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Effectiveness of Multimedia Electronic Training on the Nurses' Adherence to Patient Safety Principles: A Randomized Controlled Trial

Sepideh Faridi[1] | Zahra Farsi[2] | Nahid Rajai[3] | Majid Najafi Kalyani[4] | Andrew J. Fournier[5]

[1]Emergency Nursing Department, Nursing School, Aja University of Medical Sciences, Tehran, Iran | [2]Research and Ph.D. Nursing Departments, Nursing School, Aja University of Medical Sciences, Tehran, Iran | [3]Department of Critical Care Nursing, Nursing School, Aja University of Medical Sciences, Tehran, Iran | [4]Department of Medical-Surgical Nursing, School of Nursing and Midwifery, Shiraz University of Medical Sciences, Shiraz, Iran | [5]Grand Canyon University, Phoenix, Arizona, USA

Correspondence: Zahra Farsi (zahrafarsi2021@gmail.com; z.farsi@ajaums.ac.ir; zahrafarsi@gmail.com)

ABSTRACT

Background and Aims: Ensuring patient safety is a fundamental responsibility of nurses. Training methods that enhance nurses' adherence to patient safety principles are essential, especially in critical situations where face-to-face training may not be feasible. This study aimed to investigate the effectiveness of multimedia electronic training in improving nurses' adherence to patient safety principles.

Methods: This randomized controlled trial was conducted in 2021 and 2022 with 60 nurses from a hospital in Tehran, Iran. Participants were randomly assigned to the intervention ($n = 30$) and control ($n = 30$) groups. Both groups attended an initial face-to-face session to introduce the study objectives. The intervention group then received a multimedia electronic training program on patient safety principles over 6 weeks (six 2-h sessions) and had access to a web-based question-and-answer platform. The control group received no intervention. Data were collected using an individual characteristics questionnaire and a patient safety adherence scale (with reverse scoring) before and 14 days after training. Statistical analyses, including independent t-tests, paired t-tests, χ^2 tests, and Fisher's exact tests, were conducted using SPSS software ($p < 0.05$).

Results: Before the intervention, no significant difference was observed between the intervention and control groups in adherence scores (144.17 ± 17.43 vs. 143.13 ± 18.22, $p = 0.823$). However, after training, the intervention group had significantly higher scores than the control group (166 ± 0.439 vs. 144.50 ± 17.71, $p < 0.001$). Additionally, adherence scores in the intervention group improved significantly after training ($p < 0.001$), while no significant change was observed in the control group ($p = 0.633$).

Conclusion: Multimedia electronic training is an effective approach to enhancing nurses' adherence to patient safety principles. This method is particularly beneficial in situations where traditional face-to-face training is unavailable. Integrating multimedia e-learning into nursing education programs is recommended to improve patient safety outcomes.

Trial Registration: This trial was registered at the Iranian Registry of Clinical Trials (No. IRCT20221129056661N1) on January 11, 2023.

1 | Introduction

In modern care-treatment settings full of complexity and diversity, adverse events threaten patients' lives and health [1]. Furthermore, healthcare-related injuries are rising [2]. Consequently, the World Health Organization has identified patient safety as the top priority for enhancing healthcare quality and emphasized the implementation of the necessary measures to achieve this objective [3]. Patient safety principles are achieved through scientific methods for achieving the minimum incidence and impact of adverse events while maximizing recovery from such events in a reliable healthcare system [4]. These principles include infection control, risk management, safe environment, equipment medicines management, and so forth [5].

Evidence has demonstrated that 134 million adverse events resulting from unsafe care occur annually in hospitals in low- and middle-income countries, resulting in 2.6 million deaths [6]. In low- and middle-income countries, inadequate human resources, overcrowding, a lack of equipment for patient care and treatment, and poor hygiene all contribute to unsafe patient care [7]. As one of these countries, Iran has a statistically high rate of adverse events. A meta-analysis demonstrated that the prevalence of adverse events was between 10% and 80% [8]. In another study, the rate of reporting adverse events for a blood infection, pressure ulcer, patient fall, and hospital infection were 76.1%, 66.2%, 59%, and 57.7%, respectively [9]. Such rates of adverse events run contrary to the patient's rights charter, which requires that patients receive the desired and safe services [10].

Nurses' adherence to patient safety principles is essential for improving quality of care and preventing practice errors [11]. Nurses should adhere to organizational instructions for identifying hazards and harm through the assessment of patients, care planning, monitoring, surveillance activities, cross-checking, and accurate communication with other healthcare providers [12].

One of the major challenges in healthcare systems is ensuring that nurses adhere to patient safety principles, as non-compliance can lead to serious adverse events and increased patient harm [13, 14]. Non-adherence and noncompliance undermine the professional beliefs, norms, and expectations associated with the healthcare role [15]. Adherence to and compliance with organizational instructions are influenced by personal willingness, socioeconomic conditions, culture, level of knowledge and attitude [16], encouragement by leaders and colleagues, workload, and pressure caused by a shortness of time [17]. However, in Iran's nursing curriculum, the issue of patient safety principles has not been considered as it should be. With a lack of enforcement on problem-solving, judgment, and clinical decision-making at the graduate level and the failure of universities to consider clinical experience at the post-graduate level, the situation is ripe for students entering clinical employment for the first time to be unaware of patient safety guidelines [18]. In this study, patient safety refers to nurse's adherence to safety principles across five key dimensions: medication errors, delay in providing care and harming patients during, patient identification, and patient falls [19].

Several studies have shown the effect of training on nurses' adherence to patient safety principles [20–22]. At the international level, various trainings on the principles of patient safety are provided to increase the awareness and knowledge of health professionals regarding patient safety, and the effect of trainings on increasing patient safety has been reported in previous studies [23, 24]. Organizations use training courses to improve employees' knowledge, skills, and attitudes. Despite the many educational environments and the availability of job-related training, this training is not utilized as effectively as it should be [25]. Bona fide safety training should focus on identifying and analyzing events threatening patient safety and incorporating specific principles to prevent adverse problems and complications [26]. Numerous studies have proposed and evaluated various educational approaches, such as face-to-face educational classes, providing self-study booklets, training based on clinical guidelines, web-based training, and utilizing social networks to empower nurses to improve their performance and knowledge [27–30].

Advancements in computer technology have revolutionized traditional education models. Despite the availability of traditional training methods, studies indicate that these methods often fail to maintain engagement and long-term retention among healthcare professionals e-learning is an instructional method that uses electronic devices to deliver educational content, combining text, images, audio, and video to enhance knowledge and skills. This approach includes online and offline interactive technologies that support student learning. E-learning techniques comprise web-based training, computer-assisted training, and virtual classrooms [31]. One of the most effective subsets of e-learning is multimedia electronic education, which utilizes multiple digital formats such as animations, simulations, and interactive content to enhance comprehension and engagement [32]. Unlike traditional e-learning platforms, which may primarily focus on structured courses and assessment tools, multimedia electronic education emphasizes diverse media components to support knowledge acquisition [33]. The most significant advantage of multimedia electronic education is its ability to communicate concepts through a combination of text, sound, images, and videos, making learning more engaging and effective [34].

Kwapong found that students from multiple universities were willing and able to use interactive tools such as WhatsApp, chat rooms, and video conferences to engage in more group and virtual interactive activities [35].

Despite the importance of teaching patient safety, there is limited research on face-to-face training and e-learning's impact on nurses' adherence to safety instructions. Given the existing challenges in nurses' adherence to patient safety and the limitations of traditional training methods, this study investigates the effectiveness of multimedia electronic education as an innovative approach to improving compliance with patient safety principles. The findings of this study can inform hospital administrators and policymakers on the effectiveness of multimedia electronic training as a practical strategy to enhance patient safety compliance among nurses.

H0: Multimedia electronic training does not affect nurses' compliance with patient safety principles.

2 | Methods

This randomized controlled trial was conducted between 2021 and 2022 and was registered in the Iranian Registry of Clinical Trials (No. IRCT20221129056661N1, Date: 2023/01/11).

2.1 | Participants and Setting

Sixty nurses from the intensive care, critical care, and emergency departments of a Tehran hospital were recruited through convenience sampling and randomly assigned to intervention and control groups using a coin toss by a blinded research assistant. We selected the intensive care, critical care, and emergency departments because these units are high-risk environments where adherence to patient safety principles is crucial. These departments frequently encounter adverse events such as medication errors, delays in care, patient identification mistakes, and patient falls, making them suitable settings for evaluating the impact of multimedia electronic training. Furthermore, the research team has experience working in these units and has observed, through firsthand experience, the high incidence of patient safety violations. This practical insight reinforced the necessity of selecting these departments for the study.

Eligible participants had to consent, possess at least 1 year of nursing experience, have worked in their current department for at least 1 month, hold a bachelor's degree in nursing, not have completed a patient safety course in the past 6 months, and have access to smartphones and WhatsApp for educational purposes. Those who chose not to continue were excluded.

The sample size was estimated to be 28 nurses in each group, based on the mean and standard deviation of the patient safety culture of nurses in the previous study [36], with a confidence level of 95% and a test power of 90%. A total of 35 nurses were included in each group, considering the possibility that approximately 20% would drop out. In this study, 15% of nurses dropped out. The most significant reasons for the nurses' refusal to continue participating in the study were overwork and illness. In the end, 30 participants remained in each group. The sampling period took 3 months, from the end of December 2022 to the end of February 2022.

$$n = \frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2 (\delta 1^2 + \delta 2^2)}{(\mu_1 - \mu_2)^2}$$
$$= \frac{(1.96 + 1.28)^2((11.55)^2 + (10.51)^2)}{(141.95 - 151.55)^2} = 28$$

2.2 | Data Collection

Data collection tools included an individual characteristics questionnaire (age, work experience, sex, marital status, employment status, level of education, job, participation in patient safety culture, and electronic training workshops in the last year) (see Supporting Information Additional File 1).

To evaluate nurses' adherence to patient safety principles, we used the validated and reliable Patient Safety Violation Scale (see Supporting Information Additional File 2). We employed this tool with reverse scoring for clearer interpretation. The original scale measures the frequency of safety violations, where higher scores indicate more violations. Unable to obtain the "adhere to the principles of patient safety" tool, we consulted with experts and adapted the Patient Safety Violation Scale, reversing the scoring to align with our study objective— measuring adherence. This adjustment ensures clarity and consistency in interpreting the results, with higher scores indicating greater adherence.

The scale of adherence to patient safety principles contains 42 items and five dimensions, including medication errors (items 1–11), delay in providing care (items 12–25), harming patient during care (items 26–29), patient identification (items 30–37), and patient falls (items 38–42). According to tool-makers, the response scale includes the expressions "never," "1 to 5 times," "6 to 10 times," and "more than 10 times," each of which is scored on a 4-point Likert scale ranging from 1 to 4, respectively, and whose total score ranges from 42 to 168. A higher score means lower patient safety principles [19]. In this way, the expressions "more than ten times," "6 to 10 times," "1 to 5 times," and "never," each of which was scored on a 4-point Likert scale ranging from 1 to 4, respectively. A higher score means higher adherence to patient safety principles.

Shali et al. confirmed the validity and reliability of this scale. The Cronbach's α of the scale and the test-retest interclass correlation coefficient were 0.933 and 0.92, respectively (37). To ensure the rigor of the study, 10 nursing faculty members confirmed the scale's validity. Thirty nurses completed the scale to assess its internal consistency. The Cronbach's α of the scale was 0.933, confirming its reliability.

2.3 | Intervention

The researchers created multimedia electronic training materials that incorporated patient safety principles and culture, based on safety standards from Iran's hospital accreditation guidelines by the Ministry of Health and Medical Education [37].

1. Ten nursing experts validated the content. Multimedia electronic scenarios and educational materials, including videos and narrated PowerPoint presentations, were compiled onto a CD. A researcher met with nurses from both groups to explain the study's goals while following health protocols. Nurses completed a questionnaire on individual characteristics and adherence to patient safety principles before the intervention. The intervention group participated in a 6-week e-learning program with six 2-h multimedia electronic sessions, receiving one CD per week across all shifts. Table 1 presents the headings of the training sessions. A WhatsApp group was created for discussions, and researchers provided weekly phone reminders. Incentives encouraged participation. Fourteen days after training, all nurses retook the adherence scale. This interval was chosen to provide sufficient time for the

TABLE 1 | Training session content.

Sessions	Title	Time (minute)	Presentation method
1st Session	Introduction, stating the objectives and title of the study	45–60	In-person
2nd Session	Safety promotion concept and patient safety culture, incident reporting, supervisor and manager expectations, and actions	120	Electronic training (in WhatsApp and multimedia electronic content on CD)
3rd Session	How to work as a team in hospital departments, open communication, communication and feedback about the occurrence of errors, nonpunitive response to personnel errors, management support for patient safety, teamwork in hospital units	120	Electronic training (in WhatsApp and multimedia electronic content on CD)
4th Session	Overlap of shifts according to the ISBAR communication model, critical results of paraclinical examinations under patient safety standards, and recommendations required during patient delivery	120	Electronic training (in WhatsApp and multimedia electronic content on CD)
5th Session	Identifying the patient's identity, high-risk patients, pain management, informed consent, preventing the patient from falling, avoiding delays in providing care, and not harming the patient during given care are all necessary	120	Electronic training (in WhatsApp and multimedia electronic content on CD)
6th Session	Medication rules, narcotic drugs, how to combine medications, how to feed patients (oral, enteral, and total parenteral nutrition), patient identification, and how to care for sick and emergency patients	120	Electronic training (in WhatsApp and multimedia electronic content on CD)
7th Session	Transfers within the hospital, transfer, and delivery of the patient to the ward and operating room, and delays in the provision of care were cited as causes for concern	120	Electronic training (in WhatsApp and multimedia electronic content on CD)

Abbreviation: ISBAR, identify, situation, background, assessment, and recommendation.

participants to apply the training in their clinical practice while reducing the impact of short-term recall bias. In previous studies, the level of knowledge retention was tested 2 and 4 weeks after the training [38, 39].

The control group received no intervention and was assessed first to avoid content transfer. Both groups had the same pretest and posttest intervals, and after data collection, the educational content was provided to the control group on CD.

To prevent content contamination, the control group was assessed before the intervention group. The educational content was distributed via CD to individual participants, and discussions were limited to a private WhatsApp group for the intervention group. Furthermore, participants were advised to refrain from sharing training materials with colleagues outside their group. Figure 1 shows the study process.

2.4 | Data Analysis

Researchers used SPSS (version: 14) software to analyze data with a significance level of 0.05. The Kolmogorov–Smirnov test assessed data normality, leading to the use of parametric tests for normally distributed data. An independent t-test and paired t-test compared quantitative variables between and within groups, respectively. For qualitative variables, a χ^2 test and Fisher's exact test were employed for intergroup and within-group comparisons. All tests were two-sided. The statistical analyst was blind to nurse group allocations.

2.5 | Ethical Considerations

The Ethics Committee of Aja University of Medical Sciences in Tehran, Iran, approved this study (No. IR.AJAUMS.REC.1400.068). The researchers adhered to the ethical principles of the Helsinki Declaration. This included informing participants of the study's objectives, obtaining written informed consent from nurses, allowing them to withdraw at any time, ensuring confidentiality, and being honest in data collection and analysis. We also followed the principles of the Committee on Publication Ethics.

3 | Findings

3.1 | Individual Characteristics

The mean age of the nurses was 30.93 ± 4.93 (25–35 years), and the mean length of their work experience was 8.49 ± 5.63
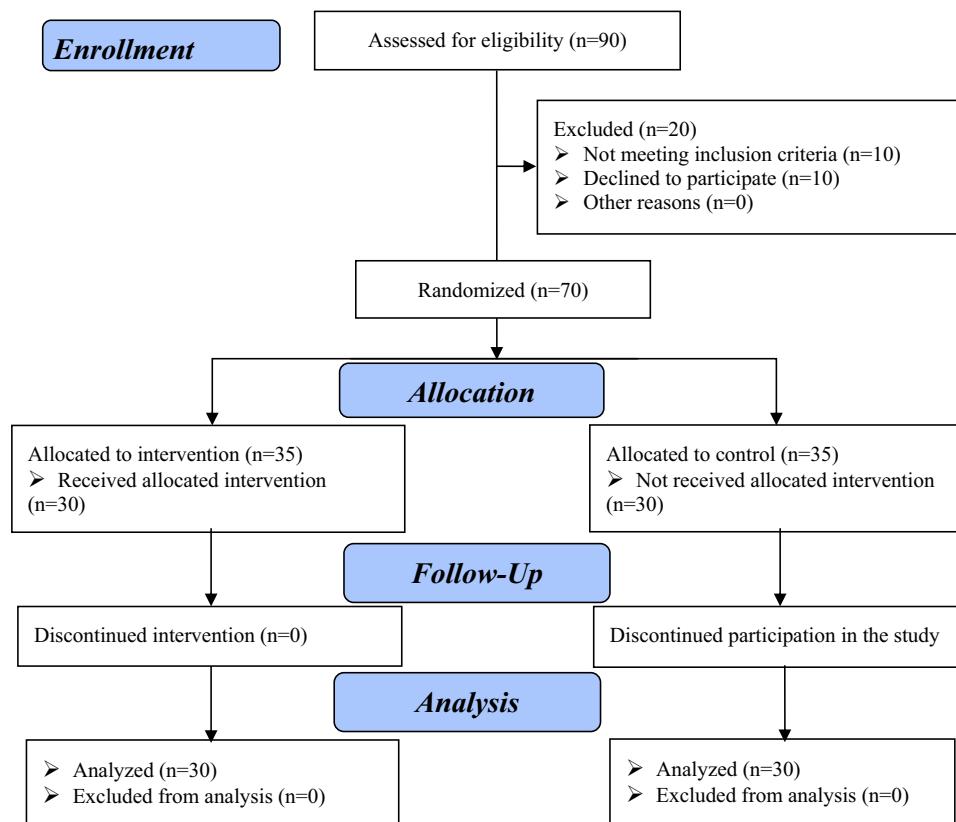
FIGURE 1 | The study process.

(3–14 years). Of the sample, 63.3% of nurses were male, 58.3% were married, and 71.7% held a bachelor's degree. In the studied sample, 53.3% of nurses were officially employed. In previous years, 11.7% of nurses had participated in safety culture workshops, while 33.3% had participated in e-learning workshops. There were no significant differences between the two groups regarding individual characteristics ($p > 0.05$) (Table 2). Of note is that there were no significant differences in work experience or education between the two groups.

3.2 | Primary Outcomes

Before the intervention, the total score ($p = 0.823$) of adherence to patient safety principles of the two groups ($p > 0.050$) did not differ. The total score ($p < 0.001$) of adherence to patient safety principles in the intervention group was significantly higher than in the control group following the training (Table 3).

In addition, the intervention group's total score ($p < 0.001$) of adherence to patient safety principles ($p < 0.05$) increased significantly after the training compared to before training. In the control group, there was no significant difference between the total score ($p = 0.633$) of adherence to patient safety principles before and after the intervention ($p > 0.05$) (Table 3).

3.3 | Secondary Outcomes

The dimensions of adherence to patient safety principles (medication errors, delay in providing care, patient injury during care, patient identification, and patient fall) were not statistically significant in the two groups before the intervention. However, there was a significant difference after the intervention ($p < 0.05$).

The dimensions of adherence to patient safety principles before the intervention in the two groups were not statistically significant. However, after the intervention, there was a significant difference ($p < 0.05$) in that the score of the intervention group was higher than the control group. Also, the dimensions of adherence to patient safety principles in the intervention group were significantly higher after the intervention than before the intervention ($p < 0.05$) but not significant in the control group ($p > 0.05$) (Table 3). Among the individual dimensions, medication errors had the largest difference between groups ($t = 6.557$) and the delay in providing care dimension had the lowest difference between groups ($t = 4.341$).

According to Cohen's method, the total effect size of electronic training on the nurses' adherence to patient safety principles was 1.66.

4 | Discussion

This study investigated the effect of multimedia electronic training on nurses' adherence to patient safety principles. Post-training, the intervention group showed higher total scores and improved adherence across all dimensions compared to the control group, indicating that multimedia electronic training can enhance adherence to these principles. The primary

TABLE 2 | Individual characteristics of nurses in the two intervention and control groups.

Variable	Group Intervention	Control	Statistical value, df, *p* value
	Mean $\pm$ SD	Mean $\pm$ SD	
Age (years)	31.0 $\pm$ 5.09	30.87 $\pm$ 4.86	$t = 0.104$[a], df = 58, $p = 0.918$
Work experience (years)	8.32 $\pm$ 5.98	8.67 $\pm$ 5.36	$t = -0.239$[a], df = 58, $p = 0.812$
Number of children	0.57 $\pm$ 0.89	0.47 $\pm$ 0.81	$t = 0.451$[a], df = 58, $p = 0.654$
	f (%)	*f* (%)	
Sex			$p = 0.180$[b]
Male	22 (73.3)	16 (53.3)	
Female	8 (26.7)	14 (46.7)	
Marital status			$p = 0.295$[b]
Single	10 (33.3)	15 (50.0)	
Married	20 (66.7)	15 (50.0)	
Employment status			$\chi^2 = 0.269$[c], df = 2, $p = 0.874$
Official	17 (56.7)	15 (50.0)	
Treaty	6 (20.0)	7 (23.3)	
Contractual	7 (23.3)	8 (26.7)	
Education level			$p > 0.99$[b]
Bachelor	22 (73.3)	21 (70.0)	
MSc	8 (26.7)	9 (30.0)	
Job			Value: 1.938[b], $p = 0.492$
Nurse	30 (100)	28 (93.3)	
Head nurse	0 (0)	1 (3.3)	
Nurse as shift manager	0 (0)	1 (3.3)	
Participation in the patient safety culture workshop in the last year			$p = 0.424$[b]
Yes	5 (16.7)	2 (6.7)	
No	25 (83.3)	28 (93.3)	
Experience participating in e-learning workshops in the last year			$p = 0.785$[b]
Yes	9 (30.0)	11 (36.7)	
No	21 (70.0)	19 (63.3)	

Abbreviations: df, degree of freedom; f, frequency; SD, standard deviation.
[a]Independent-*t* test.
[b]Fisher's exact test.
[c]χ^2.

outcome showed that post-training, the intervention group had significantly higher total adherence scores compared to the control group. Therefore, the null hypothesis was rejected. Additionally, adherence improved across all dimensions, indicating that multimedia electronic training can enhance compliance with these principles. Among the secondary outcomes, medication errors had the largest improvement, while the delay in providing care had the smallest improvement.

Additionally, Park et al. found that blended learning involving scenarios and web-based education improved nursing students' patient safety competency. Active collaborative learning with simulated scenarios fosters critical thinking skills essential for ensuring patient safety [40]. The role of interaction in distance education has been emphasized in other studies [41, 42].

The evidence also indicates that electronic education through the presentation of PDF (Portable Document Format) files via the social network Telegram positively affected the nurses' knowledge, attitude, and performance in preventing medication errors [43], which is consistent with the present study. In addition, Sabin et al. mentioned that a combination of web-based evaluation methods and evaluation based on skills and performance could be an effective evaluation method for ensuring that nursing students administer drugs safely [44].

TABLE 3 | A comparison of the total score and the dimensions' scores of adherence to patient safety principles before and after the electronic training in the two groups.

Dimensions of adherence to patient safety principles		Intervention (n = 30) Mean ± SD	Control (n = 30) Mean ± SD	Independent t-test Statistical value, df, p value
Medication errors	Before training	36.43 ± 4.31	36.63 ± 4.71	t = −0.172, df = 58, p = 0.864
	After the training	42.93 ± 1.78	37.30 ± 4.36	t = 6.557, df = 38.42, p < 0.001
	Paired t-test	t = −9.894, df = 29, p < 0.001	t = −0.712 df=29 p = 0.482	
Delay in providing care	Before training	45.13 ± 11.51	45.87 ± 11.53	t = −0.247, df = 58, p = 0.806
	After the training	55.70 ± 0.47	46.73 ± 11.30	t = 4.341, df = 29.09, p < 0.001
	Paired t-test	t = −5.051, df = 29, p < 0.001	t = −0.477 df = 29 p = 0.637	
Patient injury during care	Before training	14.17 ± 2.55	13.63 ± 2.53	t = 0.814, df = 58 p = 0.419
	After the training	15.83 ± 0.75	13.97 ± 2.16	t = 4.479, df = 35.849, p < 0.001
	Paired t-test	t = −3.831, df = 29, p < 0.001	t = −0.935 df = 29 p = 0.358	
Patient identification	Before training	29.83 ± 2.72	29.0 ± 3.03	t = 1.122, df = 58, p = 0.267
	After the training	31.70 ± 1.47	28.73 ± 3.12	t = 4.717, df = 41.22, p < 0.001
	Paired t-test	t = −4.229, df = 29, p < 0.001	t = −0.577 df = 29 p = 0.568	
Patient fall	Before training	18.60 ± 1.75	18.00 ± 2.21	t = 1.164, df = 58, p = 0.249
	After the training	19.83 ± 0.91	17.77 ± 2.11	t = 4.920, df = 39.46, p < 0.001
	Paired t-test	t = −3.892, df=29, p < 0.001	t = −0.641 df = 29 p = 0.527	
Total score of adherence to patient safety principles	Before training	144.17 ± 17.43	143.13 ± 18.22	t = 0.224, df = 58, p = 0.823
	After the training	166.0 ± 4.39	144.50 ± 17.71	t = 6.454, df = 32.55, p < 0.001
	Paired t-test	t = −7.421, df = 29, p < 0.001	t = −0.482 df = 29 p = 0.663	

Abbreviations: df, degree of freedom; SD, standard deviation.

Disfani et al. found that imparting patient safety principles to emergency medicine interns had a noteworthy and favorable impact on their knowledge, perception, attitude, and skills [45]. These findings align with this study, albeit with the distinction that Disfani et al. employed in-person instruction to teach safety principles.

In traditional learning environments, most educational content occurs through teacher and student interaction. In contrast, interaction has been less important in many e-learning courses, and only preprepared educational content is available to the students [46]. A lower importance on interaction can negatively impact the effectiveness of this type of training, the learners' motivation to learn more, and their satisfaction with the training process [47, 48]. Kumtepe's study revealed that one aspect of supporting learners in distance education is fostering positive interaction between students, professors, and staff [49]. More attention must be paid to creating interaction in online education environments as a necessity and requirement [50].

Fatimah et al. showed that after nurses received patient safety training based on SBAR (Situation-Background-Assessment-

Recommendation), the number of reported errors in the administration of injectable drugs decreased significantly [51], which was consistent with the results of the current study. Costa et al. concluded that interactive education through smartphones and electronic devices is more effective than the traditional method for learning educational programs [52].

In contrast to the present study's findings, Johnson et al. reported that e-learning did not increase nurses' knowledge of patient falls [53]. The study by Johnson et al. differed from the present study regarding intervention protocol and the number of safety indices examined. Johnson et al. also differed in the training modality, providing passive, one-way online training in text messages, which were other factors that contributed to this disparity. In this study, training was provided interactively through textual means, video files, and with more sessions.

Thus, this study addresses the gap in knowledge noted by Zeng and Luo [54], who wrote that future researchers should investigate the types of learning materials that create better outcomes for learning. Moving learners towards this type of education is possible by considering suitable and engaging interactive environments to motivate learners and providing frequent positive feedback. The total effect size of electronic training on nurses' adherence to patient safety principles indicated a very large impact. Also, the findings of this study indicate that electronic multimedia training can improve nurses' adherence to patient safety principles. This aligns with the results of Mohammadi et al. [55], which demonstrated that training in bioethical principles led to an increased ethical attitude among prehospital emergency personnel. Since adherence to ethical principles, including patient safety compliance, is an integral part of nursing performance, the results of these two studies confirm the importance of targeted training in improving the quality of nursing services.

5 | Implication

The high workload of nurses makes electronic education a valuable resource, allowing them to learn anytime and anywhere. This study focused on crucial e-learning content related to patient safety and measures to enhance it, which is essential for all healthcare professionals. However, it is important to consider the drawbacks of electronic education, including increased reliance on technology, high costs, diminished teacher-student interaction, and potential technical issues [56]. Such methods should be used in conjunction with other effective teaching methods.

6 | Implications for Nursing Policy

Patient safety e-learning offers several significant benefits for nursing practice and healthcare policy. First, it enhances knowledge retention and promotes the application of safety protocols in clinical settings, ensuring that nurses are better equipped to prevent errors. Additionally, it increases compliance with regulatory requirements, which is critical in maintaining high standards of patient care. Finally, the adoption of structured e-learning approaches has been linked to reductions in medical errors, including medication errors, misidentifications, and procedural mistakes. By integrating multimedia electronic training into nursing education programs, healthcare institutions can ensure that their staff remain updated on best practices while improving overall patient safety outcomes.

6.1 | Study Limitations

A limitation of this study was the short follow-up with nurses, highlighting the need for longer-term training assessments. Additionally, researchers could not evaluate nurses' patient safety skills. In Iran, low internet speeds, high costs, and expensive equipment hindered the use of more effective e-learning methods.

7 | Conclusion

Multimedia electronic training can improve nurses' adherence to patient safety principles, potentially reducing medication errors, delays, injuries, misidentifications, and falls. This training is vital for enhancing healthcare outcomes. The study's findings can guide more effective training for healthcare workers.

Future studies should explore the comparison of different e-learning methods, particularly evaluating the impact of synchronous versus asynchronous learning on nurses' adherence to patient safety principles. It is also essential to assess the long-term sustainability of e-learning effects and how adherence to safety principles changes over extended periods. Expanding research to other healthcare professionals, such as physicians and surgical technicians, can provide insights into the broader applicability of patient safety e-learning. Additionally, investigating the role of advanced interactive technologies, including virtual reality (VR) and augmented reality (AR), could enhance training effectiveness. Future research should also focus on measuring the direct impact of multimedia electronic training on actual patient safety outcomes, such as reductions in medical errors and improvements in clinical practice.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets used and/or analyzed during the current study and the data that support the findings of this study are available from the corresponding author upon reasonable request.

Transparency Statement

The lead author Zahra Farsi affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.