted by the MOH. For this study, ethical permission was not required since the study did not include patients, minors, or vulnerable research subjects that could produce psychological or physical harm to participants.

3 Results

Respondents were distributed between all regions in Saudi Arabia as follows: 40% ($n = 24$), central region; 21.7% ($n = 13$), south region; 15% ($n = 9$), east region; 11.67% ($n = 7$), west region; and 11.67% ($n = 7$), north region. Most respondents have work experience <5 years (56.7% [$n = 34$]), with only 3.3% ($n = 2$) having experience >20 years.

NMTs were asked a question to assess their knowledge on the use of radiation detection and monitoring tools during a radiological disaster. There were no significant differences in knowledge on the use of scintillation gamma camera ($P = 0.314$), well counter ($P = 0.744$), Geiger counter ($P = 0.935$), thyroid probes ($P = 0.980$), portable monitor ($P = 0.830$), or portable multichannel analyzer ($P = 0.413$) and years of experience, as shown in Table 1.

Table 1. Knowledge of the use of equipment in a radiological response by years of work experience.

Equipment	<10 years of experience		≥10 years of experience		*P*-value
	Yes	No	Yes	No	
Scintillation gamma camera	82.60% (38)	17.40% (8)	92.85% (13)	7.14% (1)	0.314
Well counter	52.17% (24)	47.82% (22)	57.14% (8)	42.85% (6)	0.744
Geiger counter	93.47% (43)	6.52% (3)	92.85% (13)	7.14% (1)	0.935
Thyroid probes	78.26% (36)	21.73% (10)	78.57% (11)	21.42% (3)	0.980
Portable monitor	67.39% (31)	32.60% (15)	64.28% (9)	35.71% (5)	0.830
Portable multichannel analyzer	67.39% (31)	32.60% (15)	78.57% (11)	21.42% (3)	0.413

Table 2. Responses related to the knowledge of using radionuclide detection equipment to assess patients for radioactive contamination.

Parameter	To scan a large number of individuals for possible radiation exposure	To identify unknown internal radiation contamination	To assess radioiodine uptake	To assess the radiation exposure rate of an area or patient
A scintillation gamma camera is best used	23.33% ($n=14$)	**58.33%** ($n=35$)	10% ($n=10$)	8.33% ($n=5$)
A Geiger counter is best used	18.33% ($n=11$)	16.66% ($n=10$)	5% ($n=3$)	**60%** ($n=36$)
A thyroid probe is best used	11.66% ($n=7$)	6.66% ($n=4$)	**81.66%** ($n=49$)	0% ($n=0$)
A portal monitor is best used	**43.33%** ($n=26$)	25% ($n=15$)	6.66% ($n=4$)	25% ($n=15$)

The correct answers are presented in bold.

The majority of respondents were willing to learn more about scintillation gamma camera (77.7%) ($n=42$), well counter (83.93% [$n=47$]), Geiger counter (80% [$n=44$]), thyroid probes (85.71% [$n=48$]), portable monitor (85.71% [$n=48$]), and portable multichannel analyzer (87.72% [$n=50$]). The responses show that Geiger counters were the most available equipment in nuclear medicine departments (94.92% [$n=56$]), followed by scintillation gamma camera (89.66% [$n=52$]), well counter (81.03% [$n=47$]), thyroid probes (57.89% [$n=33$]), and portable multichannel analyzer (33.33% [$n=19$]).

In the event of a radiological disaster, 70% ($n=42$) of the respondents reported that they are comfortable in performing decontamination of radiological disaster victims. Half of the respondents (50% [$n=30$]) reported that a regular urine bioassay using a well counter can test for internal contamination of gamma radiation. Responses related to the knowledge of using radionuclide detection equipment to assess patients for radioactive contamination are presented in Table 2. Table 3 shows the responses regarding the knowledge of radiation shielding against different types of radiation sources. For the overall radiation protection knowledge related to emergency response, the mean score was 4.38 points (SD = 1.78) with a maximum of 9 points and a minimum of 1 point.

In the event of nuclear reactor accident, nuclear weapon detonation, and dirty bomb detonation, the majority of respondents (88.33% [$n=53$], 57.63% [$n=34$], and 63.33% [$n=38$], respectively) were willing to assist with radiation detection or monitoring at their facilities. Approximately 70% of respondents reported that they feel prepared to be part of a response team in a hospital setting during a radiological disaster. However, the majority of them (55.93% [$n=33$]) reported that they did not receive radiological disaster preparedness training within the last 5 years, and 93.22% ($n=55$) believe that continuing education programs should include training for radiological disaster procedures. Moreover, the majority of respondents (68.97% [$n=40$]) stated that they are not a member and/or have signed up to volunteer in a disaster field through their career. Finally, 62.07% ($n=36$) are unfamiliar with the online resources and the Saudi Center for Disease Prevention and Control (Weqaya) guidance titled "A guide to Medical Response During Radiation Emergency" and "A Guide to Medical Management During Radiation Emergency." The study shows that NMTs who received radiological disaster preparedness training within the last 5 years were significantly more familiar with the available resources ($P=0.031$). The results show that there was no asymptotic significance between the NMTs who participated in training for the last 5 years and correct knowledge assessment answers as presented in Table 4.

4 Discussion

With the shortage of medical specialists to deal with victims of radiological accidents, planning and response to these accidents required utilizing the NMT's experience. Their knowledge in the radiation field and willingness to participate in response during radiological disasters are vital in emergency response because they have access to radionuclide detection equipment in the nuclear medicine departments. These equipment's include scintillation gamma camera, well counter, Geiger counter, and thyroid probe. In this study, most

Table 3. Responses regarding the knowledge of radiation shielding against different types of radiation sources during radiological disaster.

Radiation sources	Shielding materials				
	Air	Lead	Plexiglas	Concrete	Plastic-lined lead container
Caesium-137	6.66% ($n=4$)	**21.66%** ($n=13$)	35% ($n=21$)	13.33% ($n=8$)	23.33% ($n=14$)
Plutonium-239 and/or uranium-235	6.7% ($n=4$)	25% ($n=15$)	11.7% ($n=7$)	**41.7%** ($n=25$)	15% ($n=9$)
Iodine-131	8.3% ($n=5$)	41.7% ($n=25$)	5% ($n=3$)	5% ($n=3$)	**40%** ($n=24$)
Phosphorus-32	6.7% ($n=4$)	21.7% ($n=13$)	**30%** ($n=18$)	16.7% ($n=10$)	25% ($n=15$)

The correct answers are presented in bold.

Table 4. Responses regarding the general knowledge during radiological disasters for respondents who had training for the last 5 years.

Questions related to knowledge	Correct responses	P-value
A regular urine bioassay using a well counter can test for internal contamination of which of the following ionizing radiation	48.14% ($n=13$)	0.795
Best use of a scintillation gamma camera during a radiological disaster	55.55% ($n=15$)	0.436
Best use of a Geiger counter during a radiological disaster	59.25% ($n=16$)	0.287
Best use of a thyroid probe during a radiological disaster	85.18% ($n=23$)	0.739
Best use of a portal monitor during a radiological disaster	48.14% ($n=13$)	0.357
Best shielding materials for Cs-137 contamination	62.96% ($n=17$)	0.957
Best shielding materials for Pu-239 and/or U-235	37.03% ($n=10$)	0.373
Best shielding materials for I-131 contamination	37.03% ($n=10$)	0.852
Best shielding materials for P-32 contamination	33.33% ($n=9$)	1.00

respondents reported the availability and accessibility of these equipment. However, portable multichannel analyzers and portal monitors are not commonly available. The study found various levels of knowledge on the use of the equipment for emergency response. Most respondents showed that they are able to use the equipment for potential radioactive contamination with different types of radiation. Most respondents have <5 years' experience, but their knowledge on the use of the equipment in radiological emergencies showed no difference from that of respondents with more years of experience. In this study, the one-way ANOVA test suggested no correlation between the work experience and the overall radiation protection knowledge related to emergency response (F (8,50) = 1.935; $P = 0.075$). In consistence with our study, several studies found that there is no relationship between the knowledge of radiation protection and work experience (Maharjan *et al.*, 2020; Szarmach *et al.*, 2015). On the other side, studies reported that there is a relation between the knowledge of radiation protection and work (Su *et al.*, 2000).

Training and continuing education on radiological emergency preparedness and response are necessary to balance the shortage in knowledge. A previous study by Sheikh *et al.* (2012) found that respondents who attended training were more familiar and comfortable using radiation detection equipment. In the present study, approximately 44% of the respondents reported receiving emergency preparedness training in the last 5 years. This percentage is higher than that reported in a previous study, which found that only 35.3% of registered NMTs in the United States have training in the last 5 years (Van Dyke *et al.*, 2013). This is because the MOH regularly offers training programs. However, this percentage does not reflect the level of knowledge and familiarity with equipment used during emergencies. The study shows no significant difference between the trained NMTs and their preparation to work as a part of a response team in a hospital setting during a radiological disaster ($P = 0.306$). Effective training programs and motivation of the NMTs are necessary to prepare qualified personnel for radiation emergency response.

Respondents who reported receiving training were significantly more familiar with the Centers for Disease Control and Prevention guidance documents and other online resources ($P = 0.031$). Likewise, NMTs who received radiological disaster preparedness training within the last 5 years were significantly more willing to assist with radiation detection or monitoring in the event of nuclear reactor accident ($P = 0.016$), nuclear weapon detonation ($P = 0.002$), and dirty bomb detonation ($P = 0.003$). These findings indicate the importance of radiological emergency training and the need for continuing education on radiological emergency preparedness and response. Several studies indicated that lack of knowledge and training on radiological emergency preparedness could be a potential reason for medical staff unwilling to assist during radiological accidents (Dallas *et al.*, 2017; McCurley *et al.*, 2009).

As a limitation of this study, the number of respondents is quite low ($n = 60$), with a response rate of 63.31%, which may represent a weakness of the study. However, this was counterbalanced by a good representation of all regions of Saudi Arabia.

5 Conclusion

NMTs are valuable in terms of medical response to radiological accidents. With their willingness to participate in emergency response, NMTs can help in planning and be part of the response team. Based on the overall radiation protection knowledge related to emergency response, NMTs can perform radiation detection, population monitoring, patient decontamination, and assist with radiological dose assessments during radiation emergencies. These tasks are commonly useful for all kinds of radiological accidents but more important for large-scale accidents. Therefore, the NMTs would be most useful in the case of nuclear weapon detonation where a massive influx of patients to the hospital is expected.

Most respondents have considerable knowledge and familiarity with the use of equipment. However, as this study showed, there is a need for effective training and continuing education, which would increase the willingness to respond to radiological accidents and fill the gaps in NMTs' knowledge and familiarity with emergency response resources. Therefore, this study recommends following the training guidance of the Incident and Emergency Centre, International Atomic Energy Agency, which covers the critical topics for emergency response including guidance on general management, protecting responders, initial on-site response, transferring patients, setting up the emergency area, managing contaminated patients, diagnosis, assess and treat overexposed patients, as well as the radiological advanced techniques and methods for the response.

Acknowledgments

Authors extend their appreciation to the Ministry of Health and the Deanship of Scientific Research at Jazan University for supporting this research.

Conflicts of interest. The authors declare that they have no conflicts of interest in relation to this article.

References

Becker SM. 2011. Learning from the 2011 Great East Japan Disaster: insights from a special radiological emergency assistance mission. *Biosecur. Bioterror.* 9: 394–404.

Carr Z, Clarke M, Akl EA, Schneider R, Murith C, Li C, Parrish-Sprowl J, Stenke L, Cui-Ping L, Bertrand S, Miller C. 2016. Using the grade approach to support the development of recommendations for public health interventions in radiation emergencies. *Radiat. Prot. Dosim.* 171: 144–155.

Coleman CN, Sullivan JM, Bader JL, Murrain-Hill P, Koerner JF, Garrett AL, Weinstock DM, Case Jr C, Hrdina C, Adams SA, Whitcomb RC. 2015. Public health and medical preparedness for a nuclear detonation: the nuclear incident medical enterprise. *Health Phys.* 108: 149.

Dallas CE, Klein KR, Lehman T, Kodama T, Harris CA, Swienton RE. 2017. Readiness for radiological and nuclear events among emergency medical personnel. *Front. Public Health* 5: 202.

Davari F, Zahed A. 2015. A management plan for hospitals and medical centers facing radiation incidents. *J. Res. Med. Sci.* 20: 871.

Ghaedi H, Nasiripour AA, Tabibi SJ, Assadi M. 2020. Pillars of hospital preparedness in radiation emergency management. *Health Phys.* 119: 306–314.

Hrdina CM, Coleman CN, Bogucki S, Bader JL, Hayhurst RE, Forsha JD, Marcozzi D, Yeskey K, Knebel AR. 2009. The "RTR" medical response system for nuclear and radiological mass-casualty incidents: a functional TRiage-TReatment-TRansport medical response model. *Prehosp. Disaster. Med.* 24: 167–178.

IAEA. 2018. *Arrangements for the termination of a nuclear or radiological emergency*. Safety Standards Series No. GSG-11.

IAEA. 1998. *Planning the medical response to radiological accidents*. Safety Reports Series No. 4.

Lim HCS, Ng KS, Tan HH, Leong KWG. 2011. Review of the hospital preparedness for radiation emergencies and medical management of multiple combined radiation injury victims. *Proc. Singap. Healthc.* 20: 197–207.

Maharjan S, Parajuli K, Sah S, Poudel U. 2020. Knowledge of radiation protection among radiology professionals and students: a medical college-based study. *Eur. J. Radiol. Open* 7: 100287.

McCurley MC, Miller CW, Tucker FE, Guinn A, Donnelly E, Ansari A, Holcombe M, Nemhauser JB, Whitcomb Jr RC. 2009. Educating medical staff about responding to a radiological or nuclear emergency. *Health Phys.* 96: S50– S54.

Miller CW, Whitcomb RC, Ansari A, McCurley C, Guinn A, Tucker F. 2007. The roles of medical health physicists in a medical radiation emergency. *Health Phys.* 93: S187– S190.

Miller K, Groff L, Erdman M, King S. 2005. Lessons learned in preparing to receive large numbers of contaminated individuals. *Health Phys.* 89: S42– S47.

Polit DF, Beck CT. 2004. *Nursing research: principles and methods*. Lippincott Williams & Wilkins.

Pomerleau AC, Ansari A, Miller CW. 2013. Radiation public health emergencies, community resilience, and the role of nuclear medicine technologists. *JNMT* 41: 184–185.

Sheikh S, McCormick LC, Pevear J, Adoff S, Walter FG, Kazzi ZN. 2012. Radiological preparedness-awareness and attitudes: a cross-sectional survey of emergency medicine residents and physicians at three academic institutions in the United States. *Clin. Toxicol.* 50: 34–38.

SNMMI-TS Scope of Practice Task Force. 2017. Nuclear medicine technologist scope of practice and performance standards. *J. Nucl. Med. Technol.* 45: 325–336.

Su WC, Huang YF, Chen CC, Chang PS. 2000. Radiation safety knowledge of medical center radiological technologists in Taiwan. *Radiat. Oncol.* 50: 1–3.

Szarmach A, Piskunowicz M, Świętoń D, Muc A, Mockałło G, Dzierżanowski J, Szurowska E. 2015. Radiation safety awareness among medical staff. *Pol. J. Radiol.* 80: 57–61.

Tsubokura M, Gilmour S, Takahashi K, Oikawa T, Kanazawa Y. 2012. Internal radiation exposure after the Fukushima nuclear power plant disaster. *JAMA* 308: 669–670.

Van Dyke ME, McCormick LC, Bolus NE, Pevear J, Kazzi ZN. 2013. Radiological emergency preparedness: a survey of nuclear medicine technologists in the United States. *J. Nucl. Med. Technol.* 41: 223–230.

Veenema TG, Lavin RP, Bender A, Thornton CP, Schneider-Firestone S. 2019. National nurse readiness for radiation emergencies and nuclear events: a systematic review of the literature. *Nurs. Outlook* 67: 54–88.

Cite this article as: Shubayr NA, Alashban YI. 2022. Knowledge on radiation emergency preparedness among nuclear medicine technologists. *Radioprotection* 57(1): 27–31