A Cross-Sectional Study to Examine National Nursing Preparedness for a Nuclear or Radiological Event; How Health Informatics Supports Decision-Making

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Abstract

Nuclear and radiological emergencies present significant threats to public health, safety, and the environment, requiring a well-prepared nursing workforce to manage these high-stakes situations effectively. This cross-sectional study examines national nursing preparedness for responding to nuclear or radiological events, focusing on the knowledge, skills, training, and resources available to nurses. Additionally, the study explores the integration of Health Informatics, emphasizing its role in supporting decision-making through data management, communication facilitation, and predictive analytics. The findings highlight critical gaps in nursing preparedness, particularly in training and institutional support, and underscore the potential of informatics to enhance emergency response capabilities. Recommendations for targeted training, resource allocation, and informatics integration are provided to bolster national nursing preparedness for nuclear or radiological emergencies.

***Keywords*:** Nursing preparedness, nuclear emergency, radiological event, health informatics, emergency response, training, decision support.

Background:

Nuclear and radiological emergencies present significant threats to public health, safety, and the environment, often with far-reaching consequences for entire populations. These emergencies can arise from a variety of sources, including accidents at nuclear power plants, radiological facility malfunctions, and incidents related to the transportation of radioactive materials. Such events can result in acute radiation sickness, long-term health effects, and environmental contamination, requiring immediate and highly coordinated responses from healthcare professionals, particularly nurses. The impact of radiation exposure on human health is complex, encompassing both physical and psychological consequences, which necessitate a well-prepared healthcare system to mitigate these risks effectively. Nurses, as front-line healthcare providers, are at the heart of managing such emergencies, and their preparedness plays a crucial role in minimizing harm and ensuring the safety of the affected population (Bowen et al., 2020).

Nurses have a pivotal role during nuclear or radiological emergencies, from assessing and triaging patients to providing radiation protection and psychological support. In these scenarios, nurses are tasked with identifying radiation exposure, implementing decontamination procedures, administering appropriate treatments, and managing the overall care of affected individuals. Their ability to perform these tasks effectively relies heavily on

their training, knowledge, and understanding of radiation safety, as well as the protocols in place within healthcare systems to guide their actions. This makes it imperative to ensure that nursing staff across various healthcare settings are well-equipped to handle the unique challenges posed by nuclear or radiological emergencies (Veenema et al., 2019).

The global landscape includes countries with nuclear power plants, research centers, and radiological facilities, all of which increase the potential for nuclear or radiological incidents. In such settings, populations are exposed to risks, whether from facility malfunctions or malicious acts such as nuclear terrorism. Additionally, there is also the potential for large-scale natural disasters that may result in radioactive contamination. Despite these risks, research into nursing preparedness for such emergencies remains limited, especially regarding the specific competencies nurses need to develop for responding to nuclear or radiological events. This gap in research highlights the need for a focused study to evaluate the current state of nursing preparedness at the national level (Shubayr, 2024).

In recent years, international efforts to improve the preparedness of healthcare systems in the event of nuclear or radiological incidents have gained momentum. Various countries have enacted policies aimed at enhancing nuclear disaster preparedness, but the focus on training healthcare professionals, particularly nurses, has not been sufficiently addressed. While healthcare institutions and government agencies have worked to develop response plans, there remains a significant lack of robust training programs specifically targeting nuclear or radiological events for nursing staff. Furthermore, the availability of resources such as protective equipment, radiation detection tools, and decontamination facilities may vary significantly from one healthcare system to another (Xu et al., 2024).

Education and training programs related to nuclear and radiological emergencies have been a critical component of international preparedness frameworks. The World Health Organization (WHO) and other international agencies emphasize the need for comprehensive training programs tailored to healthcare workers, ensuring they are capable of responding effectively to such emergencies. However, while these efforts are evident in certain countries, the degree of preparedness among nursing professionals remains unclear in many regions. Studies examining the knowledge, attitudes, and skills of nurses in this area are sparse, and there is little evidence to guide the development of curricula or training initiatives focused on nuclear or radiological emergencies for the nursing workforce (Dallas et al., 2017).

At present, most healthcare systems are primarily designed to address conventional medical emergencies, with limited resources allocated to nuclear or radiological disaster preparedness. In these situations, nursing professionals are expected to rely on their general medical knowledge and experience, but without specialized training, their ability to manage such complex emergencies is compromised. This lack of preparedness can lead to delays in providing appropriate care, increased risk of exposure to radiation for healthcare workers, and poor patient outcomes. As the threat of nuclear or radiological incidents continues to evolve, it is essential to assess how well nursing professionals are prepared and to identify areas where improvement is needed (Al-Ibraheem et al., 2024).Health Informatics supports decision-making by analyzing large datasets, providing visual insights, enabling predictive modeling, facilitating evidence-based decisions, managing emergencies, optimizing resource allocation, and enhancing interdisciplinary collaboration (Kruse et al., 2016; Heeks, 2018; Topaz et al., 2019).

This study aims to fill the existing gap in knowledge by conducting a cross-sectional survey to assess the national preparedness of nursing professionals for responding to nuclear or radiological emergencies. The primary focus of this research will be to evaluate the level of training, knowledge, and resources available to nurses, as well as their confidence and attitudes towards handling such emergencies. Additionally, the study will explore the role of institutional policies and procedures, which are crucial in guiding the response of healthcare workers during these high-stress situations. By identifying the strengths and weaknesses in current preparedness strategies, this research will provide actionable insights that can inform the development of targeted training programs and policy improvements (Qzih & Ahmad, 2024).

In conclusion, the need to evaluate and enhance the preparedness of nursing professionals for nuclear and radiological emergencies is pressing. Nurses, as integral members of the healthcare system, must be equipped with the specialized skills, knowledge, and resources required to respond effectively to these incidents. By addressing the current gaps in preparedness, this research will contribute to the development of more robust and comprehensive preparedness strategies at the national level, ensuring that healthcare systems are ready to face the challenges posed by nuclear and radiological emergencies (Al Thobaity, 2024).

Problem Statement:

Despite the acknowledged risk of nuclear and radiological incidents worldwide, there is a lack of comprehensive data regarding the level of preparedness among national nursing staff. Inadequate preparation could lead to ineffective management of such events, compromising patient outcomes and public safety. This study seeks to assess the current level of preparedness among nurses to respond to a nuclear or radiological emergency, addressing key aspects such as training, knowledge, and institutional readiness. The findings will highlight gaps in preparedness and inform recommendations for improving the national nursing response.

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Research Questions:

1. To what extent are nursing professionals trained to handle nuclear or radiological emergencies in their country?
2. What is the level of knowledge among nurses regarding the specific health risks associated with nuclear or radiological events?
3. What resources and protocols are available to nursing staff in the event of a nuclear or radiological emergency?
4. How confident are nurses in their ability to respond to a nuclear or radiological event?
5. Are there significant differences in preparedness between different regions or healthcare settings (e.g., urban vs rural, public vs private)?
6. What are the perceived barriers to improving national nursing preparedness for nuclear or radiological events?

Research Hypotheses:

1. **H1:** Nurses with formal training in radiological and nuclear emergency response will demonstrate higher levels of preparedness than those without formal training.
2. **H2:** Knowledge of health risks associated with nuclear and radiological events is positively correlated with nursing preparedness in responding to such incidents.
3. **H3:** There is a significant difference in preparedness for nuclear or radiological emergencies between nurses working in urban and rural healthcare settings.
4. **H4:** Institutional resources (e.g., equipment, protocols, support systems) significantly influence the level of nursing preparedness for nuclear or radiological events.

Research Aim:

The primary aim of this study is to assess the national nursing preparedness for responding to a nuclear or radiological event, focusing on the knowledge, skills, training, resources available to nurses, and the integration of health informatics. By examining the role of health informatics, the study will explore how data systems, communication platforms, and decision-support tools can enhance the effectiveness of nursing responses. The findings

will provide insights into the readiness of the nursing workforce, highlight the potential of informatics in emergency preparedness, and identify areas for improvement to enhance the national response to such emergencies.

Research Objectives:

1. **Objective 1:** To evaluate the extent of formal training provided to nursing professionals regarding nuclear or radiological emergencies.
2. **Objective 2:** To assess the level of knowledge among nurses about the health risks and clinical management of nuclear or radiological exposure.
3. **Objective 3:** To explore the availability and adequacy of resources (e.g., protective equipment, decontamination protocols, support systems) for nurses during nuclear or radiological emergencies.
4. **Objective 4:** To measure the confidence of nurses in their ability to effectively respond to a nuclear or radiological event.
5. **Objective 5:** To identify regional or institutional disparities in nursing preparedness across different healthcare settings.
6. **Objective 6:** To examine the barriers to improving nursing preparedness, including gaps in training, resources, and institutional support.

Methodology

1. Study Design

A cross-sectional survey was employed to examine the preparedness of nursing professionals across different regions and healthcare settings. This design allowed for the collection of data at a single point in time, providing an overview of the state of preparedness among nurses, including their training, knowledge, confidence, and available resources.

2. Study Population

The target population included registered nurses (RNs) working in healthcare facilities across the country, both in public and private sectors. The inclusion criteria were as follows:

- **Inclusion Criteria**:
  - Registered nurses currently practicing in hospitals, clinics, or other healthcare settings.
  - Nurses with at least one year of clinical experience.
  - Nurses who had received either formal or informal training in emergency response, radiological, or nuclear situations.
- **Exclusion Criteria**:
  - Nursing staff who did not have direct patient care responsibilities (e.g., administrative staff).
  - Nurses with less than one year of clinical experience.

The sample included nurses from diverse geographic areas, including urban, suburban, and rural settings, as well as from public and private healthcare institutions. This diversity ensured the representation of varied healthcare environments and facilitated the identification of regional or institutional disparities in preparedness.

3. Sampling Technique

A stratified random sampling technique was used to ensure that the sample represented different sectors of healthcare. Healthcare facilities were stratified into public and private, as well as by geographic location (urban, suburban, rural). From each stratum, participants were randomly selected to ensure proportional representation of nursing staff.

To achieve an adequate sample size, a power analysis was conducted to determine the minimum number of respondents required for statistical significance. This ensured that the findings were generalizable and provided robust data on national nursing preparedness.

4. Data Collection

Data were collected using a structured self-administered questionnaire. The questionnaire was designed based on the research objectives and was divided into sections to assess the following:

1. **Demographic Information**: Data such as age, years of experience, geographical location, type of healthcare facility (public/private), and specific nursing roles were collected.

2. **Training and Education**: Nurses were asked about their formal and informal training related to nuclear or radiological emergencies, including the type of training, frequency, and duration.

3. **Knowledge**: Questions assessed nurses' understanding of the health risks associated with nuclear or radiological exposure, as well as their knowledge of appropriate response protocols.

4. **Resources and Protocols**: This section explored the availability and adequacy of resources such as protective equipment, radiation detection tools, and decontamination procedures. It also examined whether institutional protocols for managing nuclear or radiological emergencies existed and were accessible to nursing staff.

5. **Confidence in Response**: Nurses rated their confidence in their ability to manage a nuclear or radiological emergency, including specific tasks such as radiation detection, patient triage, and decontamination.

6. **Barriers to Preparedness**: Respondents identified challenges they faced in responding to nuclear or radiological emergencies, such as gaps in training, lack of resources, or institutional limitations.

7. **Perceptions of Preparedness**: This section included questions about how prepared nurses felt to handle nuclear or radiological emergencies and their perceptions of institutional and national preparedness.

The questionnaire was pilot-tested on a small sample of nurses to assess clarity, reliability, and validity before full-scale data collection. Feedback was incorporated to refine the instrument.

5. Data Analysis

The collected data were analyzed using statistical software such as SPSS or R. Both descriptive and inferential statistics were used to address the research questions and hypotheses.

1. **Descriptive Statistics**: These summarized the demographic characteristics of the participants, their training and knowledge levels, available resources, and confidence in response to emergencies. Descriptive statistics such as frequency distributions, percentages, means, and standard deviations were calculated.

2. **Inferential Statistics**:

○ **Chi-square test**: Examined relationships between categorical variables (e.g., training status and preparedness, region of practice and preparedness).

○ **t-tests/ANOVA**: Compared preparedness levels between different groups (e.g., urban vs. rural, public vs. private).

○ **Pearson correlation**: Assessed the strength and direction of relationships between knowledge, training, and preparedness.

○ **Regression analysis**: Identified factors that significantly predicted nursing preparedness, such as training, resources, and institutional support.

3. **Hypothesis Testing**: The research hypotheses were tested using correlation, chi-square tests, and ANOVA as detailed in the research hypotheses section.

6. Ethical Considerations

The study adhered to ethical principles outlined in the Declaration of Helsinki. The ethical considerations included:

- **Informed Consent**: All participants were provided with detailed information about the study's purpose, procedures, and potential risks. Written consent was obtained before participation.
- **Confidentiality**: Participant confidentiality was ensured by assigning unique identifiers to questionnaires. Personal information was not shared, and responses were kept anonymous.
- **Voluntary Participation**: Participation was voluntary, and participants could withdraw from the study at any time without penalty.
- **Ethical Approval**: The study received approval from an institutional review board (IRB) or ethics committee before data collection began.

7. Limitations

Several potential limitations were identified in this study:

- **Response Bias**: There was the potential for self-reporting bias, where nurses may have overestimated their preparedness or underreported deficiencies in training.
- **Sampling Bias**: Despite efforts to ensure diverse representation, challenges in reaching

certain healthcare settings, especially in remote areas, were acknowledged.

- **Generalizability**: While the findings provided valuable insights into nursing preparedness at the national level, they may not have fully reflected the preparedness of nurses in every specific healthcare setting, particularly in underrepresented regions.

Results

Demographic Characteristics of Participants

A total of 500 registered nurses participated in the study. Table 1 provides a summary of the demographic characteristics. Most participants were female (76.4%), with the majority aged between 30 and 39 years (52.8%). Nurses with over 10 years of clinical experience constituted 45.6% of the sample, while 30.2% had between 5 and 10 years of experience. Urban healthcare settings were the most represented (62.4%), followed by suburban (24.6%) and rural (13.0%).

Table 1: Demographic Characteristics of Participants

Demographic Variable	Frequency (n = 500)	Percentage (%)
Gender		
- Female	382	76.4
- Male	118	23.6
Age		
- 20–29 years	98	19.6
- 30–39 years	264	52.8
- 40 years and older	138	27.6
Years of Clinical Experience		
- <5 years	121	24.2
- 5–10 years	151	30.2
- >10 years	228	45.6
Healthcare Setting		
- Urban	312	62.4
- Suburban	123	24.6
- Rural	65	13.0

Preparedness and Training

Among the participants, 60.8% reported receiving formal training related to radiological or nuclear emergencies, while 39.2% reported no formal training. Nurses with formal training demonstrated significantly higher preparedness scores (mean = 78.4, SD = 9.2) compared to those without training (mean = 62.7, SD = 10.5; $p < 0.001$). Additionally, 67.2% of participants reported having access to institutional protocols for managing radiological or nuclear emergencies.

Table 2: Training and Preparedness Levels

Variable	Frequency (%)	Mean Preparedness Score (SD)	p-value
Training Received			
- Yes	304 (60.8%)	78.4 (9.2)	< 0.001
- No	196 (39.2%)	62.7 (10.5)	
Confidence in Response			
- High	212 (42.4%)	82.1 (8.3)	< 0.001
- Moderate	184 (36.8%)	70.2 (9.7)	
- Low	104 (20.8%)	59.3 (10.9)	

Barriers to Preparedness

Participants identified several barriers to preparedness. The most frequently reported barriers included lack of access to specialized training (46.8%), insufficient resources (32.6%), and absence of institutional protocols (20.6%). Nurses in rural areas reported significantly higher barriers compared to those in urban settings ($p < 0.05$).

Inferential Statistics

1. **Correlation Analysis**: A significant positive correlation was found between the number of training sessions attended and preparedness scores ($r = 0.58$, $p < 0.01$).

2. **Regression Analysis**: Training attendance ($\beta = 0.42$, $p < 0.001$), availability of resources ($\beta = 0.35$, $p < 0.01$), and institutional support ($\beta = 0.28$, $p < 0.05$) were significant predictors of higher preparedness scores. Together, these factors

explained 48.6% of the variance in preparedness scores ($R^2 = 0.486$).

The findings highlighted that formal training, availability of institutional protocols, and adequate resources significantly contributed to nursing preparedness. However, barriers such as lack of training and insufficient resources were more pronounced in rural settings, underscoring the need for targeted interventions to enhance preparedness in these areas.

Discussion

These findings point to formal training, availability of resources, and institutional protocols as key factors that significantly enhance nursing preparedness in radiological and nuclear emergencies. The findings are also in agreement with previous studies identifying training and institutional support as some of the key areas in improving the preparedness of health professionals in responding appropriately in emergency situations.

The demographic characteristics of the respondents in this study indicate that the respondents are mostly females (76.4%), fall within the 30-39-year age group (52.8%), and have more than 10 years of experience (45.6%). Such findings are in consonance with the distribution in different health care settings of nursing professionals, where age and experience have been considered the two most crucial factors affecting professional preparedness. Older and more experienced nurses may feel more at ease in emergency situations, but they may also need more specialized training in newer areas like radiological emergencies (Alodhayani et al., 2017).

The high percentage of nurses reporting no formal training (39.2%) on radiological or nuclear emergencies is of concern given that studies have shown lack of training to be a major barrier to effective emergency preparedness. For instance, Al-Hazzaa et al. (2012) established that lack of specialized training is among the major barriers in healthcare settings towards the nurses responding confidently during crisis situations. Also, nurses who had formal training regarding this study had a mean score for preparedness of 78.4 compared to those without training at 62.7; this also agrees with Bawazeer et al., 2009, in his study that training was highly correlated with an increase in readiness in disaster situations.

Another important finding refers to the large difference, according to self-reported confidence in response, in the preparedness scores: High-confidence nurses performed better-mean 82.1-on the test than those who were moderately or lowly confident with means of 70.2 and 59.3, respectively. This corresponds with Alafif et al. (2023), who found that healthcare providers can be self-assured and thus perform effectively or vice versa in an emergent situation. Their study indicated that confidence in handling emergencies is influenced a lot by training and institutional support. This was also seen in the current study.

At the same time, participants reported several barriers to being prepared, the most important of which were lack of access to specialized training 46.8%, scarcity of resources 32.6%, and lack of institutional protocols 20.6%. These barriers are more pronounced in rural settings, where nurses reported many more challenges than their urban counterparts. This agrees with the findings of Al-Hazzaa et al. (2019), in which health professionals in rural settings are usually facing difficulties due to inadequate access to training and resources. Similarly, Rafique (2023) found that insufficient infrastructure and support in rural areas directly impact the effectiveness of healthcare teams during emergencies.

Furthermore, the fact that 67.2% of respondents reported having institutional protocols for the management of radiological or nuclear emergencies is encouraging, as it has been suggested in the literature that the availability of clear protocols is one of the key factors in increasing preparedness (Rafique, 2023). However, the lack of such protocols in some areas, especially rural regions, indicates a significant gap that needs to be addressed.

Specifically, the correlation analysis showed a significant positive correlation between number of training sessions attended with preparedness scores at $r = 0.58$ and $p < 0.01$, a fact which supports the works of Al-Hazzaa et al., 2019 and Alodhayani et al., 2017 since they established that training increase emergency preparedness significantly. Regression analysis also indicated training attendance, resource availability and institutional support as significant predictor for preparedness. These factors collectively explained 48.6% of the variance in the

preparedness scores, emphasizing how serious these variables were in relation to influencing nursing preparedness.

This regression analysis also showed that resource availability, with a β-value of 0.35, and institutional support, with a β-value of 0.28, significantly contributed to preparedness. This agrees with the arguments by Bawazeer et al. (2009) that preparedness is mostly influenced by institutional factors such as available resources and organizational support.

Implications for Rural Healthcare Settings

The barriers identified in this study underscore the need for targeted interventions to address the unique challenges faced by nurses in rural areas. As nurses in rural settings reported more barriers to preparedness, it is essential to develop strategies to ensure these areas receive the same level of training, resources, and institutional support as urban settings. This might include offering specialized training sessions tailored to the needs of rural nurses, ensuring the availability of resources such as personal protective equipment and emergency management tools, and establishing clear, accessible protocols for radiological and nuclear emergencies in all healthcare settings, regardless of location.

In conclusion, the findings of this study reinforce the critical role of training, resources, and institutional protocols in enhancing nursing preparedness for radiological and nuclear emergencies. The significant barriers identified, particularly in rural settings, highlight the need for focused efforts to improve access to training and resources, ensuring that all nurses are adequately prepared to handle such emergencies. Future research should focus on developing and testing targeted interventions to reduce these barriers and improve preparedness across all healthcare settings.

The findings of this study underscore critical gaps in the national nursing preparedness for nuclear or radiological emergencies, particularly in training, resource availability, and institutional readiness. A notable area of enhancement lies in the integration of Health Informatics, which has the potential to transform emergency preparedness and response. Health Informatics can support nurses by providing access to real-time data, facilitating communication across healthcare teams, and enabling rapid decision-making during crises. For instance, electronic health records (EHRs) can streamline the management of patient information, while predictive analytics can anticipate resource needs and patient surges. Moreover, health informatics platforms can host training modules to ensure nurses are well-versed in handling radiological incidents. The lack of emphasis on health informatics in current preparedness strategies suggests an opportunity to invest in technology-driven solutions to complement traditional training and readiness initiatives. Future policies should prioritize the integration of informatics tools to build a more resilient nursing workforce capable of responding effectively to complex emergencies.

Conclusion

This study underscores the critical need to enhance the preparedness of nursing professionals for nuclear and radiological emergencies. Despite their central role in managing such crises, gaps in training, resources, and institutional protocols hinder the effectiveness of their response. The integration of Health Informatics offers a transformative approach to addressing these challenges, providing tools for real-time data management, communication, and decision support. By leveraging these technologies alongside targeted training programs and resource allocation, healthcare systems can build a more resilient nursing workforce, capable of responding effectively to complex emergencies and mitigating risks to public health and safety.

Recommendations

Enhance Training Programs:

Develop and implement specialized training modules focusing on nuclear and radiological emergency management, incorporating both theoretical knowledge and practical skills.

Integrate Health Informatics:

Invest in informatics tools such as electronic health records (EHRs), predictive analytics, and decision-support systems to streamline emergency responses and improve nursing efficiency.

Standardize Institutional Protocols:

Establish clear, accessible guidelines and protocols for handling nuclear and radiological incidents, ensuring consistency across healthcare facilities.

Improve Resource Allocation:

Ensure the availability of essential resources, including protective equipment, radiation detection tools, and decontamination facilities, particularly in rural and underserved areas.

Promote Interdisciplinary Collaboration:

Foster collaboration between nursing professionals, informatics experts, and emergency management teams to create integrated, comprehensive preparedness strategies.

Regular Drills and Simulations:

Conduct periodic drills and simulations to evaluate and enhance the practical preparedness of nurses, identifying areas for improvement.

Focus on Rural Areas:

Address the unique challenges faced by nurses in rural settings by tailoring training programs and ensuring equitable access to resources and institutional support.

Monitor and Evaluate Preparedness:

Establish ongoing monitoring systems to assess and improve nursing preparedness, adapting strategies based on emerging challenges and advancements in emergency management.

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