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Evaluation of emergency nurses' knowledge of medical response in nuclear and radiological emergencies : a cross-sectional study

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Abstract

Background Evaluating emergency room nurses' knowledge of radiation protection, health effects, and decontamination procedures is crucial for preparedness in nuclear and radiological emergencies. This study aims to evaluate the level of knowledge among emergency nurses in Saudi Arabia regarding medical responses to nuclear and radiological emergencies.

Methods A multicenter cross-sectional study was conducted via a self-structured questionnaire with 15 true–false questions divided into three domains, namely, radiation protection measures, radiation health effects, and decontamination procedures, each with five items and a possible score of 1 point per correct answer. The collected data were analyzed via descriptive and inferential statistics. The study followed the STROBE checklist for methodological rigor.

Results A total of 594 emergency nurses participated in this study, with the majority being young (64.50% aged ≤ 30), female (68.69%), bachelor's degree-holding (67.68%), single (63.64%), having ≤ 4 years of experience (56.06%), working in public health facilities (88.89%), and lacking training in medical response (85.35%). The mean knowledge scores for participants were highest for radiation exposure effects (3.27 ± 0.91), followed by radiation protective measures (2.32 ± 0.99), and lowest for decontamination procedures (1.46 ± 1.07). Overall knowledge was measured at a mean score of 7.06 ± 1.68, with 97.47% of the nurses categorized as having poor knowledge level. Nurses in private hospitals scored higher (7.77 ± 1.82) than those in public hospitals (6.97 ± 1.65) on overall mean knowledge ($P = 0.034$). Concerning findings include emergency nurses' misconceptions about the protection provided by dense materials, the effectiveness of increasing distance from a radiation source, and prioritizing decontamination of victims over life-saving measures. Additionally, they were unaware of the immediate symptoms following radiation exposure and misunderstood that the primary threat in a radioactive bomb event is the explosion rather than the radiation itself.

Conclusion This study revealed poor knowledge among emergency nurses regarding medical responses to radiation emergencies and highlighted the critical need for enhanced and standardized training in radiation

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emergency preparedness among nurses. The gaps in knowledge identified in this study could significantly impact the effectiveness of healthcare responses in radiation emergency scenarios. Therefore, targeted educational interventions and policy changes are recommended to address these shortcomings.

Keywords Emergency nursing, Radiation exposure, Protective measures, Decontamination, Radiation emergencies

Background

Nuclear and radiological emergencies (NREs), though infrequent, pose a significant threat to public health and safety, demanding a swift and efficient response from healthcare systems worldwide [1, 2]. These emergencies can arise from a variety of sources, including nuclear power plant accidents, radiological terrorism, and accidental exposure to radioactive materials [3, 4]. The impact of such incidents extends far beyond immediate physical injuries, encompassing long-term health effects due to radiation exposure and psychological trauma [5].

The critical role of emergency nurses (ER-Ns) in medical response to these emergencies is increasingly recognized, as they often serve as frontline responders, providing essential care and support to affected populations [5–8]. Their roles include initial assessment and triage, providing immediate medical care, understanding and implementing radiation exposure protection measures, managing potential health effects of radiation exposure, and executing effective decontamination procedures [9–12]. The knowledge and skills required for these tasks are specialized and differ significantly from those of routine emergency nursing practices [13–16].

In medical responses to NREs, ER-Ns are crucial in implementing radiation exposure protection measures and decontamination procedures. They must master the principles of radiation protection—time, distance, and shielding—to minimize exposure for patients and healthcare providers, use personal protective equipment (PPE) effectively, and follow safety protocols to prevent contamination risks in healthcare settings [4, 17–19]. ER-Ns also play a key role in decontamination, removing radioactive contaminants from patients to control contamination spread and manage internal exposure risks, all while maintaining clear communication with patients under stress [20–23]. Additionally, they need comprehensive knowledge of the health effects of radiation exposure, from mild symptoms like skin erythema to severe conditions such as acute radiation syndrome (ARS), to provide timely and accurate diagnoses and initiate critical treatment protocols that significantly influence patient outcomes [4, 24].

The effectiveness of ER-Ns in handling radiation exposure protection measures, decontamination, and managing health effects of radiation is vital. Several Prior studies report substantial knowledge deficiencies among ER-Ns [3, 11, 15]. Evaluating the baseline knowledge level of ER-Ns is crucial for identifying training needs, guiding educational interventions, and informing policy changes and resource allocation to enhance preparedness. To address this critical issue, this study hypothesizes that ER-Ns in Saudi Arabia exhibit insufficient knowledge about radiation protection measures, health effects of radiation, and decontamination procedures. The current study is inspired by the Saudi Ministry of Health (MOH)'s efforts to coordinate medical responses to NREs across the nation. The MOH established an expert team tasked with developing guidelines, selecting referral hospitals based on predefined criteria, and evaluating hospital preparedness for such emergencies. Although an extensive evaluation was conducted as reported in a recently published study [1], it primarily involved nurse supervisors and did not specifically assess the knowledge of ER-Ns regarding medical response to NREs. This gap highlights the need for a focused evaluation of ER-Ns' competencies in medical responses to NREs. Therefore, our study specifically aims to evaluate the level of knowledge among ER-Ns in Saudi Arabia regarding medical responses to NREs.

Materials and methods

Study design and setting

A multicenter cross-sectional study was undertaken from July 2023 to January 2024 to assess ER-Ns' knowledge of radiation exposure and protective measures during NREs. The study followed the STROBE checklist for methodological rigor. The research was conducted across 23 hospitals in Saudi Arabia, comprising 21 public referral hospitals across the country's 13 administrative regions and two major private hospitals in the Jazan region. This inclusion of both public and private hospitals allows for a comparison of knowledge levels between ER-Ns employed in different hospital settings.

Ethical considerations

The study adhered to ethical guidelines, complied with the principles of the Declaration of Helsinki, obtaining electronic informed consent to ensure the participants' awareness of the study's aims, voluntary participation, and confidentiality. Jazan University's institutional review board approved the study, ensuring ethical procedures (approval code: 43/C/1773).

Study population and sample size

The study targeted registered nurses currently working in or with prior experience in emergency departments, excluding those without such experience. An a priori power analysis conducted using G*Power version 3.1.9.7 [25], based on effect sizes from a previous study [26], determined that a minimum sample size of $N = 321$ was necessary to achieve an effect size (f) of 0.20, with a significance level of 0.05 and a power of 0.80. We invited a total of 1,280 ER-Ns to participate, aiming to ensure adequate coverage for potential nonresponses and achieve the required sample size. From those invited, 594 participants completed the questionnaire, resulting in a response rate of 46%.

Recruitment and sampling

Participant recruitment utilized convenience sampling, facilitated by nursing supervisors in collaboration with the MoH expert team. Due to the lack of direct contact details for ER-Ns, these supervisors were essential in identifying and reaching eligible participants. The research team initiated contact through phone calls to hospital nursing supervisors, explaining the study's objectives and seeking their assistance in participant recruitment. Subsequently, supervisors received emails containing detailed study information and a link to an online questionnaire created via Google Forms. These supervisors were tasked with disseminating the email to all the registered ER-Ns under their purview. To maximize participation, follow-up reminders were sent via WhatsApp.

Data collection tool

In this study, the data collection instrument used was a self-administered questionnaire, which was divided into demographic information and items related to NREs. The demographic section captured age, gender, education level, type of healthcare facility worked at, years of experience, and prior training. The questionnaire about knowledge of responses to NREs used in the study was adapted from a previous study [27]. The questionnaire included 15 true‒false questions assessing knowledge, categorized into three domains: radiation protective measures, radiation exposure effects and decontamination, each with five items and a possible score of 1 point per correct answer. An overall knowledge score (range: 0–15) and separate scores for each subcategory (range: 0–5) were computed from these questions.

The content validity of adapted the questionnaire was assessed by a panel of experts in nursing, disaster management and survey methodology who evaluated the clarity, relevance, and comprehensiveness of the items. Their assessment was based on expert judgment, supported by a comprehensive review of the current literature to ensure that each item was relevant and clear, aligning with the study's objective. The experts reviewed each questionnaire item to confirm its appropriateness for measuring the targeted competencies in NRE preparedness and response among emergency nurses. A pilot study involving 26 participants was conducted to evaluate the internal consistency and content validity of the questionnaire. The overall Cronbach's alpha for the questionnaire was calculated as 0.74, indicating good internal consistency. No further modifications were deemed necessary based on participant feedback.

For evaluating knowledge levels, a two-level system was employed: for the overall score, scores of 10 or below were classified under the "poor knowledge" level, indicating a need for improved understanding and training, whereas scores above 10 were categorized as "acceptable knowledge," signifying a satisfactory level of understanding. Similarly, within each subcategory, scores of 3 or below were designated "poor knowledge," and scores above 3 were designated "acceptable knowledge." This scoring system provided a clear demarcation of knowledge proficiency, both overall and within each specific area of NREs response.

Age and years of experience were categorized into discrete groups to avoid assumptions of linearity and simplify interpretation. These categories reflect distinct career stages (e.g., early, mid, late career), allowing for more meaningful group comparisons. Additionally, treating these variables as categorical helps address potential non-normality and ensures that our analysis captures non-linear effects across the career trajectory.

Data analysis

Data analysis was conducted via the Statistical Package for the Social Sciences (SPSS) program (version 26; IBM Corporation, New York). The data were compiled as descriptive statistics, with categorical variables presented as frequencies and percentages and continuous variables described by mean values and standard deviations (SDs). The Shapiro‒Wilk normality test was used, revealing that the data were not normally distributed. Nonparametric tests, the Mann‒Whitney U test and the Kruskal‒Wallis test, were executed to examine associations between the overall mean knowledge score and sociodemographic variables. A linear regression analysis was employed with the overall mean knowledge score as the dependent variable and sociodemographic variables as predictors. The threshold for statistical significance was set at $p < 0.05$.

Results

A total of 594 ER-Ns participated in this study, with the majority being young (64.50% aged ≤ 30), female (68.69%), bachelor's degree-holding (67.68%), single (63.64%), having ≤ 5 years of experience (56.06%), working in public health facilities (88.89%), and lacking training in medical response (85.35%) (Table 1). The analysis revealed a significant difference in overall knowledge scores between

Table 1 Summary of the demographic characteristics of the participants and the overall knowledge scores

Item	Variables	Count (%)	Knowledge Mean ± SD	*P* value
Gender	Female	408 (68.69%)	7.12 ± 1.62	0.444
	Male	186 (31.31%)	6.92 ± 1.83	
Age Group (Years)	≤ 30	383 (64.50%)	7.07 ± 1.71	0.731
	31–44	172 (28.96%)	7.10 ± 1.64	
	≥ 45	39 (6.57%)	6.69 ± 1.70	
Educational Qualification	Diploma	130 (21.72%)	7.19 ± 1.59	0.231
	Bachelor's degree	402 (67.68%)	6.93 ± 1.66	
	Postgraduate studies	62 (10.44%)	7.68 ± 1.95	
Marital Status	Married	216 (36.36%)	7.25 ± 1.68	0.220
	Single	378 (63.64%)	6.94 ± 1.68	
Years of Experience	≤ 5	333 (56.06%)	6.98 ± 1.67	0.746
	6 to10	129 (21.72%)	7.09 ± 1.78	
	≥ 11	132 (22.22%)	7.20 ± 1.65	
Type of Hospital	Public	528 (88.89%)	6.97 ± 1.65	**0.034**
	Private	66 (11.11%)	7.77 ± 1.82	
Previously Received Training	No	507 (85.35%)	7.04 ± 1.68	0.776
	Yes	87 (14.65%)	7.14 ± 1.71	

healthcare facility types, with ER-Ns in public health facilities scoring lower (6.97 ± 1.65) than those in private facilities (7.77 ± 1.82) ($p = 0.034$). Further comparison of overall knowledge scores between ER-Ns in private and public hospitals reveals noteworthy demographic differences. In private hospitals, the younger group (≤30 years) had a higher mean score of 7.89 ± 1.91, compared to their counterparts in public hospitals, who scored 6.94 ± 1.64 (≤30 years), 7.11 ± 1.68 (31–44 years), and 6.69 ± 1.70 (≥45 years). Similarly, less experienced ER-Ns (≤5 years) in private hospitals had a higher mean score of 7.71 ± 1.86, outperforming public hospital groups, which scored 6.85 ± 1.61 (≤5 years), 7.12 ± 1.82 (6–10 years), and 7.07 ± 1.59 (≥11 years). ER-Ns with a bachelor's degree in private hospitals also had a higher mean score of 7.53 ± 1.84 compared to those in public hospitals (6.84 ± 1.63). The highest mean score was observed among ER-Ns with postgraduate qualifications in private hospitals, who achieved 8.25 ± 1.71, compared to 7.53 ± 2.03 in public hospitals.

The findings regarding the percentage of respondents who answered each knowledge item correctly are detailed in Table 2. In the category of radiation protection measures, most ER-Ns (93.4%) correctly identified time, distance, and protective barriers as critical in reducing radiation exposure, and 62.1% were aware that PPE does not prevent all types of radiation exposure. However, there were notable misconceptions, with only 25.3% correctly identifying the protection offered by dense materials, 21.2% understanding the effectiveness of increasing distance from a radiation source, and 29.8% knowing the correct use of a self-contained respirator in radiation events.

In terms of radiation exposure effects, 86.9% of the ER-Ns correctly identified early symptoms of high radiation exposure, 80.3% understood that high doses of radiation over a short period could lead to acute radiation syndrome, and 79.8% recognized the dangers of alpha particle inhalation and ingestion. However, only 33.3% were aware that symptoms do not immediately follow exposure to alpha and gamma radiation, and 53.0% correctly reported that the main threat at a radioactive bomb site is the explosion rather than the radiation itself.

In the decontamination category, while 62.6% knew that removing clothes reduces most external radioactive contamination, misconceptions are prevalent. Only 18.7% correctly understood the disposal of decontamination equipment, 23.7% recognized the necessity of decontaminating individuals to prevent further radiation exposure, 25.8% prioritized life-saving measures over decontamination, and 15.7% were aware that full-body decontamination is not always necessary after radioactive contamination.

The mean scores and the distribution of knowledge levels among participants across domains are presented in Table 3. The mean knowledge scores for participants were highest for radiation exposure effects, followed by radiation protective measures, and lowest for decontamination procedures, with an overall knowledge score of 7.06 ± 1.68 (range of 3–11). The percentage of participants with poor knowledge was 92.42% for decontamination knowledge, 86.36% for radiation protection measures, and 62.63% for radiation exposure effects, with an overall poor knowledge level of 97.47% across all categories.

Table 4 presents a linear regression analysis examining the relationships between the overall knowledge mean score and various demographic variables. The analysis

Table 2 Nurses' knowledge of protective measures, exposure effects, and decontamination procedures

Item	Correct *n* (%)
Radiation Protective Measures	
The three recommended factors for reducing radiation exposure are time, distance, and protective barriers. (T)	555 (93.4%)
Personal protective equipment worn by first responders is sufficient to prevent all types of radiation exposure. (F)	369 (62.1%)
It is only possible to protect against all types of radiation with dense materials, such as lead or concrete. (F)	150 (25.3%)
Doubling the distance from the radiation source will reduce exposure by half. (F)	126 (21.2%)
Emergency nurses need to wear a self-contained respirator when responding to a radiation event because the lungs are the most sensitive organs to radiation exposure. (F)	177 (29.8%)
Radiation Exposure Effects	
Exposure to high doses of radiation over a short period of time can lead to acute radiation syndrome. (T)	477 (80.3%)
Early symptoms of high exposure to radiation include nausea, vomiting, and headache. (T)	516 (86.9%)
Inhalation and ingestion of alpha particles can be more dangerous to the body than external pollution. (T)	474 (79.8%)
Symptoms of radiation exposure occur within minutes after exposure to alpha and gamma radiation. (F)	198 (33.3%)
The biggest threat at the site of a bomb containing radioactive materials is the explosion, not from the radioactive materials. (T)	315 (53.0%)
Decontamination	
Decontamination of victims of radioactive contamination should take priority over life-saving measures. (F)	153 (25.8%)
Removing clothes removes most external radioactive contamination. (T)	372 (62.6%)
All equipment used in radioactive decontamination must be disposed of after use. (F)	111 (18.7%)
People who have been exposed to radiation must be decontaminated to prevent radiation exposure to others. (F)	141 (23.7%)
There is a need for a full-body decontamination of the patient after radioactive contamination. (F)	93 (15.7%)

Note: (T) = true; (F) = false

Table 3 Distribution of nurses across knowledge levels

Category	Mean ± SD	Poor level *n* (%)	Acceptable level *n* (%)
Radiation protective measures	2.32 ± 0.99	513 (86.36%)	81 (13.64%)
Radiation exposure effects	3.27 ± 0.91	372 (62.63%)	222 (37.37%)
Decontamination procedures	1.46 ± 1.07	549 (92.42%)	45 (7.58%)
Overall	7.06 ± 1.68 (Range: 3 to 11)	579 (97.47%)	15 (2.53%)

Table 4 Linear regression of the overall knowledge mean score with demographic variables

Predictor	Estimate	SE	t	*p*	Stand. Estimate	95% Confidence Interval	
Intercept	7.37	0.28	26.68	< 0.001		Lower	Upper
Gender:							
Female – Male	0.29	0.29	1.01	0.314	0.17	-0.16	0.51
Age groups:							
≥ 45 – ≤30	-0.63	0.58	-1.09	0.278	-0.37	-1.05	0.3
31–44 – ≤30	-0.29	0.38	-0.76	0.448	-0.17	-0.61	0.27
Educational qualification:							
Diploma – Bachelor	0.33	0.37	0.89	0.377	0.2	-0.24	0.63
Postgraduate– Bachelor	0.59	0.46	1.29	0.2	0.35	-0.19	0.88
Marital status:							
Single – Married	-0.41	0.32	-1.3	0.196	-0.25	-0.62	0.13
Years of experience:							
6 to10 – ≤5	0.04	0.41	0.1	0.917	0.03	-0.45	0.5
≥ 11 – ≤5	0.17	0.44	0.37	0.709	0.1	-0.42	0.62
Type of hospital:							
Private – Public	0.83	0.39	2.12	**0.035**	0.49	0.03	0.95
Previously received training:							
No – Yes	0.04	0.36	0.12	0.908	0.02	-0.4	0.45

revealed that the type of hospital where the ER-Ns were employed emerged as a significant predictor, with those working in private hospitals scoring higher ($p = 0.035$) than their counterparts in public hospitals did.

Discussion

In managing NREs, it is essential to assess the knowledge of ER-Ns about radiation exposure protection, the health effects of radiation, and decontamination procedures. This evaluation is crucial for ensuring that ER-Ns are prepared to handle these emergencies effectively, protecting themselves and their patients. By pinpointing areas where ER-Ns require additional training or information, healthcare systems can improve their ability to respond to emergencies [28]. Additionally, understanding how well-prepared ER-Ns can help in making informed decisions about training programs and resource distribution [1, 28]. The aim of this study is to evaluate the readiness of ER-Ns in dealing with NREs, with a focus on their knowledge of radiation protection, managing the health impacts of radiation, and carrying out decontamination processes.

The overall knowledge score was 7.06 ± 1.68, with 97.47% of participants falling into the poor knowledge level. The findings of this study indicate a significant knowledge gap among ER-Ns. Several previous studies that evaluated ER-N knowledge regarding NREs reported that a significant knowledge gap exists among ER-Ns in the fields of radiation safety, protective measures, exposure effects, and decontamination procedures [3, 11, 15].

Our study revealed that 85% of ER-Ns lacked specialized training. In comparison to Japan, fewer than 30% of nurses at disaster-based hospitals are trained for radiation exposure scenarios, whereas 60% are trained at nuclear emergency hospitals [29]. Yamada et al. noted that nurses keen on training were more willing to engage in nuclear disaster response [5]. Although 48.6% of the ER-Ns had access to training information, only 41.3% reported availability at their workplaces, highlighting a significant gap in institutional support. Factors such as scheduling conflicts and staffing shortages hinder attendance and reduce time for professional development. Additionally, the broad focus of MOH training programs, which cater to various healthcare roles, may not meet the specific needs of ER-Ns, suggesting a need for more specialized training tailored to their roles in NRE readiness and response.

In the domain of radiation protection measures, while a majority of ER-Ns correctly identified time, distance, and protective barriers as critical for reducing radiation exposure, there were notable misconceptions about the protection offered by dense materials and the effectiveness of increasing distance from a radiation source. This aligns with the general findings of previous studies that have shown limited knowledge of radiation safety among ER-Ns [26, 30, 31].

The findings of the radiation exposure effects domain revealed that only 33.3% of the ER-Ns were aware that symptoms do not immediately follow exposure to alpha and gamma radiation and that 53.0% correctly identified that the main threat at a radioactive bomb site is the explosion rather than the radiation itself, highlighting significant gaps in knowledge about radiation exposure and its effects. Alpha and gamma radiation exposure can indeed lead to delayed onset of symptoms, which may not appear until hours, days, or even weeks after exposure [32]. This delay can be attributed to the time it takes for radiation to cause cellular damage and for these effects to manifest as observable symptoms. The lack of immediate symptoms can lead to a false sense of safety and potentially delay necessary medical intervention. This underlines the importance of education and training for healthcare professionals in recognizing and responding to radiation exposure, even when symptoms are not immediately apparent. The finding that only slightly more than half of the ER-Ns correctly identified the explosion as the main threat at a radioactive bomb site is also concerning. In the event of a nuclear explosion, the immediate danger is indeed the blast itself, which can cause significant physical trauma and damage [32]. While radiation exposure is a serious concern, the initial blast can cause immediate and severe injuries and understanding this is crucial for an effective emergency response.

In the decontamination domain, the mean score was the lowest at 1.46 ± 1.07, with 92.42% demonstrating poor knowledge. The findings from previous studies suggest that the most significant deficiency in knowledge pertains to patient decontamination processes in radiological incidents [19, 28, 33, 34]. It is crucial for ER-Ns to be skilled in-patient decontamination, as they are tasked with decontamination prior to triage and medical care. ER-Ns must be knowledgeable about the appropriate timing and methods for conducting patient decontamination to reduce exposure risks for both themselves and others [34]. A concerning finding was that the prevalent misconception regarding decontamination of victims of radioactive contamination should take priority over life-saving measures, with only 25.8% correctly prioritized life-saving measures over decontamination. This misconception could lead to harmful delays in treatment during radiological emergencies, where timely medical intervention is crucial for affected individuals. In the context of NREs, the primary focus should be on stabilizing the patient and addressing life-threatening conditions before proceeding with decontamination procedures. This approach is supported by guidelines and practices in emergency medicine, which emphasize the importance of adhering to the principle of "life before limb" — in this case, prioritizing life-saving measures over decontamination efforts [35]. The misconception among ER-Ns may stem from a lack of understanding of the principles of radiation emergency medicine and the specific protocols for managing contaminated patients. Healthcare professionals, especially those likely to be the first responders in such emergencies, must have a clear understanding of the prioritization of medical interventions. Training and education programs should emphasize the critical importance of initial medical stabilization and the appropriate sequencing of care in radiological incidents.

The type of hospital where ER-Ns worked significantly predicted their overall knowledge scores, with ER-Ns in private hospitals scoring higher than those in public hospitals. Despite the smaller sample size of private hospital ER-Ns ($n=66$) compared to public hospital ER-Ns ($n=528$), our analysis showed that private hospital ER-Ns outperformed public hospital ER-Ns across various demographic groups, including age, years of experience and education. Furthermore, the highest mean score was observed among ER-Ns with postgraduate qualifications in private hospitals, who achieved 8.25 ± 1.71, compared to 7.53 ± 2.03 in public hospitals. Several studies have investigated disparities in knowledge and practices between ER-Ns in public and private hospitals. Private hospitals possess greater organizational learning capabilities [36], potentially leading to higher knowledge scores among their ER-Ns [37, 38]. While organizational factors likely contribute, the educational background of private hospital ER-Ns may also enhance their knowledge levels. Further research is needed to assess the combined effects of organizational support, training opportunities, and nurse qualifications on these differences.

Strengths and limitations

The strength of this study lies in being the first of its kind in Saudi Arabia, conducted across multiple centers. It targeted a population from referral hospitals nationwide, providing a comprehensive assessment of actual knowledge levels and training needs. This helps tailor educational interventions and informs policy changes and resource allocation, thereby enhancing national preparedness for NREs. This multicenter framework allows for a broad, insightful analysis that can significantly impact the strategic planning of NRE response efforts in the country. The inclusion of ER-Ns in private hospitals provides valuable insights into the potential role these healthcare facilities can play in supporting national response efforts.

However, its limitations include the use of a cross-sectional design and convenience sampling, which limit the generalizability of the findings due to potential selection bias, as ER-Ns with greater interest or opinions might be more inclined to participate. The recruitment method involved supervisors at participants' institutions, which might have introduced selection bias, potentially impacting the representativeness of the sample. Additionally, the response rate was 46%, which exposes the study to non-response bias and may further limit the generalizability of the findings. Furthermore, the questionnaire items were not detailed and focused more on general knowledge rather than specific medical response items, which might limit the depth of insights into specialized emergency response skills. This limitation was justified by the initial aim of broadly assessing overall preparedness and identifying key areas for deeper investigations in future studies.

Conclusion

The findings of this study highlight significant NRE knowledge gaps among ER-Ns in the areas of radiation protection measures, exposure effects, and decontamination procedures. Concerning findings include ER-Ns' misconceptions about the protection provided by dense materials, the effectiveness of increasing distance from a radiation source, and prioritizing decontamination of victims over life-saving measures. Additionally, they were unaware of the immediate symptoms following radiation exposure and misunderstood that the primary threat in a radioactive bomb event is the explosion rather than the radiation itself. These gaps in knowledge could impact patient safety and outcomes in situations involving radiation exposure. The study emphasizes the urgent need for enhanced education and training to ensure ER-Ns are adequately prepared for such situations. Given that a large proportion of the study sample comprised younger ER-Ns (≤30 years old) who may lack advanced disaster medicine training, integrating specialized NRE education into nursing curricula is essential. This would strengthen preparedness and response capabilities, helping ensure that ER-Ns are better equipped to manage NREs effectively in the future.

Implications of the study

The implications of this study are significant for enhancing the readiness and response capabilities of ER-Ns in NREs. By assessing knowledge of radiation protection, the health impacts of radiation, and decontamination procedures, this study identifies critical gaps in nurse training and informs the development of targeted educational programs. To address these gaps, we recommend implementing interactive training workshops that focus on hands-on decontamination practices, simulation-based learning scenarios that cover a range of radiological emergencies, and continuous professional development modules on radiation safety and health impact management. Such programs are essential for ensuring that ER-Ns are well prepared to protect themselves and their patients during NREs. The findings indicate a substantial lack of specialized training, with a majority of ER-Ns demonstrating poor knowledge. This highlights the need for healthcare systems to improve their training strategies and resource allocation to better equip their emergency response teams. Ultimately, this study provides valuable insights that can guide healthcare administrators and policymakers in strengthening the NRE preparedness and response framework by focusing on targeted educational interventions, informed resource distribution, and policy adjustments to support ER-Ns across both the public and private sectors.

Abbreviations

ARS	Acute Radiation Syndrome
ER-N	Emergency Nurse
MOH	Ministry of Health
NRE	Nuclear and Radiological Emergency
PPE	Personal protective equipment
SD	Standard deviation

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Author contributions
N.S. was responsible for the conceptualization, design, data collection, analysis, interpretation of the data, drafting, revising, and final approval of the manuscript, and ensuring the accuracy and integrity of the work.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study adhered to ethical guidelines, complied with the principles of the Declaration of Helsinki, obtaining electronic informed consent to ensure the participants' awareness of the study's aims, voluntary participation, and confidentiality. Jazan University's institutional review board approved the study, ensuring ethical procedures (approval code: 43/C/1773).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Publisher's note

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