Original Article

Effect of a training package for the prevention of ventilator associated pneumonia using a blended online learning method on the knowledge and performance of nurses working in the intensive care unit

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Abstract

Background & Objective: It seems necessary to provide effective training methods to nurses in preventing ventilator-associated infections. The aim of This study was assessment of the knowledge and performance of Intensive Care Unit (ICU) nurses following a training package on the prevention of Ventilator-Associated Pneumonia (VAP) using a Blended Online Learning (BOL) method.

Material & Methods: In this semi-experimental study, 60 nurses from the ICUs of two main hospitals in Najaf were included in the intervention and control groups. In the BOL group, a 45-minute online training session was held. Afterward, a virtual channel was formed and at a specific time, videos were shared for 5 days for further study and short questions were asked for group discussion. In the control group, two 2-hour online training sessions were held once a week. The knowledge and performance of nurses were evaluated before the intervention as well as two and four weeks after the intervention. Data analysis was performed using SPSS 21 software with a significance level of 5%.

Results: The mean values of the knowledge scores were 29.3 ± 4.7 and 29.7 ± 4.1 in the intervention group and 22.6 ± 4.6 and 20.5 ± 4.7 in the control group two and four weeks after the intervention, respectively. The mean values of the performance scores were obtained at 34.1 ± 5.4 and 33.5 ± 5.6 in the intervention group and 23.8 ± 4.6 and 24.3 ± 5.7 in the control group, respectively. The results of the repeated measures ANOVA showed that there was a statistically significant difference between the two groups in terms of the mean score of knowledge ($p = 0.001$) and the mean score of performance ($p = 0.031$).

Conclusion: Training using the BOL method was effective in improving the level of knowledge and performance of nurses and can be used as a suitable training method in VAP prevention programs.

Keywords: blended online learning, critical care nurses, knowledge, performance, ventilator-associated pneumonia

Introduction

Ventilator-Associated Pneumonia (VAP) is the most common hospital infection (1) that develops within 48-72 h after tracheal intubation and its main characteristic is the appearance of infection symptoms (fever and increased white blood cells) in patients (2). It is estimated that this pneumonia occurs in 9%-27% of all mechanically ventilated patients. The prevalence of this pneumonia in America is 2%-6% (3), and in studies conducted in Iran, it has been estimated to be 12%-32% prevalent (4-6). The incidence rate of VAP In Intensive Care Units (ICUs) in Iraq has been reported to be 25%-57.59% (7-8). Ventilator-associated pneumonia

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increases the length of hospitalization in the ICU, the use of more human resources, the cost of treatment, and mortality (9-10). The occurrence of each case of VAP can push up the cost of treatment to 40,000$ (12).

Ventilator-associated pneumonia has been raised as an enormous challenge for nurses in ICUs (13). Considering the high prevalence of VAP and its negative effects, it seems that the best way to deal with this infection is to prevent it (14). Nurses have a unique role in the prevention and control of hospital infections; meanwhile, providing high-quality and standard care to patients hospitalized in the ICU is necessary to prevent the occurrence of VAP (15- 16). The results of numerous studies are indicative of nurses' insufficient knowledge and unfavorable performance in controlling and preventing the occurrence of VAP. Therefore, it is highly recommended to empower nurses, particularly in ICUs, to prevent and reduce hospital infections (e.g., VAP) (17-18). Various researchers in different studies, to empower nurses and improve their performance and their knowledge in preventing VAP, have adopted different approaches, such as holding training classes, providing booklets and self-study books on hospital infections, workshop and training based on clinical guidelines and in social networks and web (19-22).

Moreover, the Centers for Disease Control and Prevention has paid attention to the training of nurses as an important strategy in the prevention of hospital infections (23). The concept of traditional education has changed drastically in the last few years. Physical presence in the classroom is no longer the only learning option, with the advent of the Internet and new technologies and access to computers, it is possible to access high-quality electronic education (24). Various types of Blended Learning (BL) methods, which are a combination of face-to-face and onsite training with online training, have been proposed. In this method, online training is delivered asynchronously using a Learning Management System (LMS) (25).

The experience of facing to The COVID-19 pandemic necessitated the adoption of an emergency measure in all countries throughout the world. All educational institutions were forced to close until further notice and had to provide creative solutions to continue the learning process, especially electronic and online education types (26). Kwapong (2022) conducted a qualitative study on female university students' experiences in virtual education during COVID-19. The results of the study revealed that poor internet connection, limited financial resources, limited time to comprehend educational materials, and lack of electronic devices were the most significant issues faced by students in online education. In addition, they showed that the students had both the willingness and ability to use interactive tools, such as Whats App, various chat rooms, and video conferences, to study more in the form of group and virtual interactive activities (27).

In traditional learning environments, educational content was primarily learned through teacher-learner interaction, while in many e-learning courses, less attention has been paid to the issue of interaction and only the prepared educational content is made available to the learners (28). This can influence the effectiveness of this type of training, the motivation of learners to learn more, and their satisfaction with the training process (29-30). The results of a study by Kumtepe (2018) demonstrated that one of the dimensions of supporting learners in distance education is creating a positive interactive environment between learners, professors, and staff (31). Creating interaction in online education environments as a necessity and need deserves more attention (32). Blended Online Learning (BOL), an emerging method of online education, is fully online rather than a combination of face-to-face and online learning and is a combined method of "asynchronous online" learning using an LMS and "synchronous online learning" using various applications, such as web conference, Adobe Connect, WebEx, and WizIQ (25).

Existing studies predict that online or web-based BL will soon be proposed as an alternative to traditional face-to-face education, especially in higher education, because of its potential to provide more people with access to effective education, as well as lacking the challenges of online-only education, and it will be presented as the most accepted educational method (33). On the other hand, the findings of some studies demonstrate a much weaker condition of university students who have enrolled in only online courses. Based on the results of a study by Ryan et al. (2016), students receiving the BL method had the same, and in some cases, even better performance than the students educated with the traditional education method (34). Considering the importance and necessity of training nurses in the prevention of VAP in ICUs, the researcher conducted a study to determine the impact of a training package for the prevention of VAP using a BL method on the knowledge and performance of nurses working in the ICU.

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Material & Methods

Design and setting(s)

The present semi-experimental study was performed using a parallel design and a control group in Najaf, Iraq, in 2022. The research environment was the ICUs of two main hospitals in Najaf (namely Al-Sadr and Al-Najaf), which are the largest in this city. The reasons for choosing these centers as the research environment were because of their medical research and training nature and the greater possibility of attracting the cooperation of officials and employees as well as facilitating the sampling process.

Participants and sampling

The research population included all nurses with at least 6 months of experience working in the ICU. The eligibility criteria for entering the study were willingness to participate in the study, the experience of at least 6 months of work in the ICU, and a history of caring for patients under a ventilator. On the other hand, exclusion criteria were completing years of service before the research ended or changing the department/place of service, withdrawing from the research, participating in other training courses of VAP during the research based on questions and self-report or previous participation in-service training courses on VAP prevention.

The sample size was determined at 30 samples in each group using the formula "comparison of means in two independent communities", taking into account the results of a study by Mohammadpour Anvari (35), the confidence level of 95%, the test power of 80%, and the dropout rate of 20%.

$$n=\frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2\times[(S_1{}^2+S_2{}^2)]}{(m_1-m)^2}$$

$$n=\frac{(1/96+0/84)^2\times[(2/86^2+2/85^2)]}{(21/07\ -18/82)^2}=25.24$$

Samples were selected based on the entry criteria and using an convenience sampling method. The ICU nurses at the Al-Sadr Hospital were assigned to the control group, while their peers at the Al-Najaf Hospital were put in the intervention group (n = 30 each). It should be noted that due to the high probability of information dissemination and exchange between nurses in each department, the random allocation of nurses in each department was not done separately. However, Al-Sadr and Al-Najaf hospitals were randomly divided into web-based learning and BL groups using the lottery method. Therefore, since the study intervention was conducted in two separate hospitals, it was not possible to disseminate information between the nurses of the two groups.

Tools/Instruments

The study tools included a knowledge assessment questionnaire and an observational checklist to measure the performance of VAP prevention. The nurses' knowledge assessment questionnaire included 37 items regarding the prevention of VAP. Each correct answer had one point, rendering the maximum score of 37. The level of knowledge was classified as weak if a score of < 18 was obtained (< 50% of the items were replied), as average for a score of 18-27 (50%-75% of the items were answered), and as good for a score of 28-37 (if 75%-100% of the items were replied). The validity of the questionnaire was confirmed through the qualitative assessment of the content validity and by the opinions of 7 professors of Mashhad School of Nursing and Midwifery, and its reliability was confirmed by calculating Cronbach's alpha coefficient (α=0.85).

The observational checklist to measure performance included 43 items. Each correct performance was one point, and therefore, the maximum performance score was obtained at 43. The performance level was considered weak for a score of < 22 (reply to < 50% of the items), average for a score of 22-33 (reply to 50%-75% of the items), and good for a score of 34-43 (reply to 75%-100% of the items. The reliability of the checklist was confirmed through the inter-observer agreement and the Kappa coefficient of 0.78. The validity of the mentioned instrument was confirmed through the qualitative assessment of content validity using the opinions of 7 professors of the Mashhad School of Nursing and Midwifery. After ensuring the content validity of the Persian versions, the tools were translated into Arabic along with the English text and presented to 7 experts in Najaf city to confirm their content validity. The experts' opinions were applied after the coordination and approval of the research team.

Intervention

Before the implementation of the intervention, educational content with a wide review of the latest guidelines and reliable scientific sources was prepared(1-6, 9-15, 21-22) and evaluated by 10 professors and experts, including 7 professors and faculty members of the Mashhad School of Nursing and Midwifery and 3 ICU doctors and specialists in Najaf and Iran. After applying the necessary suggestions and corrections, the scientific validity of the prepared content was confirmed.

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Afterward, according to the opinion of the research team, short video clips on practical issues, such as how to properly wash hands and mouth, tracheal tube suction, care of cuffs and respiratory equipment, were searched and downloaded, and after review and approval by the consultant professor were translated under his supervision into the Arabic language. The intervention was carried out after obtaining the approval of the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran, and coordinating with the officials of the two main hospitals in Najaf, observing the ethical considerations, and explaining the objectives of the study. The study was conducted between May and August 2022.

In the BOL group, the intervention was implemented in one week. First, a 45-minute online session was held for theoretical training. In this session, with the help of a PowerPoint presentation and lecture, the following content was delivered: the definition and different types of pneumonia, characteristics of VAP, risk factors, and prevention methods, including hand hygiene and careful hand washing, correct suctioning, observing contact precautions while caring for the patient, oral hygiene, care of tracheal tube cuff, prevention of aspiration, and prevention of contamination of respiratory equipment. Subsequently, the questions of the participants were answered, and a common time was established for further discussing the details of the presented content at the end of the meeting, which was set to be at 11 every night.

A virtual communication group was then formed on the WhatsApp messaging platform, and for 5 days at 11 pm, videos translated into Arabic were shared for practice and further study. At the same time, the researcher asked short questions about the topics related to the videos sent to the group, and the nurses' replies were examined and discussed for half an hour with other members of the group. The content of the topics presented in the sessions was as follows: first session: "the importance of and reason for VAP prevention, risk factors, and the role of nurses"; the second session: "the importance of hand washing and oral hygiene and how to do it correctly"; the third session: "the importance and consequences of correct or incorrect suctioning of patients in preventing VAP and the correct method to do it"; the fourth session: "the importance of taking care of the cuff and preventing aspiration and how to do it"; the fifth session: "the importance and method of preventing respiratory equipment contamination". After five virtual sessions, the second online theoretical training session was held for 45 min to summarize and answer possible questions and doubts.

In the control group, the prepared content was taught in the Adobe Connect platform in two 2-hour sessions once a week. In the first session, the educational content included the presentation of materials related to the definition and various types of pneumonia, as well as VAP definition, risk factors, and prevention methods, including hand hygiene and careful hand washing, correct suctioning, observing contact precautions while caring for the patient, and the importance and necessity of oral hygiene. The content of the second session was dedicated to the importance and ways of taking care of the tracheal tube cuff, the significance and ways of preventing aspiration, and the prevention of the contamination of respiratory equipment. In this group, the content was presented through PowerPoint and lectures, and at the end of each session, the questions and doubts of the nurses were answered. It should be mentioned that all training sessions were conducted by the first and third authors, and the training content and the total time of formal training were the same in the two groups (4 hours).

Data collection methods

Before the intervention, as well as two and four weeks after the intervention, the VAP prevention knowledge questionnaire was completed by the nurses in both groups. The observational performance measurement checklist was used to evaluate nurses' performance before, two weeks after, and four weeks after the intervention. To prevent bias in the evaluation of nurses' performance and completion of the relevant checklist, a blind research assistant with a master's degree in special care nursing, who was not among the department's personnel, helped in this regard. This research assistant randomly attended one of the nurses' work shifts (morning, evening, or night) using the work schedule that he had received from the department management, and observed and evaluated them by performing the procedures on the checklist (one shift for each procedure) (Figure 1). It should be mentioned that the required arrangements had been made for the presence of the researcher's assistant in the department, and the necessary explanations were given to the nurses regarding the confidentiality, safety, and anonymity of the results. Furthermore, the nurses were assured of the only-for-research purposes of the results.

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Data analysis

Data analysis was performed in SPSS 21 software. First, the normal distribution of the data was checked with the Kolmogorov-Smirnov or Shapiro-Wilk test. (Table1), The variables of knowledge and performance of nurses in two intervention and control groups in different stages of the study had a normal distribution.according to the results of the normal or non-normal distribution of the data, the homogeneity of the groups was investigated using descriptive indices and independent t, Mann-Whitney U, and Chi-square tests. To analyze and compare the main data, repeated measures ANOVA was employed. In all tests, a 95% confidence level and 0.05 significance level were considered.

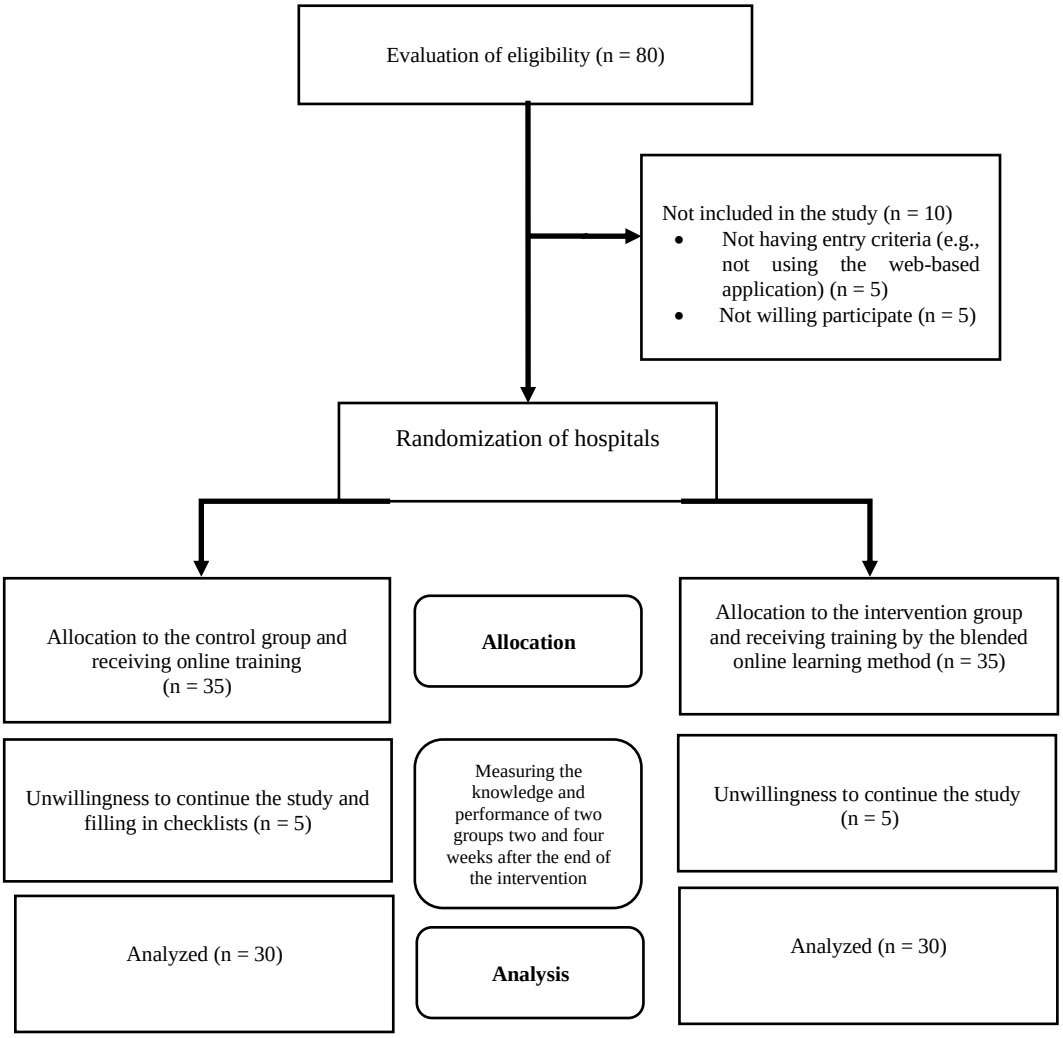


Figure 1. Flow chart of conducting the study

Results

The mean age scores of nurses in the intervention and control groups were 33.4 ± 4.6 and 34.6 ± 5.3 years, respectively. Additionally, 73.3% of the nurses in the intervention group and 63.3% in the control group were male, and most of the nurses in both groups had a bachelor's degree in nursing. The results of the statistical tests showed the homogeneity of the two groups in terms of background and demographic variables (Table 2).

Moreover, before the intervention, the two groups had no statistically significant difference in terms of the mean score of knowledge and performance. Accordingly, the mean knowledge score of nurses was 16.3 ± 4.8 in the intervention group and 15.5 ± 5.2 in the control group. Independent t-test did not show this difference to be significant (p = 0.519). The mean performance score of nurses in the intervention group was 16.8 ± 7.6, while it was 15.9 ± 7.1 in the control group. According to the

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independent t-test, this difference was not significant (p = 0.636) (Table 3).

Regarding the first specific goal of the research, which was to determine the effect of BL on nurses' level of knowledge in preventing VAP, the analysis of the study results demonstrated that before the intervention, the mean knowledge score was 16.3 ± 4.8 in nurses in the intervention group and 15.5 ± 5.2 in the group control. The mean values of nurses' knowledge scores were 29.3 ± 4.7 and 22.6 ± 4.6 two weeks after the intervention and 29.7 ± 4.1 and 20.5 ± 4.7 four weeks after the intervention in the intervention and control groups, respectively.

Table 1. The results of the test of whether the dependent variables of the study have a normal distribution by group

Variable	Group			
	Control		intervention	
	Shapiro Wilk	Result	Shapiro Wilk	Result
Knowledge score before the intervention	0.194	N*	0.028	Non**
Knowledge score two weeks after the intervention	0.013	Non	0.14	N
Knowledge score four weeks after the intervention	0.05	Non	0.06	N
Two weeks after the intervention compared to before the intervention	0.088	N	0.217	N
Four weeks after the intervention compared to before the intervention	0.621	N	0.025	Non
Four weeks post-intervention compared to two weeks post-intervention	0.017	Non	0.065	N
Total performance score before intervention	0.058	N	0.001	Non
Total performance score two weeks after the intervention	0.191	N	0.028	Non
Total performance score four weeks after the intervention	0.851	N	0.043	Non
Two weeks after the intervention compared to before the intervention	0.206	N	0.021	Non
Four weeks after the intervention compared to before the intervention	0.103	N	0.087	N
Four weeks post-intervention compared to two weeks post-intervention	0.546	N	0.117	N

Abberviations: *N: Normal, **Non: Non-normal

Table 2. Demographic characteristics of the participants in the study

Variable	Group		Test result (p-value)
	Intervention	Control	
	n = 30	n = 30	
Gender, n (%)			
Male	22 (73.3)	19 (63.3)	*p = 0.405
Female	8 (26.7)	11 (36.7)	
Age, years (mean ± SD)	33.4 ± 4.6	34.6 ± 5.3	**p = 0.467
Marital status, n (%)			
Single	10 (33.3)	8 (26.7)	*p = 0.573
Married	20 (66.7)	22 (73.3)	
Occupational status, n (%)			
Public servant	18 (60.0)	18 (60.0)	***p = 1.000
Temporary-to-permanent employee	3 (10.0)	3 (10.0)	
Contractual employee	9 (30.0)	9 (30.0)	
Education level, n (%)			
Bachelors	22 (73.3)	20 (66.7)	*p = 0.573
Masters	8 (26.7)	10 (33.3)	
History of participation in infection control classes			
Yes	19 (63.3)	14 (46.7)	*p = 0.194
No	11 (36.7)	16 (53.3)	
Work experience in ICU, years (mean ± SD)	3.1 ± 3.2	3.5 ± 0.3	**p = 0.288
Nursing experience, year, (mean ± SD)	6.7 ± 2.7	8.0 ± 3.4	**p = 0.170

*Note: Chi-square test (normal distribution); **Mann-Whitney U test (non-normal distribution); ***Fisher's exact test (normal distribution)

Table 3. Knowledge and performance scores of the intervention and control groups before the intervention

Dependent variables	Group		Results of independent t-test
	Intervention	Control	
	Mean ± SD	Mean ± SD	
Knowledge	16.3 ± 4.8	15.5 ± 5.2	df = 58 t = 6 p = 0.519
Performance	16.8 ± 7.6	15.9 ± 7.1	df = 58 t= 0.5 p = 0.636

Note: Independent T-test

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. The results of the repeated measurements ANOVA showed that there was a statistically significant difference between the two groups in terms of the mean knowledge score at different times (p = 0.001).

Bonferroni's post hoc test was used to check the existence of differences between groups. Based on the results of this test, two weeks after the intervention, the mean knowledge score of the nurses increased by 13.0±6.6 points in the intervention group and by 7.1 ± 5.5 points in the control group, compared to before the intervention. Four weeks after the intervention, the mean knowledge score of nurses grew by 13.4 ± 6.3 and 5 ± 4.4 points in the intervention and control groups, respectively, in comparison to before the intervention. In addition, the mean knowledge score of nurses four weeks after the intervention, compared to two weeks after the intervention, increased by 0.4 ± 2.3 points in the intervention group, whereas it decreased by 2.1 ± 3.2 points in the control group. Based on the results of Bonferroni's post hoc test, there was a significant difference in the mean knowledge scores between the two groups two weeks after the intervention and before the intervention (p = 0.001), four weeks after the intervention and before the intervention (p = 0.001), and four weeks after the intervention and two weeks after the intervention (p = 0.003) (Table 4).

Table 4. Mean of the knowledge score of intervention and control groups during different times

Knowledge score	Group		p-value
	Intervention	Control	
	Mean ± SD (third quartile, first quartile) median	Mean ± SD (third quartile, first quartile) median	
Before intervention	16.3 ± 4.8 16.0 (12.0, 19.5)	15.5 ± 5.2 16.5 (10.0, 19.0)	df = 6.34 f = 5.117 *p = 0.001
Two weeks after the intervention	19.3 ± 4.7 29.0 (0.25, 0.31)	22.6 ± 4.6 23.5 (0.19, 0.24)	
Four weeks after the intervention	29.7 ± 4.1 30.0 (0.27, 31.5)	20.5 ± 4.7 20.0 (17.0, 22.0)	
Difference between two weeks after the intervention and before the intervention	13.0 ± 6.6 14.5 (9.0, 17.0)	7.1 ± 5.5 6.5 (5.0, 8.0)	**p = 0.001
Difference between four weeks after the intervention and before the intervention	13.4 ± 6.3 15.5 (10.0, 17.0)	5.0 ± 4.4 6.0 (1.0, 7.0)	**p = 0.001
Difference between four weeks after the intervention and two weeks after the intervention	0.4 ± 2.3 0.0 (-1.0, 1.0)	-2.1 ± 3.2 -2.0 (-5.0, 0.0)	**p = 0.003

Note: * Repeated measures ANOVA **Bonferroni's post hoc test

Considering the second specific aim of the research, which was to determine the effect of BL on the performance of nurses in preventing VAP, the results of the study revealed that before the intervention, the mean values of nurses' performance scores in the intervention and control groups were 16.8 ± 7.6 and 15.9 ± 7.1, respectively. The mean values of the performance score were 34.1 ± 5.4 and 23.8 ± 4.6 two weeks after the intervention and 33.5 ± 5.6 and 24.3 ± 5.7 four weeks after the intervention in the intervention and control group, respectively. The repeated measures ANOVA showed that there was a statistically significant difference between the two groups in terms of performance scores at different measurement times (f = 4.784, p = 0.031).

Bonferroni's post hoc test was also applied to determine the follow-up differences between the groups. According to the results of this test, two weeks after the intervention, the mean performance score of the nurses increased by 17.3 ± 8.9 points in the intervention group and 7.9 ± 0.7 points in the control group, compared to before the intervention. Four weeks after the intervention, this score rose by 16.7 ± 8.2 in the intervention group and 8.4 ± 7 in the control group, in comparison to before the intervention. Bonferroni's post hoc test demonstrated that the difference in the mean performance score was significant between the two groups comparing two weeks after the intervention with before the intervention (p = 0.001) and four weeks after the intervention with before the intervention (p = 0.001). However, the difference in the mean performance score between the two groups four weeks after the intervention and two weeks after the intervention was not statistically significant (p = 1.000) (Table 5).

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Table 5. Mean of the performance scores of the intervention and control groups during different measurement times

Performance score	Group		Bonferroni's post hoc test
	Intervention	Control	
	Mean ± SD (third quartile, first quartile) median	Mean ± SD (third quartile, first quartile) median	
Before intervention	16.8 ± 7.6 16.0 (10.5, 20.0)	15.9 ± 7.1 16.5 (10.0, 21.0)	df = 1 f = 4.784 **p = 0.031
Two weeks after the intervention	34.1 ± 5.4 34.0 (30.0, 36.5)	23.8 ± 4.6 25.0 (20.5, 27.0)	
Four weeks after the intervention	33.5 ± 5.6 33.5 (29.5, 38.0)	24.3 ± 5.7 25.0 (18.5, 28.0)	
Difference between two weeks after the intervention and before the intervention	17.3 ± 8.9 19.0 (12.5, 23.5)	7.9 ± 7.0 7.0 (2.5, 10.5)	*p = 0.001
Difference between four weeks after the intervention and before the intervention	16.7 ± 8.2 18.0 (11.5, 21.5)	8.4 ± 7.0 9.5 (1.5, 13.0)	*p = 0.001
Difference between four weeks after the intervention and two weeks after the intervention	-0.6 ± 4.2 1.0 (-3.0, 2.0)	0.5 ± 5.4 0.0 (-3.0, 2.0)	*p = 1.000

Note: * Repeated measures ANOVA **Bonferroni's post hoc test

Discussion

The present study evaluated the knowledge and performance of nurses working in the ICU department after receiving a training package for the prevention of VAP through the BL method. The results showed that two weeks and four weeks after the intervention, the mean scores of nurses' knowledge and performance in the BL group were significantly higher than those in the online learning group. The findings of a study by Mishra et al. (2020), which was conducted to investigate the impact of the structured training program on knowledge and practice regarding a care bundle on the prevention of VAP among nurses, showed that after the intervention, the majority of nurses (57%) had a good knowledge score and 25 (83%) nurses obtained a very good performance score, which was consistent with the results of the present study. One of the reasons for this consistency could be the presentation of training in a structured format, with the difference that in the current study, the training was conducted using the BL method, while in Mishra et al.'s study, the training was presented in the form of a lecture and through PowerPoint, and the level of knowledge and performance of the nurses was measured immediately after the intervention (36).

The results of a study by Busi et al. (2016) showed that before the implementation of a structured training program on the prevention of VAP, 96.6% of nurses had insufficient knowledge and poor performance in the prevention of VAP; however, after the intervention, a significant improvement was observed in the knowledge and performance of nurses (37), which was in agreement with the results of the current study. Furthermore, consistent with the findings of the present study, those of study by Aloush (2017) was indicative of the improvement of nurses' knowledge and performance after holding a training session on VAP preventive measures (38).

On the other hand, the study by Michelangelo et al. (2020), which was conducted to determine the impact of an experiential learning strategy based on a combination of play activities, simulation models, role-playing and feedback on both the adherence to the use of bundles and the incidence of ventilator-associated pneumonia in critically ill adult patients, showed that adherence to bundles in the care of mechanically ventilated critically ill adult patients significantly improved and also decreased the incidence rate of ventilator-associated pneumonia after the VAP care package training compared to before the intervention (39).

On the other hand, regarding the effectiveness of different teaching methods, the results of Lathi et al. (2014) meta-analysis showed a significant difference between the two methods of e-learning and traditional learning in knowledge, skill and satisfaction of nurses. The results of this study presented e-learning as an alternative method for traditional teaching (40). Also, the results of He et al. (2021) study showed that synchronous online learning does not have a significant difference with traditional learning in terms of effectiveness, but it has a higher level of satisfaction among learners than traditional learning (41). The results of Du et al. (2022), which compared the blended learning method with the traditional method, also showed that blended learning as an effective teaching strategy can have a high potential for growth, especially in the long term (42). In line with the results of the present study, the results of Sung et al. (2008) and Bobbink et al.(2022) studies showed that e-learning and blended learning are effective in increasing the significant knowledge and skill of nurses, which indicates that an e-learning program can reduce time and

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cost and be an effective part of in-service nursing education programs (43-44).

In general, it can be stated that VAP is affected by numerous factors, and it seems that these factors can be improved with proper training; nonetheless, it must be acknowledged that training without adequate supervision or proper facilities to apply what has been learned might not have much effect. In addition, due to the fact that in this research, the performance of nurses in the ICU improved, it can be concluded that the nurses are aware of the importance of these types of training. The findings of the study were indicative of the significant role of interaction in the effectiveness of teaching and learning processes. Interaction in the online environment should be designed very carefully and thoughtfully to achieve the main goal of education, which is the correct and complete transfer of content to learners.

Conclusion

The results of the present study demonstrated that training nurses using a BL method could improve their level of knowledge and performance in the prevention of VAP in the ICU. It is hoped that the findings of this research can be useful in providing an effective educational method on the knowledge and performance of nursing staff and in reducing the rate of VAP in ICUs. Individual differences and the inherent ability of people in learning and performance might have been influential in the results of this research.

Among the limitations of this study, one can refer to the short duration of follow-up to measure the care performance as there was a time limit to conduct the research and there might have been dropouts in the research units. Considering the importance of personnel training in controlling hospital infections and its direct impact on patient-related outcomes, the results of the present study can be employed to provide more effective in-service training to nurses as well as students and other related personnel. It is suggested that in future studies, more studies should be performed to investigate the effectiveness of other synchronous online educational methods in combination with other asynchronous online interactive educational methods in health-related fields.

Ethical considerations

The present study was registered with the code IR.MUMS.NURSE.REC.1401.053 in the Research Ethics Committee of Mashhad University of Medical Sciences and was conducted with written permission from the mentioned committee. Before the start of the study, the nature and objectives of the research were explained to all participants, and informed consent was obtained from them. They were also assured of the confidentiality of the data and the right to withdraw from the study at any research stage.

Artificial intelligence utilization for article writing

No.

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Conflict of interest statement

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Author contributions

Zahea Sadat Manzari designed the study, supervised of the study and monitored the process of data analysis. Haidar Kazem Latif Al-Fazli implemented the intervention and wrote the first draft of the article. Morteza Ghanem Adai Al-Jubouri supervised the implementation of the intervention in Iraq.

Supporting resources

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Data availability statement

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

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