Original

Radiation Protection Capability of Operating Room Personnel: Development and Psychometric Properties of a Questionnaire

Zinat Mohebbi[1], Roya Ershadpoor[2], Mohsen Ostovari[3], Mahnaz Rakhshan[1]*

[1]PhD, Department of Nursing, School of Nursing and Midwifery, Shiraz University of Medical Sciences, Shiraz, Iran
[2]MSc, Student research committee, Shiraz University of Medical Sciences, Shiraz, Iran
[3]PhD, Department of Medical Physics and Engineering, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran

ABSTRACT

Background: Radiation protection is an important principle in some wards of the hospital such as radiology, catheterization laboratory and operating room. Due to the increasing use of radiation in the operating room, there is a need to design an accurate and appropriate tool to evaluate the radiation protection capability of operating room personnel.

Objective: This study aims to test the psychometric properties of a questionnaire on radiation protection capability.

Material and Methods: This cross-sectional study was conducted in two stages. The first stage was designing items based on the review of available literature, and the second stage was measuring the validity and reliability of the questionnaire using face validity and content validity Content Validity Index (CVI) and Content Validity Ratio (CVR). Then the questionnaire was filled out by 200 operating room nurses to evaluate the construct validity by Principal Component Analysis method. Reliability of the questionnaire was evaluated by test–retest and Cronbach's alpha analysis method.

Results: Due to the results, test–retest correlation coefficient was 0.912, and Cronbach's alpha coefficient was 0.824, indicating a desirable internal consistency.

Conclusion: This study introduces a valid and reliable questionnaire for evaluating the radiation protection capability of operating room nurses.

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Keywords
Radiation Protection, Questionnaire; Operating Room Nursing, Psychometrics, Ionizing Radiation, Operating Theatre

Introduction

Nowadays, radiation is widely used in operating rooms [1]. In addition to the practical benefits of radiation, its side effects should be considered since the ionizing radiation increases the risk of DNA damage and cancer in nurses and other operating room personnel [2-4].

The most commonly used radiation-generating device in the operating room is C-arm or fluoroscope, which is used in a variety of surgeries such as orthopaedics, urology, neurosurgery, and angiography [5]. The

*Corresponding author: Mahnaz Rakhshan
School of Nursing and Midwifery, Shiraz University of Medical Sciences, Zand Blv, Namazi Square, Shiraz, Iran
E-mail: mzrakhshan@ymail.com

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use of radiation shield significantly reduces the radiation dose received by nurses, surgeons and patients [6-8]. Awareness of the principles of radiation protection and their observance by nurses working in the operating room has a significant role in reducing the risks of ionizing radiation. [1, 9-12]. Therefore, a comprehensive tool evaluating all aspects of radiation protection in the operating room personnel could be useful [13].

The Australian Institute of Radiology (AIS) defines radiographers' 'professional capability' as the application of professional knowledge and skill to perform a desired function. This professional capability includes several skills such as knowledge, professional communication skills, teamwork skill, risk management, safety, technical skills and critical thinking skills in the field of working with X-rays [14]. Therefore, radiation protection capability is a desirable concept to evaluate the knowledge, attitude, practice and professional commitment of nurses and surgeons in risk management and protection of personnel and patients against radiation [13-15].

Literature review in databases of Web of Science, PubMed and Scopus and so on indicated that there were few questionnaires, specifically designed for measuring radiation protection capability in the operating room field, and the available questionnaires are intended for measuring limited dimensions such as knowledge of radiation protection [1, 9-12]. Also, few studies were about radiation protection capability while considering the patient safety against radiation [13, 16]. Moreover, the most of the available questionnaires about radiation protection were designed to be used in radiology wards and they are not appropriate and adequate to be used in the operating room, where the sterility rules and some other principles influence radiation protection acts [17-25]. Thus, working situation and professional duties related to the application of radiation in the operating room ward are different from radiology ward, and are not even similar in the type of radiation generating devices, physical environment, and individuals' knowledge about physics of radiation [7, 8, 26, 27].

Therefore, an operating room-specific radiation protection questionnaire should be designed.

Hence, given the increasing use of radiation in the operating room, it is important that operating room personnel have the capability to protect against radiation. In this regard, the designing and psychometrics of a valid and relevant tool can be useful in acquiring knowledge and understanding of this matter. Therefore, the aim of this study was to design a questionnaire about radiation protection capability of operating room nurses and surgeons.

Material and Methods

Design, setting and subjects

This cross-sectional study was conducted in two stages. In first stage, the items were designed based on the review of available literature, and in second stage, the validity (face validity and content validity) of the questionnaire was evaluated. Then construct validity was evaluated by Principal Component Analysis method. Reliability of the questionnaire was evaluated by test–retest and Cronbach's alpha analysis method.

In stage one, the items were extracted through literature review, including the national and international guidelines [7, 8, 26], books [27, 28] and related articles within the past 10 years [1, 9-13, 17-25]. Then the selected items were evaluated by the panel of experts. The panel of experts included several experienced specialists in the field of operating room nursing, psychometrics, radiology and nuclear medicine as well as some experienced radiographers in the operating room, all of whom were familiar with the concept of radiation protection. Eventually, the final draft with 120 items was approved. The considered dimensions of the questionnaire include knowledge, attitude, practice and professional commitments. A 5-point Likert scale (never, rarely, occasionally, usually, and always) was used to score the items.

Data analysis

Validity

To evaluate the validity of the questionnaire, both face validity and content validity (Content Validity Ratio (CVR) and Content Validity Index (CVI)) were tested using qualitative and quantitative approaches. Construct validity was also determined by Principal Component Analysis method.

Face validity

Face validity was confirmed by quantitative and qualitative methods. Qualitative face validity was evaluated by a panel of 6 experts. Each expert checked the questionnaire and presented their opinions about the difficulty, relevancy, comprehensibility and ambiguity of each item.

In quantitative validity method, the importance of each item was evaluated by the 6 experts (concept and psychometric) and 6 operating room nurses. The importance of each item was evaluated using a five-point Likert scale. Finally, if the impact score of the item was equal or greater than 1.5, the item was kept for the following steps [29].

Content validity

Qualitative and quantitative methods were used to determine the content validity. This phase was performed by 8 experts. In the qualitative content validity, each expert checked the questionnaire and presented their opinions about the grammar of items, the use of appropriate words and placement of items in the proper domain.

Quantitative content validity was evaluated by using Content Validity Ratio (CVR) and Content Validity Index (CVI). CVR was evaluated to check the necessity of the items by a three-point Likert scale. According to Lawshe [30], a score, which was higher than 0.75, was significant.

CVI was evaluated to check the relevancy, simplicity and clarity of the items. In CVI survey based on the Waltz Content Validity Index, a higher score of 0.79 was recommended for the acceptance of the items [31].

Construct validity

The questionnaire was filled out by 200 operating room nurses using census method for evaluating the construct validity. Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were investigated to test the correlation between the items of the questionnaire. KMO score, which was higher than 0.7, was significant.

Principal Component Analysis (PCA) was used to integrate the correlated items and to obtain the true dimensions of the questionnaire. Item reduction and contribution of items to the instrument were measured by factor loading and "alpha if item deleted" method [32]. SPSS Version 25 was used for the analysis of the data.

Reliability

Reliability with internal consistency approach were checked through the Cronbach's alpha and test-retest analysis amongst 200 operating room nurses. Test-retest approach was used to measure the stability of the questionnaire among 26 operating room nurses. Based on the recommendations [33], the retest was taken 14 days after the primary test.

The minimum and maximum score of clinical capability were 27 and 135, respectively. In addition, good, moderate, and weak classes of radiographers were determined based on achieving ≥75%, 50%-75%, and <50% of the total score, respectively. Table 1 shows the cut off points of the scale.

Table 1: Cut off points of clinical capability and its subscales.

Scales	Clinical capability	knowledge	Attitude	practice
Good	> 108	>40	>28	>40
Moderate	81-108	30-40	21-28	30-40
Weak	< 81	< 30	< 21	< 30

Results

Participants' demographics

200 operating room nurses were tested in order to evaluate the construct validity and reliability of the designed questionnaire. The mean age of the participants was 33.34 ± 8.09 years and length of work experience was 9 ± 7.37 years, respectively. Table 2 shows the result of participants' demographic information.

Validity

Face validity

In qualitative face validity, the pool of items was checked by the experts' panel and inappropriate and extra items were removed from the questionnaire. In doing so, the items were reduced from 120 to 63. In quantitative face validity, the items with the score of less than 1.5 were removed from the questionnaire; hence, the items were reduced from 63 to 40. The mean score of quantitative face validity was 3.024, respectively.

Content validity

After evaluating the qualitative content validity, 1 item was removed from knowledge dimension and 3 items from attitude dimension. After evaluating the quantitative content validity, 1 item was removed from attitude dimension, 2 items were removed from practice dimension and 1 item was removed from professional commitment dimension. Also, one item in attitude dimension and one item in practice dimension were changed. Finally, the present questionnaire consisted of 32 items, of which 10 items were in knowledge dimension, 7 items in attitude dimension, 10 items in practice dimension and 5 items in professional commitment dimension. The average content validity index of the questionnaire (S-CVI/Ave) was 0.97 and the average Content Validity Ratio (s-CVR/ Ave) was 0.93, respectively. Table 3 shows the results of face validity, CVR and CVI.

Construct validity

Kaiser–Meyer–Olkin measure of sampling

Table 2: Demographic characteristics of the participants in the reliability part of the study.

Variable	Frequency	Percent
Age		
Under 30	87	44.6
30-40	73	37.4
Above 40	35	17.9
Gender		
Men	111	55.8
Women	88	44.2
Marital status		
Single	80	40
Married	120	60
Education level		
Associate degree	26	13.1
Bachelor Degree	132	66.7
Master Degree and physician	40	20.2
Occupation		
Operating room nurse	168	84
Surgeon	32	16
Type of hospital		
State hospital	145	72.5
Private hospital	55	27.5
Shift type		
Fixed shift	46	23.2
Shift in circulation	152	76.8
Work field		
Orthopaedic	89	45.2
Urologic	46	23.4
General and cardiology	62	31.5
Type of employment		
Official	76	38.4
Unofficial	122	61.6
Working Experience as operating room personne		
under 5 years	76	40.42
above 5 years	112	59.58
Working Experience as operating room radiographer		
under 5 years	125	67.2
above 5 years	61	32.8

Table 3: The results of quantitative part of face validity and content validity.

Items of the questionnaire	IS	CVR	CVI
1- I know the effects of radiation exposure (at a higher dose than the standard level) on human health.	4.16	1	1
2- I know about As Low As Reasonably Achievable (ALARA) principle.	2.75	0.85	0.85
3- I know the standard distance from the X-ray generator.	4.14	1	1
4- I know the correct locations of film badge, depending on the type of imaging.	3.78	0.9	0.85
5- I know the standard method of keeping film badge safe after work.	4.14	0.75	1
6- I Know the ten day rule about women's radiography (because of the possibility of pregnancy).	2.07	0.95	1
7- I know that pulsed fluoroscopy can reduce the personnel and patient's radiation exposure.	3.2	1	1
8- I know that scattered radiation from the patient's body is the most important source of personnel's radiation exposure.	4.6	1	1
9- I know the potencies of C-arm device in reducing the patients and personnel's radiation exposure.	2.36	1	1
10- I know that collimation or limiting the field of radiation to the desired level reduces the patients and personnel's radiation exposure.	5	0.95	0.85
11- The width of the operating room space around the under irradiation patient is essential (for the observance of standard distance).	4. 7	1	1
12- Existence of safety instructions and radiation warning posters is essential in the operating room.	4.05	0.85	1
13- The use of film badge is essential for all the personnel exposed to radiation in the operating room.	4.41	1	1
14- Regular health check and blood test are required for operating room personnel.	4.9	1	1
15- Using lead gloves is essential if personnel's hands are close to the source of radiation.	3.52	0.8	1
16- When using a portable X-ray machine in the operating room, the use of lead Paravan is also essential, in addition to other safeguards.	4.9	0.75	0.85
17- It is essential to use a hazard warning light above the door of under radiation operating room.	4.9	0.75	1
18- I assure female patients' possibility of pregnancy before the surgery.	4.9	1	1
19- I record the correct frequency and duration of the radiation in the patient's file.	2.04	1	1
20- I regard the standard distance of the X-ray generator to the patient's skin.	4.7	1	1
21- In vertical imaging, I regard the correct positioning with the image intensifier above and X-ray generator under the patient.	2.8	1	1
22- In horizontal imaging, I stand on the side of image intensifier.	3.44	0.85	0.85
23- I use my personal dosimeter.	2.31	1	1
24- I use lead aprons, despite being heavy, for my personal protection.	5	1	1
25- I use thyroid shield during radiation exposure.	5	0.95	1
26- I place genital shield for the patient under radiation.	4.9	1	1
27- I place thyroid shield for the patient under radiation.	5	1	1
28- Patient's radiation protection is important for me.	5	1	1
29- I cooperate with other operating room personnel in the field of radiation protection.	3.28	0.8	1
30- I use standard guidelines and scientific texts about radiation protection.	4.8	0.95	1
31- I am responsive for my radiation protection act.	4.9	0.75	1
32- I participate in radiation protection training courses periodically.	4.05	1	1

IS: Item Impact score, CVR: Content validity ratio, CVI: Content Validity Index adequacy was 0.837; Bartlett's test of sphericity was 3438.304 (P value = 0.0001), respectively.

The results of PCA (Table 4) showed that the factor loading of most of the items was the highest value in its considered dimension. According to Table 4, item 1 to 10 had the highest value in knowledge dimension, and item 11 to 17 had the highest value in attitude dimension. Items 19, 20, 22, 26 and 27 had the highest value in practice dimension; however, no item had a high value in professional commitment dimension. Finally, according to factor loading of items, 5 items considered in profession-

Table 4: Principal component analysis of clinical capability dimensions.

Items of the questionnaire	Knowledge	Attitude	Practice	Professional commitment
Q1	0.687	-0.118	-0.283	-0.164
Q2	0.712	-0.169	-0.168	-0.100
Q3	0.680	-0.029	-0.290	-0.085
Q4	0.775	0.012	-0.223	-0.174
Q5	0.747	-0.055	-0.264	-0.074
Q6	0.711	-0.176	-0.142	0.061
Q7	0.683	-0.129	-0.294	-0.106
Q8	0.767	-0.121	-0.166	-0.117
Q9	0.761	-0.141	-0.234	-0.107
Q10	0.731	-0.079	-0.167	-0.150
Q11	-0.048	0.705	-0.322	-0.120
Q12	-0.053	0.727	-0.297	-0.026
Q13	0.001	0.705	-0.355	-0.068
Q14	-0.067	0.759	-0.307	0.011
Q15	0.018	0.689	-0.223	0.044
Q16	0.012	0.645	-0.203	0.187
Q17	0.028	0.746	-0.257	0.156
Q18	0.384	0.326	0.178	0.297
Q19	0.176	-0.051	0.267	0.063
Q20	0.391	0.250	0.529	0.218
Q21	0.415	0.178	0.367	0.478
Q22	0.497	0.134	0.508	0.322
Q23	0.547	-0.077	0.062	0.151
Q24	0.293	0.487	0.425	-0.435
Q25	0.204	0.471	0.403	-0.546
Q26	0.184	0.263	0.718	-0.374
Q27	0.203	0.170	0.720	-.380
Q28	0.370	0.271	0.262	0.116
Q29	0.108	0.258	0.174	0.207
Q30	0.328	0.125	0.068	0.217
Q31	0.579	0.210	0.287	0.383
Q32	0.597	-0.198	0.040	0.172

al commitment dimension were suggested to be removed.

The Scree plot showed that three or four dimensions could be sufficient for the questionnaire (Figure 1).

Reliability

Internal consistency reliability

The Cronbach's alpha coefficient of final version of the questionnaire was 0.824. Moreover, Cronbach's alpha coefficient of each dimension of the questionnaire (except professional commitments) was good; Cronbach's alpha of knowledge items was 0.927, that of attitude items was 0.877, that of practice items was 0.723, and that of professional commitments items was 0.449; that was low and showed that the items of professional commitments dimension are not appropriate for the questionnaire.

Test-retest reliability

Test reliability is measured with a test-retest correlation. Consistency of the retest, according to Spearman coefficient was 0.912.

Discussion

With respect to the importance of radiation protection capability amongst operating room nurses and the absence of a proper instrument for measuring radiation protection capability in the operating room field, the present study aimed to develop a radiation protection capability questionnaire.

According to previous studies, radiation risk decreases by using some rules and factors. The most important of these are ALARA principle, the 10 day rule, time, distance, and shielding and awareness about various monitoring devices [23, 34]. In this questionnaire, the assessment of personnel's awareness of all of these factors is considered.

The face validity, content validity, construct validity, internal homogeneity (Cronbach's alpha), and consistency (test–retest) of the questionnaire were evaluated. So far, there has not been any questionnaire particularly designed for evaluating radiation protection capability in the operating room field, and the available instruments were about limited aspects of ra-

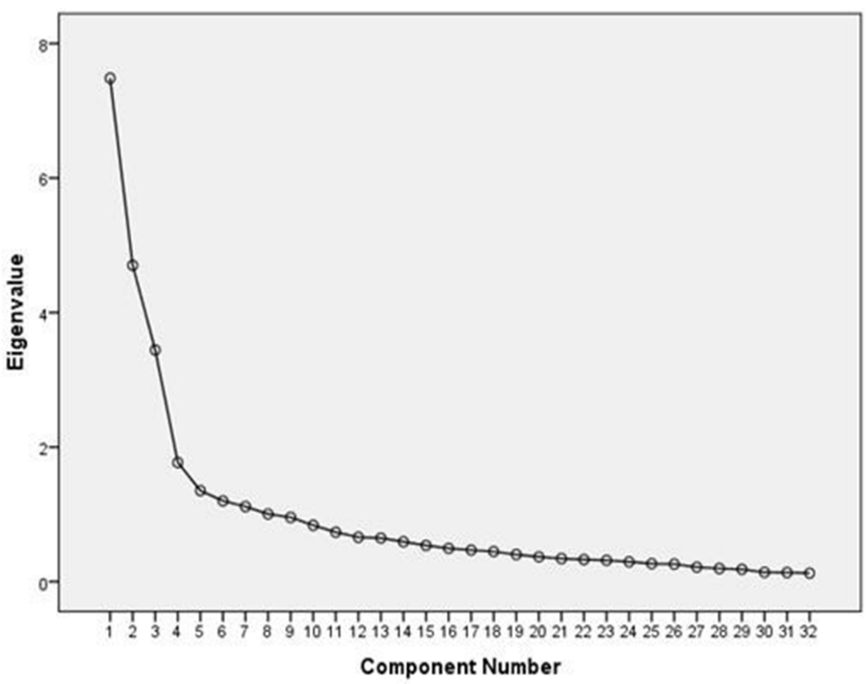

Figure 1: Scree Plot test of factor loading of the items.

diation protection capability in the operating room [9-13], and no study considered all aspects of radiation protection capability, specific to the operating room field. Moreover, the methods of validity were not confirmed in almost all of the previous studies and only the result of internal homogeneity (Cronbach's alpha) was reported in some of them.

One of the previous questionnaires was designed to evaluate the association of academic education and practical capabilities of radiology technicians in Tabriz University of Medical Science, Iran. This questionnaire was specifically for radiology ward and measured all the duties of a radiology technician, that only one part was radiation protection. Cronbach's alpha coefficient was desirable in mentioned questionnaire but validity had not been verified [13].

Another previous instrument was designed to evaluate the radiation protection knowledge, attitude and practice (KAP) in radiographers and was used in four departments of hospitals, including radiology, operating room, Endoscopic retrograde cholangiopancreatography (ERCP) and Extracorporeal shock wave lithotripsy (ESWL). s-CVR/ Ave of this questionnaire was 0.62. Other validity methods were not confirmed in this study. Also, reliability was evaluated by test-retest method that the Pearson's correlation coefficient was 0.81. This instrument was appropriate for radiology ward but was not sufficient and relevant to measure radiation protection in the operating room field [20-22].

Other similar instruments were designed to examine radiation protection knowledge in operating room nurses, that psychometric properties of almost all of these questionnaires were not confirmed [1, 9, 11, 12]. Therefore, it was not possible to compare the present questionnaire with previous ones in terms of psychometric properties.

It is obvious that the available questionnaires are not appropriate for evaluating radiation protection capability in the operating room field.

Based on previous researches, evaluating knowledge of radiation protection could be divided into three areas. These areas include radiation physics and radiation biology, radiation protection and guidelines of safe ionizing radiation use [35, 36]. Organizational guidelines and protocols are based on radiation physics and radiation protection principles under standard radiation conditions. These protocols are improved and upgraded by a medical physicist known as radiation safety officer (RSO) according to the conditions in each hospital. Therefore, knowledge of protocols and their observance will have the greatest contribution in reducing radiation damage to staff and patients. Therefore, the number of questions related to guidelines and protocols is considered more than other questions in this questionnaire.

Developing and evaluating the psychometric characteristics of a questionnaire about radiation protection capability of operating room nurses were confirmed in this study. It should be noted that unlike previous studies, patients' radiation protection is highlighted in this questionnaire.

One limitation of this study was that the radiation exposure condition was not the same in different operating rooms. Besides, different countries may have their own national guidelines and regulations.

Therefore, further studies with larger numbers of participants, different kind of operating rooms and across different countries are needed to be conducted.

Based on the results, this questionnaire is a new valid and reliable instrument that could comprehensively evaluate the radiation protection capability of operating room nurses.

Conclusion

In the present study, a questionnaire was designed in Iran for measuring radiation protection capability of operating room nurses. The results of the study show that the psychometric properties of the questionnaire are satisfactory. This psychometric questionnaire can be used in the development of programs for solving radiation protection problems in the operating rooms. By utilizing this questionnaire, educational and management needs can be estimated.

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Conflict of Interest

None

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