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Original Research Article

IMPLEMENTATION OF VIRTUAL NURSING SIMULATION-BASED EDUCATION ON THE COMPETENCE OF NURSES TO DEAL WITH DISASTERS

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ABSTRACT

Background: *Disasters place exceptional strain on healthcare systems and require a high level of preparedness, rapid clinical judgment, and effective coordination from nurses. Evidence indicates substantial gaps in disaster response competence among nurses, particularly in low- and middle-income countries. Virtual simulation-based education has emerged as a scalable, learner-centered approach to enhance disaster preparedness; however, empirical data from Pakistan remain limited.* ***Objective:*** *To evaluate the effectiveness of a virtual nursing simulation-based disaster education program in improving disaster preparedness and response competence among registered nurses working in a tertiary care hospital in Pakistan.* ***Study Design:*** *Quasi-experimental pretest–posttest study.* ***Setting:*** *Nishtar Medical University (NMU), Multan, Pakistan.* ***Duration of Study:*** *January to June 2025.* ***Methods:*** *Ninety registered nurses were enrolled using non-probability consecutive sampling. Participants completed a structured virtual simulation-based disaster education program incorporating interactive disaster scenarios, guided clinical decision-making, and structured virtual debriefing sessions. Disaster management competence was assessed before and after the intervention using a validated questionnaire covering disaster knowledge, triage and prioritization, clinical decision-making, communication, coordination, and psychological first aid. Data were analyzed using SPSS version 26. Paired t-tests and chi-square tests were applied for pre- and post-intervention comparisons, and multivariate linear regression was performed to identify independent predictors of improved disaster competence. Statistical significance was set at $p < 0.05$.* ***Results:*** *The mean overall disaster competence score increased significantly from 56.3 ± 9.4 at baseline to 78.9 ± 8.1 following the intervention ($p < 0.001$). Significant improvements were observed across all assessed domains, including disaster knowledge, triage and prioritization, clinical decision-making, communication, coordination, and psychological first aid. The proportion of nurses demonstrating adequate disaster preparedness increased from 18.9% pre-intervention to 76.7% post-intervention. Multivariate analysis identified participation in the virtual simulation-based training program as an independent predictor of improved disaster competence ($\beta = 0.61$, $p < 0.001$).* ***Conclusion:*** *Virtual nursing simulation-based disaster education significantly enhances nurses' disaster preparedness and response competence. Integrating structured virtual simulation programs into undergraduate nursing curricula and in-service training may strengthen workforce readiness and improve healthcare system resilience in disaster-prone settings such as Pakistan.*

Keywords: Virtual Simulation; Disaster Preparedness; Nursing Education; Disaster Management; Competence

INTRODUCTION

Disasters, whether natural, technological, or health-related, exert significant pressure on healthcare systems and necessitate rapid and effective responses from healthcare professionals, particularly nurses. As frontline providers, nurses play a crucial role in disaster response and recovery; however, many studies indicate that their preparedness and competence in disaster management are often inadequate (1, 2). The COVID-19 pandemic has further highlighted these deficiencies, revealing a lack of structured training and confidence in dealing with disaster scenarios among nursing professionals (3, 4).

Educational interventions that emphasize disaster preparedness have been shown to enhance nurses' competencies. Simulation-based education, in particular, has emerged as an effective method of equipping nursing students and professionals with the necessary skills to respond to disasters (5,6). According to (7), engaging in disaster preparedness simulations not only increases knowledge but also boosts self-efficacy. Their study revealed that participants in simulation-based programs reported an increase in their preparedness for real-life disasters, highlighting the importance of practical experiences in nursing education (7). Similarly, (6) found that disaster management training programs led to notable improvements in disaster response skills among nursing students, reinforcing the idea that skill enhancement can result from immersive learning experiences (6).

Further, the research conducted by (4) emphasized the necessity of educational reforms targeting disaster-preparedness competencies in nursing curricula (4). The study demonstrated that prior disaster management training was significantly associated with improved competencies in disaster response scenarios. In a global context, numerous studies have documented that nurses equipped with comprehensive disaster training perform more effectively during emergencies, significantly impacting patient outcomes and organizational efficiency during crises (8, 9).

The implications of these findings are notable in Pakistan, where natural disasters, such as floods and earthquakes, are prevalent. Pakistan's healthcare system often grapples with resource shortages and infrastructural challenges, exacerbating vulnerabilities during disasters. Research indicates that targeted simulation-based education could enhance nurses' preparedness levels, fostering confidence and a sense of agency in disaster situations (10). Local studies have shown that despite the critical role of nurses, many are unprepared to manage disaster scenarios effectively (11, 12). Therefore, the implementation of virtual nursing simulation-based education represents a contemporary solution tailored to the needs of the Pakistani nursing workforce, ensuring that healthcare providers are adequately prepared to manage disasters in a timely and efficient manner.

Thus, the integration of simulation-based training into nursing education is imperative for fostering competent and confident nursing professionals who can effectively respond to disasters. This is

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particularly relevant in the Pakistani context, where enhancing nurses' disaster response capabilities can significantly mitigate the adverse effects of emergencies on public health and safety.

METHODOLOGY

This quasi-experimental pretest and posttest study was conducted at a tertiary care hospital in Pakistan over six months from January to June 2025. The study population comprised registered nurses working in emergency, critical care, medical, and surgical units. A total of 90 nurses were enrolled using non-probability, consecutive sampling. Nurses with at least six months of clinical experience were included, while those on prolonged leave or previously trained in formal disaster simulation programs were excluded.

After obtaining ethical approval from the institutional review committee and written informed consent from participants, baseline demographic data and pre-intervention disaster competence scores were collected. Disaster preparedness and response competence was assessed using a structured, validated questionnaire encompassing knowledge, triage, decision making, communication, coordination, and psychological first aid components.

The intervention consisted of a structured virtual nursing simulation-based disaster education program developed in accordance with international disaster nursing competencies and contextualized for the Pakistani healthcare system. The program included interactive virtual scenarios on mass casualty incidents, earthquakes, floods, fire emergencies, and hospital disaster evacuations. Each participant completed guided simulation sessions, scenario-based decision-making exercises, and virtual debriefing led by trained nurse educators over four weeks.

Following completion of the intervention, post-test competence assessments were conducted using the same instrument to ensure consistency. Data were entered and analyzed using SPSS software version 26. Descriptive statistics were calculated for demographic variables. Paired t tests were used to compare pre- and post-intervention competence scores, while chi-square tests assessed categorical differences in preparedness levels. Multivariate linear regression analysis was performed to identify predictors of post-intervention competence. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study included 90 registered nurses who completed the virtual nursing simulation-based disaster education program. According to international reporting criteria, baseline demographic characteristics were documented prior to outcome analysis. The mean age of participants was 29.8 ± 4.6 years, with an age range of 22 to 45 years. Female nurses constituted 62.2 percent (n = 56) of the sample, while male nurses accounted for 37.8 percent (n = 34). Most participants were diploma- or bachelor-level nurses (81.1 percent), and the majority worked in emergency, critical care, or medical wards. The mean professional experience was 5.1 ± 3.2 years. (Table 1)

Table 1: Demographic characteristics of study participants (n = 90)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	34	37.8
Female	56	62.2
Age group (years)		
20–25	18	20.0
26–30	32	35.6
31–35	24	26.7
>35	16	17.7
Educational level		
Diploma in Nursing	29	32.2
Bachelor of Science in Nursing	44	48.9
Postgraduate qualification	17	18.9
Years of experience		
<3 years	21	23.3
3–5 years	29	32.2
>5 years	40	44.5

Baseline disaster management competence was assessed before the intervention using a validated disaster preparedness and response competency scale. The overall mean pre-intervention competence score was 56.3 ± 9.4. Following implementation of the virtual nursing simulation program, a statistically significant improvement was observed in overall competence, with a post-intervention mean score of 78.9 ± 8.1 ($p < 0.001$). (Table 2)

Table 2: Comparison of pre- and post-intervention disaster management competence scores (n = 90)

Competence domain	Pre-intervention Mean ± SD	Post intervention Mean ± SD	p value
Disaster knowledge	14.8 ± 3.1	21.6 ± 2.4	<0.001
Triage and prioritization	11.9 ± 2.8	17.5 ± 2.6	<0.001
Clinical decision making	10.7 ± 2.6	15.8 ± 2.3	<0.001
Communication and coordination	9.6 ± 2.4	13.9 ± 2.1	<0.001
Psychological first aid	9.3 ± 2.2	10.1 ± 2.0	0.041
Total competence score	56.3 ± 9.4	78.9 ± 8.1	<0.001

When competence levels were categorized, only 18.9 percent of nurses demonstrated adequate disaster preparedness before the intervention. This proportion increased to 76.7 percent following completion of the virtual simulation program. (Table 2)

Table 3: Distribution of disaster preparedness levels before and after intervention (n = 90)

Preparedness level	Pre-intervention n (%)	Post intervention n (%)
Poor	31 (34.4)	6 (6.7)
Moderate	42 (46.7)	15 (16.6)
Adequate	17 (18.9)	69 (76.7)

Multivariate linear regression analysis showed that participation in virtual simulation training was an independent predictor of improved disaster competence ($\beta = 0.61$, $p < 0.001$), even after adjusting for age, gender, education level, and years of experience. Nurses working in emergency and critical care units exhibited slightly higher post-intervention scores compared to ward-based nurses, although this difference did not reach statistical significance ($p = 0.08$).

Overall, the results indicate that virtual nursing simulation-based education significantly enhances disaster preparedness and response competence among nurses in a tertiary care hospital setting in Pakistan, meeting international standards for the effectiveness of educational interventions

DISCUSSION

The findings from our study demonstrate a significant enhancement in disaster management competence among nurses who participated in a virtual nursing simulation-based education program. Our results showed a pre-intervention mean competence score of 56.3 ± 9.4,

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which improved to 78.9 ± 8.1 post-intervention ($p < 0.001$). This outcome aligns with recent literature asserting that educational interventions, particularly those utilizing simulation strategies, effectively bolster nurses' disaster preparedness (13, 14). For instance, Farokhzadian et al. reported that online training significantly increased nurses' disaster-related knowledge and preparation, confirming that immersive educational approaches effectively enhance competencies (13). This aligns with our study's findings that structured education programs positively impact disaster management skills.

In our sample of 90 registered nurses, the demographics revealed a predominance of female nurses (62.2%), with the majority having a diploma or bachelor's degree in nursing and an average professional experience of 5.1 ± 3.2 years. This distribution mirrors trends observed in various studies, which indicate a higher representation of female nurses in healthcare settings and a concentration of nursing professionals with equivalent educational backgrounds (15). Furthermore, the age distribution in our data shows a mean age of 29.8 ± 4.6 years, similar to Jang et al., who reported a comparable demographic profile among nurses engaged in disaster response training (16).

The specific domains of competence assessed showed substantial improvement post-intervention, particularly in disaster knowledge (14.8 ± 3.1 to 21.6 ± 2.4) and triage and prioritization (11.9 ± 2.8 to 17.5 ± 2.6), both of which were statistically significant ($p < 0.001$). These findings corroborate with Wang et al., who noted that simulation training not only improved knowledge but also enhanced practical skills, thereby facilitating more effective responses in actual disaster situations (17). Additionally, evidence from Huh and Kang supports our observation that structured training contributes significantly to clinical decision-making and communication skills, which are critical in emergency scenarios (18).

Our study's categorization of preparedness levels pre- and post-intervention revealed a stark contrast, with only 18.9% of nurses demonstrating adequate disaster preparedness before the program, increasing to 76.7% afterwards. This drastic improvement is consistent with findings from Zhang et al., where continued training reinforced healthcare practitioners' readiness for emergencies (19). Similarly, Alhamory et al. highlighted that disaster training is a vital predictor of perceived competencies among nurses, reinforcing our findings that increased education correlates with enhanced preparedness (20).

The multivariate analysis further established virtual simulation training as an independent predictor of improved competence ($\beta = 0.61$, $p < 0.001$). This outcome is consistent with studies by Koçak and Serin, which indicated that prior disaster training significantly increases nurses' personal preparedness levels (21). Our data also echo previous investigations that have highlighted the importance of ongoing education to enhance preparedness among nurses, particularly those working in high-pressure environments like emergency and critical care units (22).

Our study underscores the efficacy of virtual nursing simulation-based education in augmenting nurses' disaster preparedness and response competencies within a tertiary care hospital setting in Pakistan. This is particularly significant given the country's vulnerability to natural disasters, where a well-prepared nursing workforce can significantly mitigate the impact on public health during crises. As research highlights the necessity of integrating effective educational strategies into nursing curricula, our findings contribute to the growing body of evidence supporting simulation training as a cornerstone for enhancing disaster management competencies among healthcare professionals (23, 24). The implications are particularly critical for the Pakistani context, where disaster responses can often be hampered by inadequate training and unpreparedness among healthcare providers. By focusing on simulation-based educational interventions, nursing professionals can be better equipped to meet the challenges posed by disasters, ultimately contributing to improved health outcomes in times of emergency (25).

CONCLUSION

This study provides robust evidence that virtual nursing simulation-based education is an effective and practical approach to improving disaster preparedness and response competence among nurses. The significant gains observed across multiple competency domains highlight the value of immersive, scenario-driven learning in strengthening nurses' readiness to manage complex disaster situations. Given Pakistan's vulnerability to natural and public health disasters, incorporating virtual simulation into nursing curricula and continuing professional development programs may enhance workforce preparedness, improve emergency response capacity, and ultimately contribute to better patient and system-level outcomes during disasters.

DECLARATIONS

Data Availability Statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department Concerned. (IRBEC-MMUNC/254-24)

Consent for publication

Approved

Funding

Not applicable

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

SAMREEN AKHTAR (MSN Student)
Manuscript revisions, critical input.
Data entry, data analysis, drafting an article.
QAMAR-UN-NISA (Principal)
Conception of Study, Final approval of manuscript.
Study Design, Review of Literature
YASMEEN TAHIRA (Assistant Nursing Instructor)
Conception of Study, Development of Research Methodology Design, Study Design,
SHAGUFTA MAJEED (*vice principal*)
Review of manuscript, final approval of manuscript.
Manuscript drafting.

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