Original Article

The Effect of Blended Learning on the Rate of Medication Administration Errors of Nurses in Medical Wards

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Abstract

Background: Medication error is one of the most important and most common events threatening patient safety. This study was conducted with the aim to determine the effect of asynchronous hybrid/blended learning on the rate of medication administration errors of nurses in medical wards. **Materials and Methods:** This quasi-experimental study was conducted with a pretest-posttest design in 2019. The participants of this study included 57 clinical nurses working in the medical wards of a selected educational hospital affiliated to Lorestan University of Medical Sciences, Khorramabad, Iran. The study participants were selected through census method. An asynchronous hybrid/blended learning program was used in this study. Data collection was performed using a two-section researcher-made checklist. The collected data were analyzed using descriptive [Mean (SD)] and inferential (paired sample t-test) statistics in SPSS software. A p value of less than 0.05 was considered statistically significant. **Results:** The results showed that the mean score of total errors in medication administration in the medical wards after the intervention was significantly lower than before the intervention; the mean score of errors before and after the study was 61.67 and 50.09, respectively ($t_{56} = 11.41$, $p < 0.001$). **Conclusions:** Asynchronous hybrid/blended learning as a type of e-learning, simple, relatively inexpensive, and new educational strategy can improve nurses' performance and reduce medication errors.

Keywords: *Learning, medication errors, nurses, patient safety*

Introduction

Patient safety is defined as the prevention of errors through attentive supervision of the health care delivery system and learning from errors.[1,2] Various events threaten patient safety,[3] and medication error is one of the most important and most commonly occurring events.[4] The focus of the World Health Organization (WHO) has been on error-free medication administration with the theme of medication safety since March 2017.[5] Medication error refers to any preventable events at any stage of the medication therapy process such as prescription, transcription of the physician's prescription, distribution of medications, and delivery of medications that can lead to medication misuse or patient harm.[6]

Based on the WHO reports, the cost of medication errors in the United States is estimated at $ 42 billion annually.[5] Medication errors are the leading cause of side effects, hospitalization, and disability, as well as the cause of 6.5% of patient deaths. Different types of medication errors are responsible for one-third of the errors in health care centers.[7] In Iran, accurate statistics of medication errors are not available.[8] In a study by Yousefi *et al*., the rate of medication error during 1 month was reported to be 31.6%,[9] and Gahremani and Sharifi, who studied the prevalence of medication errors in the preparation and administration of intravenous drugs for hospitalized patients, found that the highest rate of medication errors in medical wards was 50%.[10]

Medication administration is a key component of nurses' performance,[11] and since medication administration is a complex activity, there is a high risk of errors in this process.[12] Communication problems such as poor communication between the health team and the patients,[6] use of medical abbreviations, and misspellings and oral prescriptions of physicians are among the underlying causes of medication errors.[13,14] Moreover,

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various risk factors in the medical wards such as long hospitalization duration, polypharmacy, high work stress, high nurse-to-patient ratio, and long and consecutive shifts increase the likelihood of errors.[9]

Since insufficient medication knowledge of the health team, including nurses, is one of the main causes of medication errors,[15] and lack of attention to the correct principles in medicine can lead to life threatening events, educational programs, especially new educational methods such as blended learning, have been introduced as one of the most important preventive strategies for medication errors.[16-21] E-learning is a method in which one can learn more from a pervasive number of learners from anywhere and at any time at a lower financial cost. However, the results of studies by virtual education institutes have revealed the weaknesses of this approach.[22]

E-learning in education alone has not been significant in practice and suffers from lack of suitable human interaction, delayed feedback, and lack of motivation to read content. Many educators believe that blended learning is a promising approach to solving these problems. Many hybrid learning models will include a blend of both asynchronous and synchronous learning. Asynchronous learning is a learner-centered learning method widely used in e-learning. Its basic premise is that learning can occur at different times and in different spaces particular to each learner with fewer time restrictions and the possibility of flexible working hours.[23,24] Therefore, considering the role of education in the prevention of medication errors and the importance of blended learning in nursing education, this study was designed to determine the effect of blended learning on the rate of medication administration errors of nurses in medical wards.

Materials and Methods

This paper presents the results of a study in the form of a nursing MSc thesis. This quasi-experimental, one-group, and two-stage study was conducted with a pretest–posttest design in November 2019 to May 2020. The study participants included 57 clinical nurses; in total, 114 rounds of their medication administration were observed. The nurses were working in the medical wards (women's, men's, and general) of a selected educational hospital affiliated to Lorestan University of Medical Sciences, Khorramabad, Iran. Nurses were selected through census method. The study inclusion criteria included willingness to participate in the study, a work experience of at least 1 month in the medical wards, a bachelor's degree in nursing or higher, and lack of participation in similar workshops and courses. The exclusion criteria were participation in similar workshops and courses and being moved from the medical wards to other wards or hospitals.

An asynchronous hybrid/blended learning program was used in this study. Asynchronous blended learning offers a high degree of control to the learner; they go through the instruction material on their own and learn at their own pace. In this method, learners have to manage their time.[25] The intervention was a combination of workshops and electronic self-learning by means of CDs. The 2 workshops were held in 2 weeks (on Thursdays) by the researcher and a specialist in medication safety. The educational material was approved by 10 faculty members who were experts in the field of medication.

The first workshop, entitled "Medication Management and Safety", was held in continues education program (4 points) and lasted for 5 hours. The content of the workshop included introduction of the medication management and safety program and its goals, the necessity and importance of medication safety, classification and causes of medication errors, and types of education methods. At the end of the session, a group discussion was held on nurses' experiences regarding medication errors, and the importance of the update of pharmaceutical science and needs assessment of nurses.

The second workshop, entitled "Medication Calculations," was taught face-to-face. The electronic self-learning content was designed based on the educational needs determined in the first stage of observations with the aim of promoting knowledge on the principles of medication administration and reducing medication errors, and included medication guidelines and common medications in the pharmaceutical sectors (pharmacological classification, therapeutic classification, consumption in breastfeeding, nursing cares and special considerations, patient and family education, and care conditions).

The electronic self-learning content was available to participants in the D-drive of computers in hospital wards for 2 weeks. One month after the intervention, the checklist was completed in the same way as the pre-intervention stage.[26]

Data were collected using a researcher-made checklist. The checklist was designed based on the main sources of nursing principles and techniques,[27,28] and consisted of 2 parts. The first part included questions on demographic information (age, gender, level of education, marital status, and work experience), and the second part consisted of 28 items with "yes" (score: 0), "no" (score: 1), and "not applicable" as response options (the total score range of the second part: 0-28). The checklist was completed by the observer while the nurses were administering medication; if the nurse performed the practice the "yes" option was ticked, if the nurse did not perform a necessary practice the "no" option was chosen, and if there was no reason to do the practice at that time the "not applicable" option was marked. The "no" responses indicated non-compliance with the checklist principles, were considered equivalent to medication errors, and were classified in the 3 categories of deviation from safe medication administration activities (9

items), errors in preparation and administration of medication (11 items), and deviations from prescribed treatment (8 items).[28] The data related to the "not applicable" response was not considered in the analysis. The total score of the checklist ranged from 0 to 100.

Content validity was used to validate the checklist. To this end, the checklist was distributed among 10 faculty members who had enough teaching experience in the nursing principles and techniques course and were experts in the field of medication administration standards. After receiving their comments and suggestions, the necessary corrections were made and the checklist was approved. The Kuder-Richardson 21 (KR-21) was used to determine the reliability of the checklist; it was approved with a coefficient of 0.87.

To gather information, after obtaining written permission from the School of Nursing and Midwifery of Lorestan University of Medical Sciences, the researcher referred to the research environment and explained the objectives of the research to the relevant authorities. After coordinating with the nursing manager and head nurses of medical wards (women's, men's, and general), the researcher obtained permission from the research units, and then, selected a number of qualified clinical nurses and obtained informed consent from all of them. The nurses were aware of the purpose of the study and were assured of confidentiality and anonymity and that the observations would be unrelated to their evaluation.

The observer was a nursing student in the 7th semester who was undergoing an internship in the medical wards. Therefore, due to the long-term presence of the observer in the medical wards, the effect of the observer's presence on the behavior of the nurses was somewhat reduced. Necessary instructions on how to complete the checklist were provided to the observer by the researcher. The nurses were observed while preparing and administrating medication during a medication administration round by the observer (all patients under the care of the nurses were observed on different shifts, and during day, evening, or night based on randomization). The observer did not intervene unless a potential error was occurring. In this case, the observer notified the nurse and the case was recorded as an error. The data was recorded immediately after each observation. A total of 114 rounds of medication administration were observed on the 12:00, 14:00, 18:00, 22:00, 24:00, and 6:00 o'clock rounds.[29]

For the selection of medication administration rounds, the monthly schedule of the clinical nurses was obtained and the morning, evening, and night shifts of each nurse were recorded on small identical cards. Then, the cards for each shift were placed inside a box, and each time one card was randomly taken out of the box after shaking it and the shift date was recorded. After the shift was determined, the medication administration rounds of the shift were recorded by mentioning the nurse's name on small identical cards, then, the cards were placed inside a box, and each time a card was randomly taken out of the box after shaking it and the observed medication administration round was identified and recorded.[30] The checklist for the correct principles of medication administration stage was completed before conducting the educational intervention in the women's, men's, and general medical wards on 57 medication rounds. Then, the intervention was performed for 1 month.[26,31]

Data analysis was conducted using descriptive and inferential statistics in SPSS software (version 16, SPSS Inc., Chicago, IL, USA). A p value of less than 0.05 was considered statistically significant.

Ethical considerations

This study has been approved by the ethics committee of Lorestan University of Medical Sciences (Ethics committee is obtained. IR.LUMS. REC.1398.123. 20 July 2019). The participants were aware of the objectives of the research, and informed consent was obtained from all of them, and they were assured that their information would remain confidential. In order to maintain confidentiality, numbers were used instead of the names of the participants. Due to the fact that the data collection was performed through observation, the nurses' information remained confidential in the event of a medication error during medication administration. The participants were free to leave the study at any stage.

Results

The age of the nurses ranged from 24 to 38 years and their average work experience was 3.7 years. The participants' demographic characteristics are presented in Table 1. The results of paired sample t-test showed that the mean score of deviation from safe medication administration activities category was significantly lower after the intervention (37.52) compared to before the intervention (51.27) (t_{56} = 11.80, p < 0.001) [Table 2]. Paired sample t-test was used to compare the mean score of medication preparation and administration errors by nurses in the medical wards before and after the intervention. The results showed that the mean score of

Table 1: Frequency distribution of demographic characteristics

Demographic characteristics	*n* (%)
Gender	
Female	50 (87.70)
Male	7 (12.30)
Marital status	
Single	29 (50.90)
Married	28 (49.10)
Education	
Bachelor's degree	55 (96.50)
Master's degree and higher	2 (3.50)

Table 2: Comparison of mean scores of categories of medication administration errors before and after the intervention

Variables	Mean (SD)		Paired *t* test	*p*
	Before	After		
Deviation from safe medication administration activities	51.27 (20.99)	37.52 (11.34)	11.80	<0.001
Medication preparation and administration errors	58.33 (24.96)	47.81 (16.66)	7.21	<0.001
Deviation from the treatment prescribed	75.85 (18.04)	66.98 (13.42)	8.78	<0.001
Total errors in medication administration	61.67 (19.24)	50.09 (10.88)	11.41	<0.001

medication preparation and administration errors after the intervention was significantly lower than before the intervention (t_{56} = 7.21, p < 0.001) [Table 2]. In addition, paired sample t-test results showed that the mean score of deviation from the treatment prescribed after the intervention was significantly lower than before the intervention (t_{56} = 8.78, p < 0.001) [Table 2].

The paired sample t-test was also used to compare the mean score of total medication errors during medication administration in the medical ward before and after the intervention. The results showed that the mean score of total medication errors during medication administration was significantly lower after the intervention in comparison to before the intervention (t_{56} = 11.41, p < 0.001) [Table 2].

Discussion

This quasi-experimental study was performed to determine the effect of blended learning on the rate of medication administration errors of nurses in medical wards. The results revealed that the mean score of total errors and the 3 categories of medication administration errors ("preparation and administration", "deviation from safe medication administration activities", and "deviations from prescribed treatment") after the intervention were significantly lower than before the intervention.

The mean score of the errors in preparation and administration category, including the check route right, allergies, aseptic technique, etc., decreased after the intervention. The face-to-face provision of information and e-learning program resulted in the improved function of nurses in this category. This finding was consistent with the results of studies by Ford *et al*.[26] and Sharifi and Alipour[31] who examined new educational strategies for reducing nursing errors in the administration of intravenous medications. In addition, Chua *et al*. showed that sharing information could reduce nurses' medication administration errors.[32]

The mean score of errors in the safe medication administration activities category decreased after the intervention. Indeed, blended learning increased nurses' attention to matching the patient's name with the identification bracelet, double-checking high-dose drugs, preparing the medicine on the patient's bedside, and etc. This finding was consistent with the results of a study by Raja *et al*. who examined the 10 standard steps of medication administration in Neonatal Intensive Care Units (NICU) before and after the intervention.[33] The findings of Douglass *et al*. indicated that educational interventions such as simulation could improve the nurses' pharmacological performance, which was consistent with the findings of the present study.[34]

The mean score of errors in the treatments prescribed category decreased after the intervention. The present study results revealed that blended learning improved the performance of nurses in terms of medication calculations, observance of the appropriate injection rate for intravenous drugs, the rule of checking 3 times (checking the label of the medicine when taking the medicine, when preparing the medicine, and before taking it), and etc. Härkänen *et al*., in a systematic and meta-analysis review, found that the most effective educational intervention was the blended learning method (e-learning and 60 minutes of PowerPoint presentation), and the least effective educational intervention was interactive Internet-based learning.[35]

The effectiveness of blended learning interventions has been confirmed in various studies. Yigzaw *et al*. compared the effectiveness of blended learning methods with traditional learning methods in the training of midwifery care providers in Ethiopia.[36] They found that the skill scores of the traditional education group were significantly higher than those of the blended learning group.[36] It seems that skills training through traditional methods is better than e-learning methods. In the present study, the medication administration skill of medication calculation was presented through traditional training method. The results of a study by Shimizu *et al*. in Japan showed that blended problem-based learning is more effective on promoting active learning and improving knowledge without affecting the teacher's competence, and the integration of e-learning and problem-based learning in Asian countries can be an effective strategy.[37] In addition, Najafi compared the effect of blended and traditional teaching on learning and reported the superiority of the blended education over traditional education.[38] The present study results also showed that blended learning, as a type of e-learning and new educational strategy, can improve nurses' performance, reduce medication errors, and promote patient safety.

This study had several limitations. The first limitation was that the data collection method was observation, and thus, the Hawthorne effect could have occurred. We tried to minimize this effect through the long-term presence of

a nursing student who was undergoing an internship in the medical wards as the observer. The second limitation of the study was that it was only performed in medical wards, and thus, its generalizability to other wards needs further investigation. The third limitation was the small sample size of the study, and the forth limitation was the lack of a control group. It is suggested that more studies be undertaken with larger samples and a control group.

Conclusion

The combination of the concepts of education and e-learning and the application of information technology not only facilitates the transferring of new information in the field of medical sciences, but also enhances the knowledge and skills of medical graduates and improves the quality of education. In general, blended learning is receiving greater attention and is studied in different fields and with regard to various variables. In previous studies, blended learning was preferred by participants over other teaching methods. The findings of the present study showed that blended learning can improve nurses' performance. Therefore, the blended learning approach can improve the quality of care, reduce medication error, and improve medication safety.

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Conflicts of interest

Nothing to declare.

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