Research Paper

Nurses' Preparedness Toward Bioterrorism and Related Factors: A Multicenter Study

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ABSTRACT

Background: Today, bioterrorism has drawn the attention of disaster response organizations such as hospitals and nurses are at the front line of hospitals' response to bioterrorism. This study examined nurses' preparedness against bioterrorist attacks and related factors.

Materials and Methods: This cross-sectional study included 529 nurses from 9 hospitals in North Khorasan Province, Iran. A questionnaire with three dimensions, knowledge, risk perception, and personal preparedness, was used to collect data. The scores for preparedness in the three dimensions and the total score were calculated based on 100 points.

Results: The Mean±SD scores of knowledge, risk perception, personal preparedness and the total score were 3.57±11.33, 85.95±8.10, 14.95±29.47 and 37.74±6.84, respectively. There were positive statistical relationships between knowledge and female gender (P<0.001), holding a bachelor's degree (P<0.001) and receiving bioterrorism training/exercises (P<0.001). Also, there were positive relationships between risk perception and female gender (P<0.05) and holding a master's degree or higher (P<0.001). In addition, there were positive statistical relationships between personal preparedness and female gender (P<0.05), holding a bachelor's degree (P<0.001), receiving bioterrorism training (P<0.05) and work experience (P<0.001). Finally, there were positive statistical relationships between total score of preparedness and female gender (P<0.001) and receiving bioterrorism training/exercises (P<0.001).

Conclusion: Findings revealed that nurses' risk perception scored relatively high, but their knowledge and personal preparedness were alarmingly low. This finding suggests that while nurses recognize the potential threats posed by bioterrorism, they may lack the training to respond effectively. Based on the results of our study, the preparedness of the studied nurses toward bioterrorism was low, and various factors contributed to it. Because of nurses' lack of knowledge, bioterrorism training is highly recommended.

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Introduction

Today, bioterrorism has drawn the attention of organizations active in responding to emergencies and disasters in any society [1, 2]. Various types of biological agents that can be used in a biological attack, the difficulties in discovering cases of bioterrorism, and, more importantly, mass casualties in some instances of biological attacks made their management difficult and challenging [3-5]. A scenario about the origin of the COVID-19 pandemic that affected more than seven million healthcare fatalities all over the world indicated that it was a bioterrorist attack. The pandemic experience showed how bioterrorism might be dangerous and destructive [6, 7].

Among organizations active in responding to emergencies and disasters, the role of hospitals in response to bioterrorism is essential. Most of the actions to mitigate the damages of bioterrorism, detect and identify attacks, announce early warnings, prevent the spread of the agents and the increase of infected people, take care of the injured, and treat them are performed in health facilities [8, 9]. Among different health facilities, hospitals are the focal point of operations for responding to bioterrorist attacks and treating casualties [10]. In hospitals, clinical staff, such as nurses, play a significant role in responding to bioterrorism [11, 12].

Studies on past incidents showed that nurses had faced many challenges and problems when responding to bioterrorist incidents [13-15]. Concerns about health and family and lack of personal protective equipment are some of their challenges [16]. A study on the willingness of nurses to report at work in emergencies and disasters showed that among the three scenarios of earthquake, flood, and epidemic of an unknown infectious disease, the lowest willingness was related to the epidemic. Concerns for personal and family safety were the main reason for their reluctance [11]. Preparing nurses before confronting bioterrorism attacks is necessary, as this preparation positively affects their responses and ability to manage such situations [12]. Identifying the level of nurses' preparedness toward bioterrorism and related factors is the first step in developing interventions to enhance preparedness. Preparedness for emergencies, in general, and bioterrorism, in particular, necessitates addressing different dimensions, including knowledge, attitude, and practice.

Most studies in this field focused on some, but not all dimensions. One of these studies examined nurses' and doctors' knowledge and attitudes toward bioterrorism in the emergency department of hospitals in Ghana by using qualitative methods [17]. A cross-sectional study investigated nurses' preparedness against biological incidents and bioterrorism in public hospitals in Saudi Arabia [18]. This study measured nurses' necessary knowledge and skills to manage biological disasters. Ghahremani et al. assessed the impact of simulation versus workshops on nursing students' knowledge and practical skills about bioterrorism preparedness [19]. Their research involved 40 nursing students randomly assigned to either workshop or simulation groups. Data collection tools included questionnaires, a bioterrorism knowledge scale, and a performance measurement checklist. The workshop group scored lower than the simulation group in various knowledge and performance areas. The study focused solely on knowledge and skills, not preparedness attitudes.

In contrast to Ghahremani's study, Khoshnudi et al. examined the impact of education on knowledge and attitude [20]. Through a quasi-experimental study, they assessed the effects of bioterrorism education, delivered by two different methods—lectures and booklets—on the knowledge and attitudes of 80 nursing staff of a military hospital. A significant increase in the knowledge score of the lecture group was observed. Conversely, there was no statistically significant difference in attitude scores of the lecture and booklet groups [20]. Practice, as a dimension of preparedness, was neglected in Khoshnudi's study. The present study examined nurses' preparedness against bioterrorist attacks and related factors to bridge the knowledge gap in this crucial field.

Materials and Methods

The current study has a cross-sectional design.

Participants and sampling

The study aimed to estimate hospital nurses' preparedness against bioterrorist attacks. To this end, a sample size 529 was determined using PASS software, version 23.0.2 considering an effect size of 0.1, a type I error of 0.05, and a test power of 0.9. The sample was chosen from 9 public hospitals in North Khorasan Province, Iran. A stratified sampling method was used in this study. Every hospital was considered a stratum and nurses were chosen by random sampling. They could participate in the study if they had at least one year of work experience. Moreover, no exclusion criteria were applied.

Data collection tool

Since a comprehensive questionnaire was not found or available that simultaneously measures all three dimensions of nurses' preparedness against bioterrorist attacks, a mixed questionnaire was designed by merging the dimensions of two questionnaires: One used in Hamzeh Pourur's study and the other in Rebmann's study [21, 22]. The first part measured participants' knowledge about bioterrorist attacks through 30 yes/no questions. One score was given to the "yes" option and zero to the "no" option. The second dimension was the risk perception of biological attacks. This dimension consisted of six items on a 5-point Likert scale (strongly agree=4, agree=3, neither agree nor disagree=2, disagree=1 and strongly disagree=0). The third dimension consisted of 9 items, with yes/no options, which measured study participants' actions to prepare against bioterrorism. One score was given to the "yes" option and zero score to the "no" option. Scores of each dimension were transformed to a scale of 100. The mean scores of the three dimensions, knowledge, risk perception and personal preparedness, were considered total preparedness. Since all dimensions' minimum and maximum scores were 0 and 100, the midpoint (50) was used as the cutoff. Scores of 50 or above were considered a high level of preparedness, while scores below 50 indicated a low level.

To assure the validity of the questionnaire, the content validity ratio (CVR) was calculated using the opinions of 10 experts. The value of CVR for all questions was more than 0.62, which confirmed the validity of the questionnaire. Internal consistency was evaluated by calculating the Cronbach α coefficient, equal to 0.82, meaning acceptable consistency. The reliability was assessed by test re-testing a sample of 30 participants. The estimated intraclass correlation coefficient (ICC) was 0.91, which indicated the reliability of the questionnaire.

Data gathering

One of the researchers went to the target hospitals where the sample individuals worked, distributed the questionnaires and collected the completed questionnaires.

Data analysis

The data were analyzed using descriptive statistics, including Mean±SD, frequency and percentage. Also, the Mann-Whitney, Spearman and Kruskal-Wallis tests were performed for inferential statistics.

Results

The response rate was 47%. Demographic information of participants is shown in Table 1.

Most participants were married women, with a 10±6.50 mean of working years and had a bachelor's degree. The majority of studied nurses had permanent employment contracts. Only 1.5% attended bioterrorism preparedness exercises.

According to Table 2, knowledge obtained the lowest (3.57±11.33) and risk perception the highest score (85.95±8.10) of the maximum possible score (100). Scores of all dimensions except perception were below 50 (midpoint).

As shown in Table 3, there was a statistically significant relationship between gender and all dimensions of preparedness against bioterrorism attacks. Women were more prepared than men in all dimensions ($P<0.05$). The results showed a statistically significant relationship between the level of education and preparedness in terms of knowledge, risk perception, and personal preparedness ($P<0.001$). Study participants with a bachelor's degree obtained higher scores on knowledge, risk perception and personal preparedness than those with a master's degree or higher.

Work experience had an inverse statistically significant relationship with the dimension of personal preparedness. The participants with more work experience had less personal preparedness ($P<0.001$). Furthermore, there was a significant relationship between training and participating in bioterrorism exercises with different dimensions of preparedness ($P<0.001$). Those who had previously attended bioterrorism preparedness courses had higher scores on knowledge and personal and total preparedness against bioterrorism. Moreover, those who participated in bioterrorism exercises had significantly higher knowledge and total preparedness scores.

The findings showed a statistically significant relationship between the dimensions of bioterrorism knowledge and risk perception and the dimension of personal preparedness. Those with higher knowledge and risk perception had higher personal preparedness ($P<0.001$) (Table 4).

Discussion

The current study showed that the least preparedness against biological attacks was in the knowledge dimen-

Table 1. Demographic information of participants

Variables		Mean±SD/No. (%)
Years of work experience		10.09±6.5
Gender	Female	330(62.4)
	Male	199(37.6)
Marital status	Single	174(32.9)
	Married	355(67.1)
Employment status	Permanent	247(46.7)
	Temporary	136(25.7)
	Others	146(27.6)
Education level	Bachelor's degree	371(70.1)
	Master's degree and higher	158(29.9)
Bioterrorism training	Yes	16(3)
	No	513(97)
Bioterrorism preparedness exercises	Yes	8(1.5)
	No	521(98.5)

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sion, and the level of knowledge was much lower than the average (3.57 out of 100). These findings are consistent with other studies, such as the study of Hartwig et al. in the USA and Gorji et al. in Iran [23, 24]. The findings of Gorji et al. showed that 91.7% of study participants had inadequate knowledge about bioterrorism, and 93.3% had a low attitude towards bioterrorism [24]. The weakness and absence of specific courses on bioterrorism in nursing curricula and the lack of continuous occupational training can be the leading causes of this issue [25]. Because the direct relationship between knowledge and preparedness to work during pandemics and biological attacks has been well proved in previous studies [26], it is necessary to design and implement special training programs to increase nurses' knowledge of bioterrorism.

The present study shows that women are significantly more prepared for bioterrorist attacks than men, consistent with Lee and Kim's study investigating nurses' preparedness against bioterrorism and related factors in hospitals in South Korea [25]. The reason might be the increased involvement and engagement of female staff in educational programs on disaster preparedness, resulting in higher preparedness, as claimed by Hamzeh Pour and Khajehnasiri [27]. They examined the impact of education on the knowledge and attitudes of biological sciences students regarding bioterrorism. Their

Table 2. Mean scores of preparedness dimensions

Dimension of Preparedness	Mean±SD
Knowledge	3.57±11.33
Risk perception	85.95±8.1
Personal preparedness	14.95±29.47
Total preparedness	37.74±6.84

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Table 3. Relationships between dimensions of preparedness and demographic information of study participants

Demographic Variables	Dimensions of Preparedness	Knowledge		Risk Perception		Personal Preparedness		Total Preparedness	
		Mean±SD	P	Mean±SD	P	Mean±SD	P	Mean±SD	P
Gender	Male	0.65±4.13	<0.001*	85±7.05	0.045*	14.46±30.98	0.025*	36±4.35	<0.001*
	Female	5.34±13.68		86.52±8.63		15.25±28.56		38.79±7.79	
Marital status	Married	3.45±9.89	0.471*	86.19±7.55	0.571*	0	0.815*	37.78±6.46	0.312*
	Single	3.83±13.83		85.45±9.13		14.94±28.78		37.64±7.58	
Education level	Bachelor's degree	4.84±13.22	<0.001*	85.04±8.95	<0.001*	19.97±33.08	<0.001*	38.51±7.85	0.103*
	Master's degree and higher	0.61±2.6		88.1±5.05		3.16±11.96		35.91±2.74	
Bioterrorism training	Yes	26.87±29.8	<0.001*	88.12±10.46	0.355*	30.55±28.54	0.003*	53.58±12.54	<0.001*
	No	2.85±9.42		85.88±8.02		14.46±29.39		37.24±5.96	
Bioterrorism preparedness exercises	Yes	54.58±21.45	<0.001*	90±13.8	0.210*	18.05±23.71	0.121*	65.33±3.70	<0.001*
	No	2.79±9.13		85.89±7.99		14.9±29.57		37.31±5.95	
Employment Status	Permanent	5.88±15.26	0.290$	85.45±8.01	0.174$	13.27±27.36	0.270$	38.36±8.13	0.974$
	Temporary	2.04±5.96		86.37±7.03		17.23±34.15		36.95±4.71	
	Others	2.28±6.3		86.47±9.29		15.97±28.63		37.48±6.07	
Years of work experience		-	0.162Φ	-	0.083Φ	-	<0.001Φ	-	0.476Φ

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*The Mann-Whitney U test, $The Kruskal-Wallis test, ΦThe Spearman test.

study results indicate that although the mean knowledge scores of male and female students were similar before the intervention, the scores for female students increased significantly, suggesting greater engagement of female participants in the educational program [27].

The current study had a negative statistical relationship between work experience and preparedness. People with more years of service are less prepared. The findings of Grimes and Mendias also show such a relationship [28]. They investigated the intention of nurses to respond to a bioterrorist attack in a situation with a risk of infection for themselves and their families. They asked the study participants to express their intention to take care of a patient who was the victim of a bioterrorist attack on a 10-point Likert scale. They found a positive relationship between knowledge about bioterrorism and experiences of working in emergencies of infectious diseases and the intention to take care of the victims. Those who had children and more years of work experience were less

Table 4. The relationships between different dimensions of preparedness

Dimensions of Preparedness	Knowledge		Risk Perception		Personal Preparedness	
	Correlation coefficient	PΦ	Correlation coefficient	PΦ	Correlation coefficient	PΦ
Knowledge	1.000	-	-0.061	0.161	0.265	<0.001
Risk perception	-0.061	0.161	1.000	-	0.246	<0.001
Personal preparedness	0.265	<0.001	0.246	<0.001	1.000	-

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ΦThe Spearman test.

likely to respond to a bioterrorist attack [28]. The lower preparedness of long-term employees might be related to the gradual loss of the knowledge and skills acquired during academic studies over time and the lack of motivation or ability to prepare and respond to emergencies due to work pressure and personal and family responsibilities. However, Fohrman et al. found a significant relationship between service years and bioterrorism preparedness. Work experience contributes to skill development [29]. Differences in context and study environment may explain the inconsistency.

In our study, a negative relationship was observed between the level of education and preparedness, which is consistent with the findings of some other studies [30-32]. One of them evaluated the knowledge, skills, and personal preparedness of military healthcare workers for participating in global health emergency missions in the USA [31]. The study participants' knowledge, skills, and individual preparedness were average. The results of regression analysis showed that six variables had a statistically significant relationship with preparedness: Disaster and bioterrorism training, disaster experience, education level, work experience, and experience of participating in global health missions. The relationship between education level and preparedness was inverse [31]. The reason might be that nurses holding bachelor's degrees are the leading target group and participants in training courses and bioterrorism exercises.

In comparison, nurses with a higher level of education are usually senior nurses and have managerial positions, making them reluctant to participate in such programs. Therefore, they lack knowledge and, consequently, preparedness for bioterrorist attacks. The negative relationship between education level and preparedness could also be rooted in the particular nature of bioterrorism [32].

Contrary to our study, a systematic review that sought to synthesize the literature on preparedness for disaster response among nurses found that higher academic qualifications are related to increased preparedness for disasters [33]. This finding could be attributed to the distinction among biological attacks, man-made incidents, and natural disasters. The present study focused on bioterrorism, but the systematic review encompassed all disaster types. The unknown nature of biological attacks and the ensuing uncertainty tend to leave individuals, regardless of their educational background, ill-prepared for such instances. Academic training can have little impact on their preparedness.

The current study shows a statistically significant relationship between bioterrorism training and exercises with preparedness, which is consistent with the findings of Crane et al. [34]. They investigated the preparedness and willingness of healthcare workers to respond to bioterrorist attacks and related factors in a state of the USA. Of 2279 study participants, 50.54% were nurses; only 32% of nurses declared their willingness to participate in a biological attack response operation. Gender, race, and training/exercise on bioterrorism were predicting factors for preparedness. Logistic regression analysis indicated that the preparedness chance of trained healthcare workers on bioterrorism was 2.86 times more than others [34]. Educational programs enhance knowledge and contribute to increased preparedness. Chang and Kim's study proved this claim, too. Through a quasi-experimental study, they examined the effect of training on bioterrorism on nurses' knowledge, attitude, and competencies to respond to bioterrorist attacks in South Korea. They held 10 training sessions using mobile phones for the experimental group for three weeks and found significant differences between the experimental and control groups in all three dimensions of preparedness. Post-test after the intervention showed that the experimental group had higher knowledge, attitude, and competencies than the control group [35].

In the present study, there was a statistically significant relationship between knowledge risk perception and personal preparedness, similar to Setyawati et al. and Yousefi et al. [36, 37]. Setyawati et al. aimed to determine the factors affecting the preparedness of hospital nurses in Bangkok, Thailand, and found a significant relationship between the knowledge of disasters and the level of preparedness [36]. Yousefi et al. also observed a similar relationship. They conducted a systematic review of Iranian studies and declared that the levels of knowledge and performance of nurses towards disasters were average, and their attitude level was high [37]. The reason might be rooted in the fact that higher knowledge leads to better performance and preparation [38].

One of the strengths of the present study is its multicenter nature. The study participants were chosen from nurses from 9 hospitals in a province's cities. Moreover, all dimensions of preparedness, including knowledge, attitude, and practice, were studied. The practice has not been studied in many studies in this field. One limitation of the study was the low response rate. However, we explained the study's benefits to the target group and tried to convince them to participate.

Conclusion

In total, the preparedness of the studied nurses against bioterrorism was low. Various factors are related to preparedness, knowledge being the main one. It seems that the relationship of other factors with preparedness is affected by knowledge. It determines the relationship between other factors and preparedness. Therefore, it is strongly recommended that, due to the very low level of knowledge, appropriate educational interventions and exercises be designed and implemented to increase nurses' preparedness against bioterrorism. The training programs should be continuous and comprehensive and include all nurses, particularly senior nurses. Future studies should investigate the effect of different methods of training and exercises on the preparedness of different employees, not only nurses but also doctors.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (Code: IR.MUMS.FHMPM.REC.1401.212). Study participants were required to fill out a consent form indicating that their participation was voluntary and they could decline to answer any question. Furthermore, the personal data of participants was guaranteed to remain confidential.

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Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interception of the results and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflict of interest.

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