Title

NURSES' KNOWLEDGE OF RADIATION PROTECTION: A CROSS-SECTIONAL STUDY

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Highlights

1. Nurses reported their knowledge in informing abnormal radiation use and health monitoring as quite poor.
2. The lowest knowledge levels were reported for the area of radiation physics and principles of radiation use.
3. A nurse's educational level were shown to influence their knowledge in radiation.
4. Healthcare organizations need to concentrate on providing education to all nurses working with, or exposed to, radiation.

Keywords: education, ionising radiation, knowledge, nurse, safety, radiation, radiation protection, x-ray

Abstract

Introduction: Nursing roles are changing, as several countries have amended legislation so that nurses can make referrals for medical imaging examination that utilize ionising radiation. Nevertheless, nurses' radiation knowledge remains a poorly studied concept. The aim of the study was to characterize Finnish nurses' knowledge of radiation use and radiation safety. In this study, nurses were working in operating theaters, first aid clinics and cardiology laboratories.

Methods: A cross-sectional design was applied in which data were simultaneously collected from nurses working in eight hospitals. All nurses working in operating theaters, first aid clinics and cardiology laboratories (N=1500) at the hospitals in Finland were invited to participate in the study. The response rate was 17% (n=252). The employed Healthcare Professional Knowledge of Radiation Protection (HPKRP) scale included three areas of knowledge: radiation physics, biology and principles of radiation use; radiation protection; and guidelines of safe ionizing radiation use. Descriptive statistics and logistic regression analyses were used to identify factors that influence these three areas.

Results: Nurses reported high knowledge levels in radiation protection but low knowledge levels in radiation physics, biology and principles of radiation use. Moreover, nurses who had not received radiation education reported lower knowledges across all three areas than the nurses who had completed education.

Conclusion: This study identified one major factor that significantly affects nurses' radiation knowledge, namely, having completed medical radiation education, as this factor positively influenced all three of the included areas of radiation knowledge factors. Therefore, healthcare organizations should concentrate on providing education to all nurses working with, or exposed to, radiation.

Introduction

The extent to which nurses use, and are exposed to, ionizing radiation in their daily work varies internationally and depends on their specific work assignments[1-4]. Hence, several studies have investigated nurses' levels of exposure to ionizing radiation[5-6]. Today, its use is covered by guidelines issued by international radiation safety organizations[7]. In addition, in European countries, its use in healthcare settings is governed by regulations set by the European Council. Individual countries may also have their own national regulations and guidelines, such as the Radiation Act (859/2018) that governs use of ionizing radiation in Finland[3]. In recent years, nurses in several countries have been given the right to make referrals for medical imaging examinations that utilize radiation. For example, nurses have this right in the Republic of Ireland, provided they have sufficient training[8]. These changes raise important questions regarding the required level of radiation knowledge and guarantees that all of the relevant nursing staff acquire it[8-9]. Another issue relates to the overlapping involvement of distinct professional groups (nurses, doctors and radiographers with varying degrees of expertise and specialization). This complicates implementation of the changes, since evaluating the level of radiation knowledge among different occupational groups is complex[8]. Moreover, this shift in nurses' responsibilities is accompanied by a continuing need to modify their training to improve their understanding of uses, benefits and risks of ionizing radiation[8,10] Thus, international studies have identified a need for further research on the current level of radiation knowledge among nurses working in relevant environments[5-6,8,10-11], to identify deficiencies and facilitate formulation of the most effective educational interventions to meet the new requirements.

Previous studies have noted a general lack of radiation education among nurses working with radiation[5,12], and various countries' radiation safety policies impose few (if any) requirements for nurses to have such education[13]. In Finland, only a few universities of applied sciences provide modules related to radiation safety in nurse education programs.

In their workplaces, nurses receive radiation training according to stipulations in the Radiation Act (859/2018), i.e. if their work requires use of radiation and their basic education did not include a radiation module[3]. Nurses working in operating theaters, first aid clinics or cardiology laboratories who work with fluoroscopic medical imaging equipment must meet medical radiation knowledge criteria set in the Regulation of Ionizing Radiation (1044/2018) before starting work, and receive 20 hours of additional training during the next five years[4]. The completion of this training, either at the place of work or at an educational institution, is intended to ensure that nurses have sufficient competence to work in environments where radiation is used and/or there are risks of significant exposure to above-background radiation.

To ensure that nurses have sufficient radiation knowledge (defined here as an individual's ability to use radiation in a safe manner) it is first essential to establish their current level of knowledge, and identify specific deficiencies. To assist such efforts, in this study the radiation knowledge of Finnish nurses was gauged using the Healthcare Professional Knowledge of Radiation Protection (HPKRP) scale[15], which is designed to provide indications of three areas of radiation knowledge. These are: radiation physics and principles of radiation use in a medical context[3,4,5]; radiation protection, covering the protection of patients and personnel from ionizing radiation[3,5,14]; and guidelines for medical radiation use, concerning knowledge about international and national guidelines for safe use of radiation[3,7].

Methods

Aim

The aim of the study was to characterize Finnish nurses' knowledge of radiation use and radiation safety. In this study, nurses were working in operating theaters, first aid clinics and cardiology laboratories.

Two specific research questions were addressed:

1. What is these nurses' current level of radiation knowledge**?**

2. What background factors affect their knowledge of radiation use and safety?

Study design

A cross-sectional design was applied, in which data were simultaneously collected from nurses working in eight hospitals.

Participants and settings

All nurses working in operating theaters, first aid clinics and cardiology laboratories (N=1500) at four randomly selected university hospitals and four randomly selected central hospitals in Finland were invited to participate in the study. Thus, stratified random sampling based on territorial division of the Finnish healthcare system was applied. Inclusion criteria were that nurses had to be working in a unit where s/he may use ionizing radiation or be exposed to it, and had received radiation education in the form of a course or module(s) in a degree program. Nurses who are exposed to radiation daily are usually working in operating theatres, first aid clinics and cardiology laboratories in Finland. In such units no radiographer may be present, so nurses may have substantial responsibility. Invitations and questionnaires were sent to the nurses at the end of spring and beginning of autumn 2017. The response rate was 17% (n=252).

Instrument

The questionnaire was self-administered and consisted of background questions and the HPKRP scale items, which (as mentioned above) are divided into three sections. Background questions covered age, gender, work experience, educational level and information about the nurses' hospital and working unit. The Healthcare Professional Knowledge of Radiation Protection (HPKRP) scale[15] was developed for this study by the authors and used to evaluate the radiation knowledge of participating nurses. The scale's three sections cover the following areas or dimensions of radiation knowledge: Radiation physics, biology and principles of radiation use (12 items); Radiation protection (13 items); and Guidelines for safe ionizing radiation use (8 items). Participants scored aspects of their radiation knowledge specified in the items using a 10-point Likert-scale, ranging from 1 (no knowledge) to 10 (full knowledge). Thus, the scale has been designed to obtain high-accuracy information about participants' self-reported knowledge of multiple aspects of radiation and its use. It has been psychometrically tested, and found to have adequate face, content and construct validity[14], with Cronbach's alpha coefficients ranging from 0.93 to 0.96 and an overall S-CVI value of 0.83.

Data collection

All 1500 nurses working in operating theaters, first aid clinics and cardiology laboratories at the selected hospitals were invited to participate in the study by an email that was sent via their superiors. Due to a low response rate, this initial email was followed by three weekly reminders by the researchers (TSS, LH) to the superiors during the study, and on each occasion the superiors confirmed receipt of the reminder. All data were collected through the Webpropol survey program, which participants could access via a link in the e-mail. Participants' responses were anonymous and processed following published principles of good research practice.

Data analysis

The data were analyzed using SPSS versions 23.0 and 24.0 (IBM Corporation, Armonk, NY). Background data were analyzed with descriptive statistics, and presented as percentages, means and standard deviations. Logistic regression was used to analyze whether any of the background factors were related to a nurse's radiation knowledge, with binary logistic regression models built using the forced entry method, as implemented in the software. The outcome variables were transformed from Likert scale responses into dichotomous variables (0 for scores of 1.00-4.99 and 1 for scores of 5.00-10.00, designated 'lower' and 'higher' knowledge, respectively). The goodness-of-fit of the models was assessed with the Omnibus test of model coefficients, Cox & Snell and Nagelkerke R square tests, and the Hosmer and Lemeshow test, as implemented in the software. The results were investigated and presented as odds ratios with confidence intervals of 95%[16]. Statistical significance was set at $p<0.05$. Effect sizes were measured using the odds ratios of statistically significant results, and interpreted according to the following thresholds: 1.5- small, 2.5- moderate, 4- large, and 10 – very large[17-19].

Ethical considerations

Research permission was granted by all eight selected hospitals. In addition, the research committee of each hospital and head nurse of each work unit involved approved the research. The study was conducted according to principles of good research practice and respect for human dignity[20]. The study did not require permission from an ethics committee since it did not involve patients, underage children, or vulnerable research areas that could cause psychological or physical harm to participants[21].

Results

Of the 252 participating nurses, most (215, 85%) were female. The nurses had various educational backgrounds: 157 (62%) had a bachelor's degree from a university of applied sciences, 13 (6%) had a master's degree, and 82 (33%) had a diploma. Most of the participating nurses, 163 (65%), had completed separate medical radiation education that was not connected to their educational degree, but the other 89 (35%) had received no such education (Table 1).

The mean values for the three dimensions of radiation knowledge, measured using a 10-point Likert scale, varied between 3.79-6.46 (Table 2). Participating nurses scored their knowledge of radiation protection most highly (mean 6.46, SD 2.40), followed by guidelines for safe radiation use (mean 4.77, SD 2.55), and radiation physics and principles of radiation use (mean 3.79, SD 2.26).

Logistic regression analysis showed that educational level, medical radiation education and nurse's work unit correlated with each assessed dimension of radiation knowledge (Table 3). Nurses with a master's degree from a university of applied sciences reported significantly higher levels of knowledge of radiation physics, biology and principles of radiation use than nurses with diploma-level education (OR=0.07, 95% CI=0.07-0.80, p=0.03). Similarly, nurses who had completed medical radiation education reported significantly higher levels of this knowledge than nurses who had not completed such education (OR=0.16, 95% CI=0.06-0.41, p<0.01). The nurses' work units were also linked to self-rated knowledge in this dimension. For example, nurses working in a cardiology laboratory unit reported higher levels of knowledge of radiation physics and principles of radiation use than operating theater nurses (OR=5.62, 95% CI=2.14-14.80, p<0.01).

Nurses who had received medical radiation education also reported significantly higher levels of knowledge of radiation protection than nurses who had not completed such education (OR=0.21, 95% CI=0.10-0.44, p<0.01). Age was also correlated with radiation knowledge, as nurses in the 38-47 years age group reported significantly higher levels of knowledge of guidelines for safe radiation use than nurses who were 18-27 years old (OR=0.34, 95% CI=0.12-0.96, p=0.04). Once again, nurses who had completed medical radiation education reported higher levels of radiation knowledge in knowledge of guidelines for safe radiation use than nurses who had not done so (OR=0.20, 95% CI=0.10-0.41, p<0.01). Classification of logistic regression model ranged from 71.40% to 82.1%. The effect sizes calculated from the binary logistic regression were moderate (OR=2.94), large (OR=4.09, OR=4.76, OR= 5.00, OR=5.62, OR= 6.25), or very large (OR=14.3).

Discussion

The presented research revealed that participating nurses rated their knowledge of radiation protection more highly (6.46 on average, on the 10-point Likert scale) than their knowledge of the other two tested dimensions of radiation knowledge. The indication that nurses have relatively good understanding of radiation protection measures is reassuring, given the importance of radiation protection for people who may be exposed to it[22]. The participating nurses scored their knowledge of guidelines for safe radiation use second highest, but the mean Likert score was just 4.77 (in the 'lower' category). They reported that they were adept at using warning signs in radiation safety, but lacked knowledge about reporting abnormal radiation use and health monitoring. Shortcomings in knowledge of radiation safety protocols and measures have been previously noted[9], and should clearly be addressed to ensure the safe use of radiation[23].

The lowest reported knowledge levels (mean Likert score just 3.79) were for the dimension of radiation physics and principles of radiation use. Moreover, the item eliciting the lowest score (3.59) concerned knowledge of the ALARA (As Low As Reasonably Achievable) principle. Lack of knowledge of this key principle has been noted (and previously raised concerns) internationally[5,23]. Another important finding is that the nurses felt that they had not received enough radiation education, as also previously discussed[5]. However, their educational level and completion of medical radiation education were both positively correlated with their knowledge of radiation physics and principles of radiation use. In addition (and perhaps more importantly) nurses working in cardiology laboratory units reported significantly higher levels of this knowledge than operating theater nurses. This is consistent with previous findings that nurses working in radiology departments have more knowledge of radiation physics and basic radiation use than colleagues working elsewhere (including those engaged in fluoroscopic examinations in operation theaters)[5]. It should be noted that radiation doses are relatively high in operation theaters compared to the conventional radiation examinations, thus a lack of knowledge about radiation use among nurses working in them poses higher health risks. In conclusion, healthcare organizations should pay more attention to provisions of radiation education for nurses working outside radiology departments, and more generally seek to improve knowledge of radiation and foster a culture of radiation awareness and safety[23].

The need to improve education is supported by another finding, of a clear difference in knowledge of radiation protection between nurses who had and had not received radiation education. This corroborates previous reports that formal radiation safety training outside of work is positively linked to knowledge of radiation safety[9], and lack of knowledge of radiation protection increases risks of adverse events[12]. Our results also indicate that education improves knowledge of guidelines for safe radiation use, and this knowledge is associated with nurses' work units. In overall conclusion, education is essential for ensuring that staff effectively implement relevant rules and procedures for safe radiation use[24], improving the safety culture among radiation users, and adhering to both national and international guidelines.

Limitations

This study had several limitations. The results for nurses working in a cardiology laboratory regarding knowledge of radiation physics, biology and principles of radiation use, had very wide confidence intervals and should therefore be interpreted with caution (for example OR=5.62, 95% CI=2.14-14.80, $p<0.01$). The large differences in sample sizes of nurses working in the three included kinds of work units—operating theaters (n=170), cardiology laboratories (n=29) and first aid clinics (n=53)—might have also affected outcomes of the study. The differences in sample size and generally low response rates should also be considered when generalizing the presented results. Power analysis before the study could have been helpful for determining required sample sizes and strengthening the prediction of size effects, but it was not possible since we found no previous studies of the same scale or similar studied phenomena. However, the STROBE checklist was used throughout the planning, conducting and reporting of the study in efforts to improve its quality[25].

Conclusion

The study identified a major factor that significantly affected nurses' radiation knowledge: completion of medical radiation education, which was positively correlated with all three tested dimensions of radiation knowledge. Therefore, healthcare organizations should improve provisions of education for all nurses working with, or exposed to, radiation. The results show the importance of radiation knowledge and most importantly, the role of education in ensuring safe medical radiation use. However, further studies are needed to identify optimal interventions to address deficiencies in nurses' radiation knowledge, and this is particularly important in Finland, where changes to the radiation act are being considered.

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Table 1. Background information of the nurses (n=252)

Background variables	n	%
Age		
18-27	31	12
28-37	79	31
38-47	65	26
48-57	59	23
over 57	18	7
Gender		
Female	215	85
Male	37	15
Work experience in years		
0-4	45	18
5-9	44	18
10-14	43	17
15-20	41	16
over 20	79	31
Education		
Diploma level education	82	33
Bachelor degree, university of applied science	157	62
Master's degree, university of applied science	9	4
Master's degree of university	4	2
Unit		
Operating theater	170	68
Cardiology laboratory	29	12
First aid clinic	53	21
Medical radiation education		
Yes	163	65
No	89	35

Table 2. HPKRP-scale's items and sub-dimensions of competence (n=252)

HPKRP-scale main factors and items	Mean	Standard deviation
Radiation physics, biology and principles of radiation use	3.79	2.26
I know how ionizing radiation is produced	3.92	2.82
I know the differences between ionising and non-ionising radiation	3.46	2.72
I know the differences between electromagnetic and ioniszing radiation	3.28	2.47
I know the characteristics and physical features of x-rays	4.18	2.64
I know how the harmful effects of medical radiation are caused	4.90	2.81
I can describe the deterministic effects of a certain radiation doses	4.20	2.68
I can describe the stochastic effects of a certain radiation dose	3.73	2.55
I know the justification principles for medical radiation examinations	3.79	2.94
I understand the equations and measures in medical radiation examinations	3.59	2.48
I understand the meaning of the As Low As Reasonably Achievable -principle in radiation examinations	2.25	2.42
I know the fundamental principles of radiation protection	4.48	2.91
I have obtained enough education about the use of radiation in medical examinations	3.70	2.65
Radiation protection	6.46	2.40
I know how to properly use personal radiation protection equipment (PPE)	7.97	2.53
I know how to properly use the radiation protection equipment for patients	7.09	2.76
I pay attention to the other personnel while working in a controlled area and using radiation	7.38	2.93
I know how to document all the essential information concerning the use of radiation	5.73	3.49
I am aware that information concerning a patient's radiation dose must be written down in patient records	7.44	2.99
I know the protocols concerning radiation workers who are pregnant	7.40	2.88
I try to promote agreed safety protocols concerning radiation dose and radiation usage in my daily work and actions	6.86	2.76
I understand the factors affecting a patient's radiation dose	6.22	2.91
I understand the meaning of the inverse square law in radiation protection	6.18	3.33
I know how to account for differences between adult and child/adolescent patients in radiological examinations	5.45	2.85
I know how to asses my actions critically and comprehensively while working with medical radiation	5.34	2.91
I am aware of the radiation safety arrangements at my work	5.37	2.99
I understand the meaning of radiation safety culture	5.53	2.93

Guidelines of safe ionizing radiation use	4.77	2.55
I know the meaning of warning signs regarding radiation safety	5.79	3.00
I observe and notice the warning signs concerning radiation while working in the control area	5.81	3.04
I know how radiation workers' health monitoring has been organized	3.93	3.04
I am aware of the classification of radiation workers	4.43	3.11
I understand the procedures for how radiation exposure in radiation workers is monitored	5.40	3.23
I know how to report abnormal events in radiation usage	3.57	2.92
I understand the situations in which the ”abnormal event notification” must be performed	4.30	3.10
I understand the principle of dose limitation in radiation protection	4.92	3.10

Table 3. Background factors related to three areas of radiation knowledge (n=252)

Independent variable	Outcome variable					
	Radiation physics, biology and principles of radiation usage		Radiation protection		Guidelines of safe ionizing radiation usage	
	OR(CI 95%)	p	OR(CI 95%)	p	OR(CI 95%)	p
Age in years						
18-27 (ref.)						
28-37	0.41 (0.14, 1.17)	0.09	0.99 (0.4, 2.8)	0.99	0.46 (0.18, 1.19)	0.11
38-47	0.33 (0.10, 1.06)	0.06	0.84 (0.3, 2.7)	0.76	0.34 (0.12, 0.96)	**0.04**
48-57	0.49 (0.14, 1.66)	0.25	1.53 (0.4, 5.9)	0.54	0.43 (0.14, 1.34)	0.15
over 57	0.52 (0.11, 2.5)	0.41	7.75 (0.54, 109.9)	0.13	0.9 (0.19, 4.13)	0.89
Education						
Diploma level education (ref.)						
Bachelor degree, university of applied science	0.48 (0.20, 1.16)	0.10	0.67 (0.23, 1.90)	0.45	0.46 (0.21, 1.04)	0.06
Master's degree, university of applied science	0.07 (0.01, 0.80)	**0.03**	0.67 (0.05, 8.73)	0.76	1.16 (0.19, 6.92)	0.87
Master's degree of university	1.77 (0.13, 23.56)	0.66	0.43 (0.04, 4.65)	0.49	2.01 (0.23,17.94)	0.53
Medical radiation education						
Yes (ref.)						
No	0.16 (0.06, 0.41)	**0.01**	0.21 (0.10, 0.44)	**0.01**	0.20 (0.10, 0.41)	**0.01**
Unit						
Operating theater (ref.)						
Cardiology laboratory	5.62 (2.14, 14.80)	0.01	-	-	4.09(1.42,11.75)	0.09
First aid clinic	0.47 (0.14, 1.59)	0.23	0.20 (0.09, 0.44)	0.01	0.56 (0.23, 1.37)	0.21
Omnibus		0.01		0.01		**0.01**
Hosmer and Lemeshow		0.92		0.93		0.96
Cox&Snell, Nagelkerke R Square		22.9%-32.4%		31.0%-45.1%		23.4%-31.3%
Classification		75.0%		82.1%		71.4%