

Research article

Comparing the effectiveness of board game-based and drill-based education programs in improving Taiwanese nurses' fire safety knowledge, attitudes, and behavior: A quasi-experimental study

Hui-Wen Hsieh^a, Chia-Shan Wu^b, Chun-Chin Tsai^c, Yen-Chi Liao^d, Pin-Yu Chen^e,
Hui-Ling Tseng^a, Mei-Zen Huang^b, Mei-Fang Chen^{b,*}

^a Department of Nursing, Ditmanson Medical Foundation Chia-Yi Christian Hospital, Taiwan

^b Department of Nursing, National Tainan Junior College of Nursing, Taiwan

^c Department of Refrigeration, Air-Conditioning and Energy Engineering, Far East University, Tainan, Taiwan

^d Superintendent's office, Ditmanson Medical Foundation Chia-Yi Christian Hospital, Taiwan

^e Department of Nursing, Fooyin University, Kaohsiung, Taiwan

ARTICLE INFO

Keywords:

Board game

Fire drill

Nursing professional

Fire safety

Knowledge

Attitude

Behavior

ABSTRACT

Background: Fire education is currently dominated by drill-based programs, however only a limited number of participants may take part in fire drills. This gap could be addressed by the development of innovative board game-based educational programs.

Objective: This study sought to compare the effectiveness of board game-based and drill-based fire safety education programs in improving nurses' fire safety knowledge, attitudes, and behavior.

Methods: In this quasi-experimental study, 122 nurses were purposively sampled from a hospital in southern Taiwan. The participants were divided into two groups based on their willingness. Sixty-two nurses in the game-based group took part in an hour-long educational board game for fire safety; and 60 in the drill-based group took part in an hour-long fire drill organized by the hospital. The participants' pre- (T0) and post-intervention (T1) questionnaire scores on fire safety knowledge, attitudes, and behavior were recorded. The statistical methods included descriptive statistics and *t*-tests.

Results: After the interventions, both groups had improved safety knowledge, attitudes, and behavior. However, from T0 to T1, only fire safety knowledge was significantly higher in the game-based group than in the drill-based group, and there were no significant differences in fire safety attitudes and behavior between the two groups.

Conclusions: A board game-based fire education program is similar to a tabletop exercise, and drill-based programs more accurately reflect actual circumstances. Both methods can be applied based on the educational objectives and actual educational settings. The results of this study may function as a reference for designing clinical, educational, and academic interventions for fire safety in healthcare settings.

1. Introduction

Fire accidents in hospitals have increased in frequency in the past decade. According to the 2020 Taiwan Patient Safety Net statistical data, fires accounted for 17.25 % of the 1218 cases of public safety incidents in hospitals. Most of these fires occurred in a general ward or special care unit (Ministry of Health and Welfare Taiwan Patient Safety Net, 2021). Several factors have been associated with the high number of casualties, including hospital workers' lack of knowledge and incompetence in

handling fires, improper use of electrical equipment, workforce shortages, and poorly planned escape routes (Chien et al., 2020). The goal of fire safety in hospitals is to minimize the area affected by the fire, reduce casualties, and increase patient survival in the event of a fire, while simultaneously maintaining healthcare service provision. On arrival at the fire scene, firefighting teams need 6 to 15 min of preparation time. Moreover, other sections of the hospital must remain in operation even in the event of a fire, while some patients are unable to evacuate on their own. Thus, it is crucial that hospital workers handle a fire before

* Corresponding author at: 78, Sec. 2, Min-Tsu Rd., Tainan City 700, Taiwan.

E-mail address: meifang0302@mail.ntin.edu.tw (M.-F. Chen).

<https://doi.org/10.1016/j.nedt.2023.105919>

Received 27 April 2023; Received in revised form 7 July 2023; Accepted 21 July 2023

Available online 25 July 2023

0260-6917/© 2023 Published by Elsevier Ltd.

firefighters arrive and apply their emergency response capabilities to the utmost to cooperate with other units in the hospital (Chien et al., 2022). Nurses are the primary caregiving workforce in a hospital. They play a key role as frontline emergency responders when a fire occurs, and they must also ensure that patients are safely evacuated. Consequently, the emergency preparedness and response capabilities of nurses significantly affect patient safety during a fire. Therefore, it is important to improve workers' disaster prevention skills and preparedness in a proactive and appropriate manner to reduce the risk of fire events and maintain a safe hospital environment.

The Joint Commission of Taiwan announced that the second goal of the 2022–2023 Work Tasks for Healthcare Quality and Patient Safety Enhancement in Hospitals and Clinics is to “foster a patient safety culture, establish the resilience of hospital institutions, and implement patient safety incident management systems.” According to the Hospital Emergency Response Measures and Inspection Regulations outlined in the Medical Care Act, a hospital must immediately implement emergency response measures when necessary; designate evacuation methods for emergencies; organize lectures, drills, and tabletop exercises on emergency response measures; assist disabled patients to evacuate; and require newcomers and established staff members to undergo training in fire response procedures. Fire safety requires team members to possess adequate knowledge of and a positive attitude to fire prevention (Ministry of Health and Welfare Taiwan Patient Safety Net, 2021). Although hospitals hold a single annual hospital-wide emergency drill requiring significant investments in human resources and expenditure, only a few representatives from each department are allowed to participate in these drills and then share their experiences after returning to their units. Apart from the annual drill, each department also organizes its own drills with a supervisor devising scenarios that team members must handle based on their fire safety knowledge. The team members describe the work tasks related to their assigned responsibility, such as firefighting, reporting, or guiding evacuations, as well as whether they know where fire extinguishers are placed in their department. However, this approach is often a mere formality as it only allows one team at most to participate, while other staff members act as observers and may remain unclear about the evacuation route of their ward. In light of the high costs and the small number of participants and sessions in an annual drill, the development of innovative educational approaches is essential to improve the fire preparedness of hospital workers.

Many studies have shown that board games are innovative and popular tools for health education as they are easy to carry around, convenient, inexpensive, and not restricted by the number of players, age, weather, or equipment (Luchi et al., 2019; Noda et al., 2019). Board games are tabletop games that involve players moving pieces or tokens on a board according to a set of rules (Lu et al., 2018). The aura of uncertainty in board games stimulates learners' curiosity, and by taking part in suitable challenges, they can improve their engagement and joy in learning (Xu et al., 2021). Board games are used in onsite game-based learning strategies, as well as being conducive to practical clinical training programs (Lu et al., 2018). Playing board games can expand players' knowledge base and encourage learning through the process of answering questions. Board games simulate real-world scenarios and require players to take on specific roles, support each other and make clinical decisions in a risk-free and secure environment, enabling them to acquire the attitudes and behaviors required to handle different scenarios (Connor, 2017; Gauthier et al., 2019; Wu and Su, 2019). In addition, reflection and discussion after the game with regards to lessons learned and learning experience can help to develop the players' reflection ability, learning attitude and self-growth (Lu et al., 2018). However, a search of the literature, the Taiwan Patent Search System, and e-commerce websites found very few innovative fire prevention-themed board games. Therefore, the purpose of this study was to develop a board game-based educational program on fire safety and compare its effectiveness with that of the existing drill-based

educational program in improving nurses' fire safety knowledge, attitudes, and behavior.

2. Methods

2.1. Study design, sampling and procedure

This study was a quasi-experimental study based on an intervention–control design. It was performed from August to September 2022. The participants were nurses recruited using convenience sampling from one hospital in Taiwan. One month before the intervention, the details of this study were disseminated via e-mail to the hospital's nursing department so that every nurse knew about the study and could freely participate in it. The hospital required nurses to undergo a one-hour fire safety in-service training program at the units in which they served. The nurses who chose to participate in this study were divided into a game-based group or drill-based group before participating in their unit's fire safety training program. The inclusion criterion was that the participants were nurses. The exclusion criterion was previously having participated in a fire safety-themed board game intervention.

The sample size of this study was calculated using G*Power software. The effect size of knowledge, attitudes, and behavior was 0.25–0.3 in a pre-/post-intervention pilot study of 10 nurses. Based on the results of the pilot study, the effect size was set to 0.25, the alpha value was 0.05, and the power was 0.80. The required sample size was 101 or 111 after accounting for a 10 % dropout rate. Thus, each group required at least 56 participants.

2.2. Interventions

2.2.1. Drill-based educational program

The hour-long drill focused on ward evacuation. Various tasks were assigned to selected group members who had to describe their roles clearly. Those who were not assigned a role served as drill observers and participated in the group discussion afterward. An occupational safety and health (OSH) professional designated the point of origin of the fire, and then explained the procedures to the participants based on their roles. After the drill was completed, the OSH professional provided suggestions and additional comments. In particular, the OSH professional explained how to determine whether an extinguisher was expired and the correct directions for its use.

2.2.2. Board game-based educational program

Based on the literature (Liao, 2016; Pan American Health Organization, 2018) and the hospital's previous experiences, we developed a board game-based fire safety educational program called “Let's Fight the Fire!” Our goal was to encourage all hospital workers to participate in combating and preventing fires and ensure the safety of patients as well as their own. The game was validated by five experts (three firefighters and two game designers) who jointly supervised the gaming process with a nursing teacher. The board game design covered routine prevention practices and responses to an actual fire. The learning objectives, implications, and game contents are shown in Table 1.

2.2.2.1. Routine prevention: SAFE board game. The spiritual symbol of the SAFE board game was a phoenix, because a phoenix is immortal and regenerates through fire. The contents of the board game, including the game boards, answer cards and game cards are shown in (Fig. 1):

- (1) SAFE game boards (Fig. 1A): The Chinese word for “safe” is 安全, and the game boards reflected the shapes of the two Chinese characters. There were seven fire-related themes: cooking hazards, combustibles, electrical appliances, evacuation routes, fire suppression equipment, fire alarm equipment, and fire safety regulations.

Table 1
Educational program based on the “Let’s Fight the Fire!” board game.

Educational objectives	Implications	Game contents
Routine prevention: Implementing fire safety practices		
1. Developing the correct attitudes to fire safety.	1. Common causes of fire.	.Safe game board
2. Acknowledging the mission to maintain fire safety practices.	2. Maintenance and safe use of electrical equipment.	containing places commonly related to a hospital fire, such as instrument rooms, nurses’ stations, pantry, and ward.
	3. Implementation of fire safety education for patients.	.Fire prevention card
	4. Maintenance and safe use of fire safety equipment.	contents designed to cover themes such as fire suppression equipment, fire alarm equipment, fire safety regulations, cooking hazards, combustibles, electrical appliances, and evacuation routes.
	5. Hospital fire safety regulations.	
Fire event: Emergency response		
1. Learning how to report a fire.	1. Evacuation routes and devices at each unit.	.Game board for the ward fire prevention game.
2. Learning how to suppress a fire.	2. RACE procedure-based drills.	.Role cards.
3. Learning how to guide the evacuation process.	3. Task responsibilities of the announcers, firefighters, evacuation team members, and nurses.	.Contents of the equipment section.
4. Learning how to provide nursing care.	4. Correct reporting procedures.	.Contents of the scenario section.
5. Engaging in group-oriented fire drills.	5. Tips for using a fire extinguisher.	.Contents of the action section.
	6. Correct patient evacuation procedures.	.Contents of the energy boost section.
	7. Correct nursing procedures.	

RACE: Remove, Alarm, Confine and Extinguish or Evacuate.

- (2) Answer cards (Fig. 1B): The participants had to tick the red circle if the statement was correct or the red knot if the statement was wrong, or answer by ticking A, B, C or D.

(3) Game cards:

The fronts of the game cards (Fig. 1C) highlighted the importance of teamwork in fire (a phoenix) prevention, reinforcing the concept of the game. According to questions in the backs of the cards, the fronts of the game cards provided the correct answer. The correct answer to questions on the fronts of the cards was marked with an O or an X or A, B, C or D so the players could improve their fire safety knowledge. The backs of the cards provided questions on the seven fire-related themes included on the front of each card: fire suppression equipment, evacuation routes, fire safety regulations, electrical appliances, combustibles, cooking hazards, and fire alarm equipment. Fire suppression equipment covered both maintenance and the use of fire suppression equipment. Evacuation routes represented the means to escape a fire. The fire safety regulations were existing regulations on fire safety. Electric appliances, combustibles, and cooking hazards were objects and practices that could easily start a fire, to which the players had to pay extra attention. Fire alarm equipment highlighted the importance of reporting fire events. The game aimed to improve the players’ knowledge of fire prevention.

2.2.2.2. Fire event: 000 board game. The board game about a fire event was called 000 (triple zero). The name represented a fire event during which, after playing the board game, everyone knew about remaining calm (zero nervousness) with zero fire events and zero casualties. The contents of the game included four ward game boards, role cards, and

equipment, scenario, action, and energy boost sections (Fig. 2) as follows:

(1) Ward game boards:

Four boards were designed, each corresponding to one of four hospital blocks (Blocks A, B, C, and D) so that the nurses could engage in tabletop training. Because of manuscript layout restrictions, only the board for Block D is shown in Fig. 2A. Spaces on the boards allowed the players to move forwards and backwards.

(2) Role cards

The roles included site commander, announcer, emergency medical technician, firefighter, and evacuation team (Fig. 2B).

(3) Contents of the equipment section

The equipment section contents included a fire response pack (LED baton, flashlight, red crayons, whistles, smoke escape packs), and reporting devices (work telephone, ward telephone, and nursing station telephone), fire extinguisher, bag valve mask, oxygen cylinder, wheelchair (Fig. 2C).

(4) Contents of the scenario section

The scenario section contained the point of origin of the fire, the number of fires or presence of smoke, and the patient distribution status. The number of fires was determined by rolling a die. The patient distribution status was based on the emergency evacuation registration form together with patient cards (ambulatory, non-ambulatory, oxygen therapy [transport of wheelchairs, bedsheets, and oxygen cylinders], ventilator [transport of bag valve masks and oxygen cylinders]) (Fig. 2D).

(5) Contents of the action section

The action section cards included those for opening a door, closing a door, and an “O” sign (after making sure no people remained in the ward, then close the door and draw an “O” on the door) (Fig. 2E).

(6) Contents of the energy boost section

The contents of this section included water and energy boost cards. A water card enabled players to keep playing; when they ran out of water, they could use an energy boost card (question and answer) and earn two water cards (Fig. 2F).

2.2.2.3. Game play. All game sessions were conducted by a team including the lead researcher and four research assistants. The lead researcher organized the game, and each research assistant worked with a group of four to five participants. The research assistants were responsible for teaching the participants how to play the game and encouraging them to freely express their thoughts.

To ensure that all of the nurses in the experimental group were able to participate, the research was explained, two questionnaires and the board game were completed within one session, and the nurses could choose to attend any of three sessions (08:30–11:30; 13:30–15:30; and 16:30–18:30) over two days depending on their schedule. The board game sessions were conducted for 60 min divided into two parts. First, five minutes were allocated to introduce the game scenarios and game cards and explain the rules. The participants then played the routine prevention “SAFE” game for around 20 min, and the fire event “000” game for around 35 min (as explained below). Lastly, five minutes were allocated to discuss the game and award prizes.

In the routine prevention SAFE game, four to five participants were

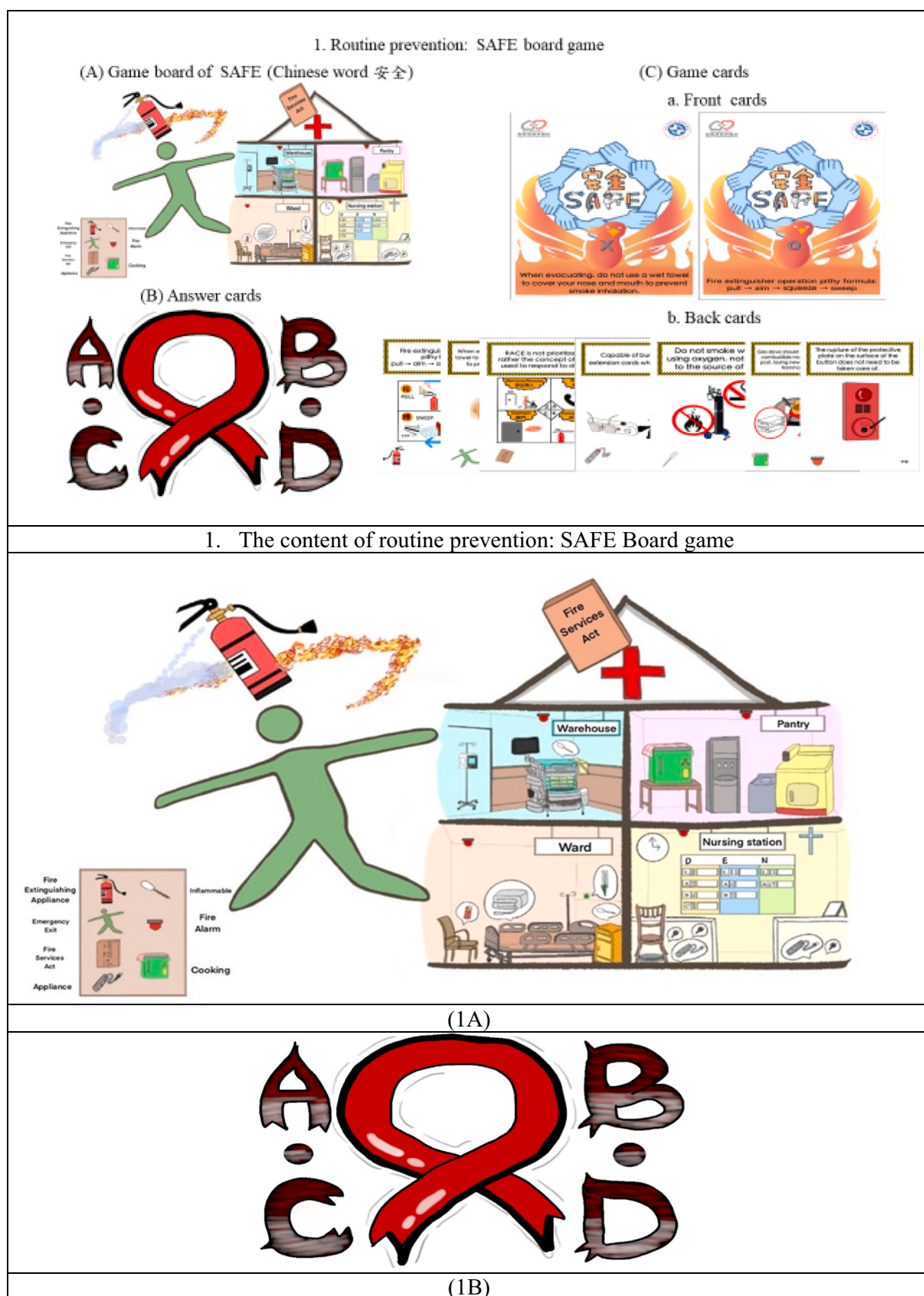
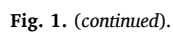


Fig. 1. Contents of the routine prevention SAFE board game (1A) SAFE game boards; (1B) Answer cards; (1C) Game cards.



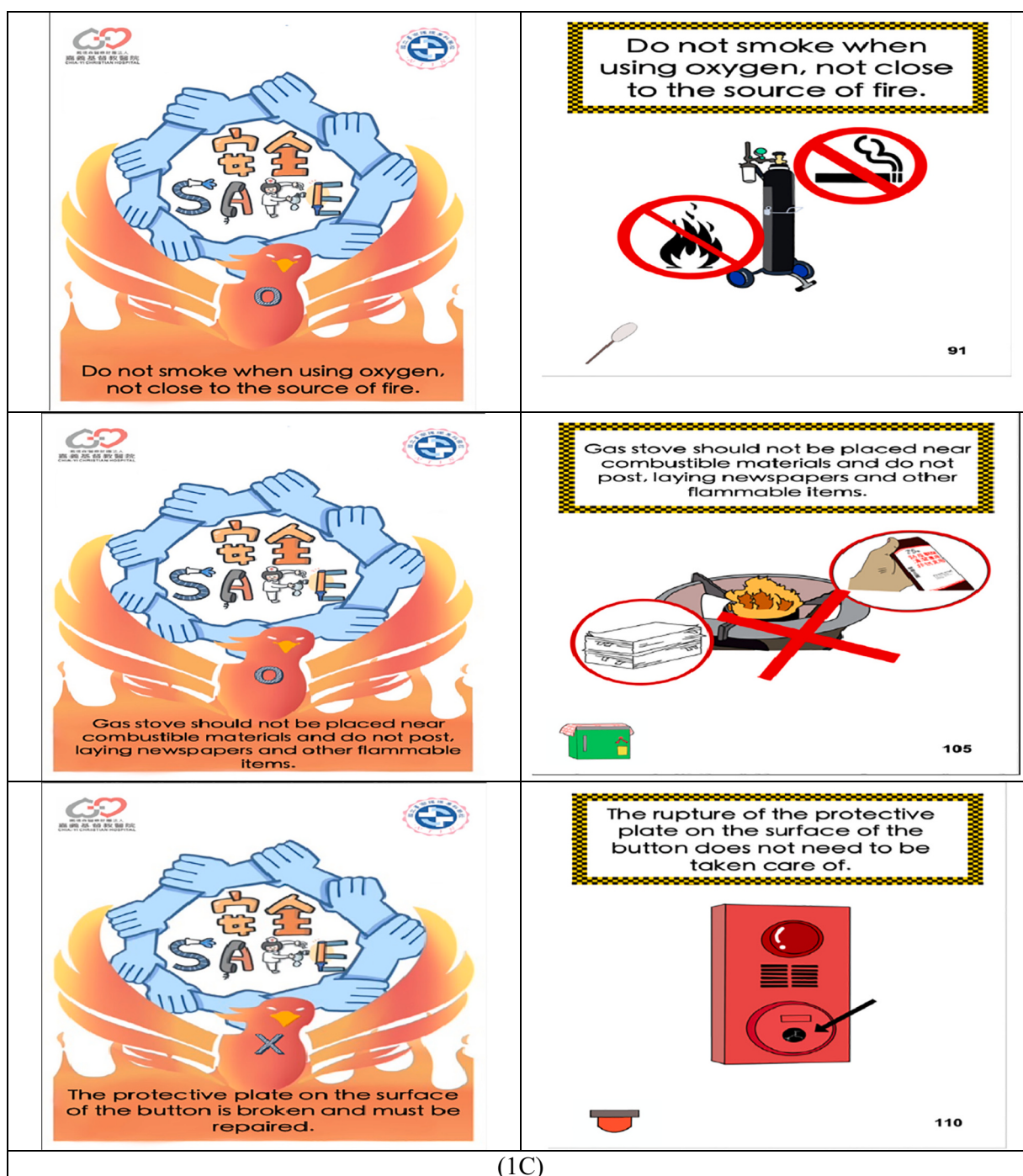


Fig. 1. (continued).

grouped together, and each participant was given a game board. One participant read a question and the others put down an answer card. The first person to answer correctly got to keep the game card, then put this card in their own Game boards of SAFE and scored 1 point. The person who read the question then read it again with the correct answer and the solution on the back of the card so that every player could understand where they had made a mistake. The player with the highest score was the winner and received a prize.

The second part of the game involved playing the fire event 000 game, which was designed for four to five players according to their working block (workers in the same block were grouped together). Two scenarios were played out in which the fire did and did not originate in a

ward. The game was played as follows. 1) The players then randomly drew role cards (site commander, announcer, emergency medical technician, firefighter, and evacuation team) and placed their role cards anywhere they wanted on the board. 2) The same group put the equipment used in response to fire on the game board of their ward. 3) The research assistant stated a patient's condition and bed number on their emergency evacuation registration form (ambulatory/non-ambulatory, on oxygen therapy, on ventilation, etc.), and the players put the patient cards on the game board of their ward. 4) A research assistant then told the players the origin of the fire (number on the game board of their ward) and each group rolled a die to determine the number of fires.

Each group was only allowed to move 20 spaces (collectively for all

(A) Game board of the ward fire prevention game



- Engine room
- Fire extinguisher
- Fire hydrant
- Wicket
- Fire door

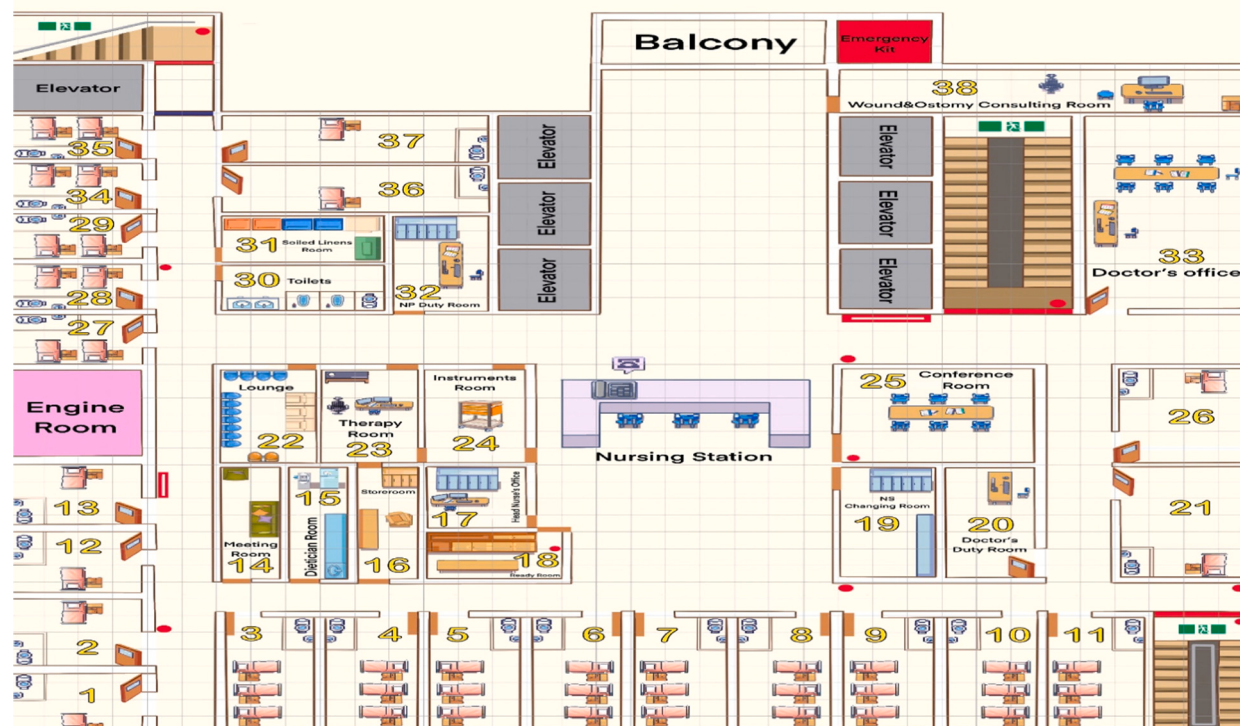
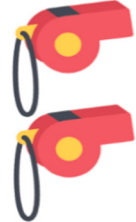


Fig. 2. Contents of the fire event 000 board game

(A) Ward D game board; (B) Role cards; (C) Equipment used in response to a fire; (D) Contents of the scenario section; (E) Contents of the action section; (F) Contents of the energy boost section.

				
Site commander	Announcer	Emergency medical technicians	Firefighter	Evacuation team

(2B) Role cards

				
LED baton	Flashlight	Red crayon	Whistle	Smoke escape pack
				
Reporting devices	Fire extinguisher	Bag valve mask	Oxygen cylinder	Wheelchair

(2C) Equipment used in response to fire

				
---	---	---	--	---

Fig. 2. (continued).

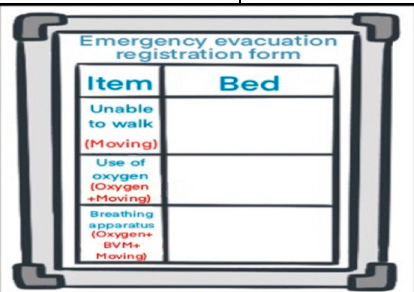
				
Ambulatory	Non-ambulatory	Bedridden and on oxygen	On ventilation	On a wheelchair and on oxygen
				
Emergency evacuation registration form		Fire	Smoke	Dice
(2D) Contents of the scenario section				
				
Opening a door	Closing a door	“O” mark		
(2E) Contents of the action section				
				
Water	Energy boost (Answer)	Energy boost (Question)		
(2F) Contents of the energy boost section				

Fig. 2. (continued).

roles). If the fire was not suppressed in a round, the next round began with twice the number of fire and smoke cards. In addition, each group had two water cards; one card was required to move 20 spaces. To get more water cards, the players had to correctly say whether the question on an energy boost card was correct or incorrect. The winning group were able to suppress the fire, and take a head count. For the losing group, the fire and smoke spread beyond its origin or there were casualties.

2.3. Measurements

Three structured questionnaires—fire safety knowledge scale, fire safety attitudes scale, and fire safety behavior scale—were used to collect data. To evaluate the effectiveness of the board game-based and drill-based educational programs, the students' learning outcomes were measured at baseline (T0) and at the end of the intervention (T1).

2.3.1. Fire safety knowledge scale

The fire safety knowledge scale was developed according to studies by Huang (2021) and Fu (2014). The scale comprised five dimensions: five items on evacuation and escape; four items on fire suppression; four items on electrical appliances and combustibles; four items on fire response prioritization; and three items on hospital fire safety policies. Ten items were multiple-choice questions, while the other ten were true or false questions. Each multiple-choice question provided four response choices; one point was earned if the question was answered correctly, none if otherwise. The true or false questions provided three choices: true, false, and unsure; one point was earned if the response was correct, none if otherwise. The higher the score, the more knowledgeable the respondent was about fire safety. The validity and reliability of the scale were evaluated by experts and with Kuder–Richardson Formula 20.

2.3.2. Fire safety attitudes scale

The fire safety attitudes scale was developed based on relevant literature (Fu, 2014; Liao, 2016). The scale consisted of six items which were measured using a five-point Likert scale (ranging from strongly disagree to strongly agree). A higher score indicated that the respondent had a more positive attitude. Reliability and validity were assessed by experts and with Cronbach's alpha. The expert content validity was 0.95.

2.3.3. Fire safety behavior scale

The fire safety behavior scale was developed based on the fire emergency response behavior scale created by Lee (2021). The scale measured the variation in a person's behavior in response to a fire. The scale comprised 21 items across five dimensions related to the RACE principle (Remove, Alarm, Confine and Extinguish or Evacuate). The items included five on rescue and evacuation; four items on alerting others immediately; three on confining the fire and smoke; six on preliminary fire suppression and evacuation; and three on evacuee placement and follow-up. The items were measured using a five-point Likert scale as 0 = not at all, 1 = probably, 2 = partially, 3 = mostly, and 4 = absolutely. A higher average score indicated that the respondent exhibited stronger fire safety behavior. The expert validity was excellent (0.97), and the Cronbach's alpha was 0.94.

2.3.4. Participants' basic attributes and factors for participating in the fire safety training program

This questionnaire was used to obtain information on the respondent's age, sex, education level, marital status, religious beliefs, annual income, nurse rank as stated on the emergency evacuation registration form, experience in handling a fire, and participation in the hospital's fire drill in the past year.

2.4. Data collection

This study was approved by the Human Research Ethics Committee. Before being enrolled in the study, each participant read and signed an informed consent form. The participant was then asked to complete a pre-intervention questionnaire immediately before and a post-intervention questionnaire immediately after playing the board game or taking part in the drill. Structured questionnaires were used to collect outcome data at T0 and T1. All questionnaires were administered by a trained research assistant who was blinded to the group assignments and did not provide any services to the participants. Each participant took approximately 20 min to complete the questionnaires. Personal characteristics were collected only at T0.

2.5. Data analysis

Statistical analyses were performed using SPSS, version 22 (IBM Inc., Armonk, NY). The chi-square test was used to examine group differences in personal characteristics. Paired-sample *t*-tests were used to compare intragroup differences in outcome variables between T0 and T1. Independent *t*-tests were used to compare differences in outcome variables between the board game and drill groups at T0 and T1 and between T0 and T1.

3. Results

3.1. Characteristics of the participants in the game-based group and drill-based group

A total of 122 nurses consented to participate in the study. No participant in either group was lost to follow-up at T1. Sixty-two participants in the game-based group and 60 in the drill-based group completed the study. All participants were female. The average ages of the game-based and drill-based groups were 33.5 and 31.3 years, respectively. The retention rate in both groups at T1 was 100 %. There were no significant differences in personal characteristics between the two groups at T0, indicating intergroup homogeneity (Table 2).

3.2. Differences in outcome variables within and between the game-based group and drill-based group

Significant improvements in both the game-based and drill-based groups in fire safety knowledge ($t = 12.58, p < .001$; $t = 6.14, p < .001$, respectively), attitudes ($t = 5.89, p < .001$; $t = 3.79, p < .001$, respectively), and behavior ($t = 5.52, p < .001$; $t = 6.09, p < .001$, respectively) were found after the intervention. However, from T0 to T1, only fire safety knowledge was significantly higher in the game-based group than in the drill group ($t = 2.81, p = .006$). No significant differences were found in fire safety attitudes and behavior between the game-based group and the drill group ($t = -0.33, p = .742$; $t = -0.16, p = .875$, respectively). The results are presented in Table 3.

4. Discussion

Our results showed that the game-based and drill-based educational programs were both feasible fire prevention educational solutions and were effective in improving nurses' knowledge, attitudes, and behavior in relation to fire safety. In line with previous studies (Chen and Tsai, 2022; Gauthier et al., 2019; Liao, 2016), the game-based and drill-based learning strategies proposed in this study improved the participants' knowledge, attitudes, and behavior. The interactive, learner-centered board game stimulated the participants' creative thinking skills and improved their decision-making, interest in learning, and self-directed

Table 2
Demographic data of the game-based and drill-based groups ($N = 122$).

	Game-based group ($n = 62$)		Drill-based group ($n = 60$)		χ^2 or t	p
	number or mean	% or SD	number or mean	% or SD		
Age, years					1.23	0.540
20–29	24	38.7	27	45		
30–39	24	38.7	24	40		
≥ 40	14	22.6	9	15		
Gender						
Female	100					
Education level					2.25	0.522
Senior high school	0	0	2	3.3		
Junior college	4	6.5	4	6.7		
University	55	88.7	52	86.7		
Graduate school	3	4.8	2	3.3		
Religion					4.09	0.394
None	31	50.0	27	45.0		
Buddhism	1	1.6	5	8.3		
Taoism	27	43.5	24	40.0		
Catholicism or Christianity	3	4.8	4	6.7		
Marital status					1.08	0.584
Single	39	62.9	40	66.7		
Married	22	35.5	20	33.3		
Divorced	1	1.6	0	0		
Nursing experience, years					4.66	0.198
< 10	38	61.3	36	60.0		
10–15	6	9.7	8	13.3		
15.1–20	6	9.7	11	18.4		
> 20	12	19.4	5	8.3		
Nurse rank					2.35	0.503
≤ N1	21	33.9	25	41.7		
N2	25	40.3	18	30.0		
N3	11	17.7	9	15.0		
N4	5	8.1	8	13.3		
Did you participate in the hospital's fire drill in the past year?					0.145	0.175
Yes	53	85.5	45	75		
No	9	14.5	15	25		
Have you experienced an actual fire event?					0.664	0.715
Yes	3	4.8	4	6.7		
No	59	95.2	56	93.3		

learning. They thereby expressed their knowledge conversion behaviors and achieved satisfactory learning outcomes via meaningful experiences (Day-Black et al., 2015). The fire drills were implemented based on conceptualized fire safety plans and enabled the participants to become familiar with their roles and gain experience. Furthermore, a fire drill provides an opportunity to verify whether alarms are working and whether people can hear them clearly. In addition, fire drills are important as they teach people how to react if there is a real fire on the premises. Thus, both solutions are feasible for fire safety education.

In this study, the nurses in both the game-based and drill-based groups significantly improved their overall scores on fire safety knowledge after the intervention. However, the effectiveness of the board game-based educational program was statistically more significant than that of the drill-based educational program. A systematic review showed that board game-based educational programs significantly improved players' knowledge, with effect sizes ranging from 0.12 to 1.81 (Noda et al., 2019). Board games are conducive to clinical instruction as they promote thinking outside the box. Unlike traditional top-down learning approaches, board game-based strategies promote learning dialogues through a bottom-up approach in which students take the initiative themselves. The inclusion of gaming strategies, such as competition, interaction, and explaining why an answer is incorrect, enables learning

to be reoriented to student experiences. These positive and in-person experiences promote the students' full engagement in the learning process (Lu et al., 2018; Noda et al., 2019). Fire drills emphasize the management of a fire scene, which is crowded and affected by environmental and sonic interference. The presence of many onlookers may also affect the knowledge acquisition process. Furthermore, the effectiveness of the board game-based educational program was statistically more significant than that of the drill-based educational program with regards to fire suppression-, evacuation-, and escape-related knowledge acquisition. This could be because a drill only involves of a group of actors while the other participants are onlookers, restricting the amount of knowledge that can be acquired. Moreover, as each unit organizes its own drill, patient evacuation is mostly a verbal task and extinguisher use is assigned to only one person. The board game scenario included a fire inside a ward, from where the players had to evacuate or rescue the patients, and it was therefore more effective than the drill scenario.

The nurses in the board game and drill groups significantly improved their overall scores for attitude to fire safety after the intervention, but there was no significant difference in total attitude score. This may be because the learners were more proactive when they were present at a fire scene. The ward fire prevention board game was designed to meet actual circumstances whereby the players were placed in their workplaces in Blocks A, B, C, and D of the hospital. As they played the game, the nurses were in their comfort zone and could easily familiarize themselves with the scenario. In addition, the game-based learning scenario they were willing to participate in was customized. Designing spaces on the board for each player to make a limited number of moves was also challenging, piqued their engagement, and trained their decision-making skills. Interestingly, the game-based group showed significantly greater improvements in the items "I perceive myself as being proactive in participating in the in-service fire safety training programs organized by the hospital" and "I think I am able to remain calm in the event of a fire" than the drill group. A possible reason is that every player had their own role to fulfill in the board game and they immersed themselves in the game (every player had their role in training and participating, and they were also able to observe how other roles were played out). The drill only required action from those with roles, while those without were merely onlookers. This may have led to the differences in improvement. Engagement in group discussions enabled the students to fight the fire with a team member, thus increasing their willingness to participate. The drill was performed according to a plan and successful fire extinguishment was the only outcome; consequently, failure was not examined. However, in the board game, the game ended when the fire spread beyond its origin or there were casualties. This design allowed the players to plan their next step carefully and improved their engagement.

Both the board game and drill groups significantly improved their behavior scores after the intervention, but no significant differences were observed in their total score. The drill-based educational program focused on improving the participants' response capabilities by taking part in person in the simulation tasks. The board game designed in this study is similar to a tabletop exercise. As the participants moved across the spaces on the game board, they trained their fire extinguishing and patient evacuation behaviors by moving wheelchairs, oxygen cylinders, fire extinguishers, bedsheets, and bag valve masks from their original positions. In addition, the positions on the board game were coded so that players could easily identify the origin of a fire, such as a patient's unit or an empty ward. These different scenarios provided more opportunities for them to enhance their fire preparedness and response capabilities. The outcome of the game (winning or losing as a team) served the basis for learning. By working as a team, the nurses learned that fire response measures do not center on individualism, but rather communication, coordination, and cooperation as a team. Moreover, the winning scenario included putting out the fire, turning off the air conditioning and electrical appliances, or handling a gas leak, as well as taking a head count of the evacuees. The losing scenario included

Table 3

Differences in outcome variables within and between the game-based group and drill-based group.

Variable	Two-group		Game-based group				Drill-based group			
	T1–T0		T0	T1	T1–T0		T0	T1	T1–T0	
	<i>t</i>	<i>p</i>	Mean (SD)	Mean (SD)	<i>t</i>	<i>p</i>	Mean (SD)	Mean (SD)	<i>t</i>	<i>p</i>
Total knowledge score	2.81	0.006**	14.44 (2.26)	17.95 (1.73)	12.58	<0.001***	13.35 (2.60)	15.58 (1.83)	6.14	<0.001***
Knowledge of evacuation and escape	3.78	<0.001***	3.15 (0.87)	4.48 (0.76)	9.71	<0.001***	2.97 (0.97)	3.53 (0.91)	3.75	<0.001***
Knowledge of fire suppression	3.30	0.001**	2.60 (0.76)	3.58 (0.67)	9.23	<0.001***	2.45 (0.83)	2.90 (0.68)	3.68	0.001**
Knowledge of hospital fire safety policies	0.32	0.751	2.52 (0.67)	2.84 (0.37)	3.53	0.001**	2.38 (0.67)	2.67 (0.57)	3.43	0.001**
Knowledge of electrical appliances and combustibles	−0.22	0.829	3.21 (0.70)	3.65 (0.52)	5.33	<0.001***	2.93 (0.86)	3.40 (0.74)	3.89	<0.001***
Knowledge of fire response prioritization	−0.17	0.863	2.97 (0.81)	3.40 (0.84)	3.54	0.001**	2.62 (1.04)	3.08 (0.79)	3.56	0.001**
Total attitudes score	−0.33	0.742	24.71 (3.49)	27.29 (2.53)	5.89	<0.001***	24.53 (3.18)	27.40 (5.28)	3.79	<0.001***
1. I perceive myself as being proactive in participating in in-service fire safety training programs organized by the hospital.	2.30	0.023*	4.11 (0.70)	4.58 (0.56)	6.21	<0.001***	4.33 (0.57)	4.57 (0.53)	3.39	0.001**
2. I perceive myself as being capable of proactively handling a fire event.	1.72	0.088	3.79 (0.91)	4.48 (0.50)	5.96	<0.001***	3.93 (0.84)	4.37 (0.74)	4.51	<0.001***
3. I think I am able to remain calm in the event of a fire.	2.42	0.017*	2.95 (1.08)	4.11 (0.79)	10.27	<0.001***	3.33 (1.15)	4.08 (0.96)	5.90	<0.001***
4. I believe fire events can be prevented.	−1.22	0.224	4.74 (2.55)	4.66 (0.47)	−0.24	0.812	4.23 (0.72)	4.58 (0.50)	4.28	<0.001***
5. I believe we should be more vigilant when strangers appear in the hospital.	0.50	0.618	4.50 (0.67)	4.68 (0.47)	3.42	0.001**	4.32 (0.60)	4.53 (0.62)	2.62	0.011*
6. I believe fire prevention and response measures are extremely important.	−1.24	0.219	4.61 (0.55)	4.68 (0.47)	0.85	0.398	4.30 (0.85)	4.38 (0.61)	1.32	0.192
Total behavior score	−0.16	0.875	69.26 (11.36)	77.69 (8.25)	5.52	<0.001***	69.23 (12.30)	78.00 (8.60)	6.09	<0.001***
Rescue and evacuation	−1.66	0.099	17.06 (2.12)	18.29 (1.67)	4.76	<0.001***	16.45 (2.95)	18.42 (2.38)	5.38	<0.001***
Alerting others immediately	−0.41	0.684	13.13 (2.41)	14.55 (1.72)	4.88	<0.001***	13.15 (2.48)	14.73 (1.77)	4.72	<0.001***
Confining the fire and smoke	−0.58	0.564	9.66 (1.79)	11.00 (1.62)	6.07	<0.001***	9.87 (2.21)	11.40 (1.14)	6.00	<0.001***
Preliminary fire suppression and evacuation	0.24	0.808	19.45 (6.41)	22.42 (5.86)	2.87	0.006**	19.53 (4.00)	22.22 (2.89)	5.18	<0.001***
Evacuee placement and follow-up	1.62	0.108	9.94 (1.65)	11.44 (1.10)	6.40	<0.001***	10.23 (1.86)	11.23 (0.36)	4.99	<0.001***

* $p < .05$.** $p < .01$.*** $p < .001$.

casualties or when the fire spread beyond its origin. The outcome of the board game guided the nurses to develop appropriate fire management behaviors.

4.1. Implications

This study has several implications for clinical practice. The game covered game items, game play, and play features. The game items used in the board game-based program (fire event contents, environment, and items), with which the nurses familiarized themselves quickly, were all designed by the hospital. Our results suggest that game play and the number of players affected learning outcomes. For game play, as fire drills require teamwork, our board game allowed a maximum of 20 moves per team per round so that the players could work as a team. Game play affects learners' learning skills, and it should be designed based on the objectives of the game. With regards to the number of participants, given that a fire could occur during the night shift when fewer staff members are present, there may be only two to three players in the game when it is used to train night shift workers, and their decision-making skills may also differ. In addition, the gamification of fire safety educational programs requires an assistant to explain the game to every group and provide suggestions. This would require

human resources. Going forward, different fire scenarios can be standardized based on the learning objectives. Correct decision-making methods and treatment procedures can be developed based on actual scenarios, which can then be filmed to produce videos. After watching these videos, the learners are likely to become more efficient at learning.

This study also has implications for teaching and research. Future studies should use more rigorous experimental designs to further investigate the effectiveness of game-based and drill-based learning approaches. The sample size should be expanded and nurses' learning outcomes should be followed up over time. This study was carried out in the relatively small setting of a regional hospital. Future studies should use similar interventional methods and implement different designs based on features of the hospital.

4.2. Limitations

There are several limitations to this study. First, the participants were recruited from one hospital in southern Taiwan, potentially limiting the generalizability of the study. Thus, further evaluation of the intervention in different areas is needed. In addition, a fire drill requires the participation of not only nurses but all hospital staff in general. The effectiveness of the board game should be reevaluated in the future by

enlarging the sample size and including other professionals or administrators. Second, for the sake of confidentiality, the participants were not pressured to give true answers, and the questionnaire did not require them to state the unit in which they were serving. Since learning outcomes would differ according to the participants' units, future studies should include this variable. Third, to achieve a sufficiently large sample size, the game-based group comprised nurses from all units of the hospital, and during the intervention, one group may have consisted of nurses from different units. The drill group comprised nurses from the same unit who took part in the drill as required by the hospital. Future studies should examine whether learning outcomes differ by group composition (i.e., members from the same unit or different units). Fourth, playing a board game requires face-to-face interactions. Hence, situations where such interactions are not possible, for example as during the COVID pandemic, would limit the use of board games. To overcome this limitation, the board game can be made into an online or virtual reality version to amplify the threat of smoke, thereby increasing engagement with the game.

5. Conclusion

Both the board game-based fire education program and drill-based fire education program were beneficial and safe in promoting fire safety-related knowledge, attitudes, and behavior of nurses. A board game-based fire education program is similar to a tabletop exercise as it is interactive, team-based, convenient and can be used repeatedly. Although drill-based programs require more human resources and higher cost, they more accurately reflect actual circumstances. Based on the fact that only representatives are allowed to participate in the drill, others may be able to practice through the board game. The unit should effectively plan education and training. For example, those who cannot participate in the drill-based program should be required to participate in board game-based fire education programs. In addition, nursing staff could participate in a board game-based fire education program and drill-based fire education program in turn, and even participate in the board game-based program before the drill-based program. Both methods can be applied based on the educational objectives and actual educational settings. The results of this study can provide a reference for healthcare providers and researchers when designing fire prevention education programs for nursing staff.

CRedit authorship contribution statement

Hui-Wen Hsieh, Mei-Fang Chen, Chia-Shan Wu, Chun-Chin Tsai, Yen-Chi Liao and Pin-Yu Chen made contributions to the study conception and design. Hui-Wen Hsieh, Mei-Fang Chen, Chia-Shan Wu, Hui-Ling Tseng and Mei-Zen Huang made contributions to data collection. Mei-Fang Chen and Chun-Chin Tsai contributed to data analysis and interpretation. Mei-Fang Chen contributed to the draft and critical revision of the manuscript. All authors approved the final manuscript for publication.

Funding

This study was funded by the Academia and Industry Collaboration Research Program of the Ditmanson Medical Foundation Chia-Yi Christian Hospital and National Tainan Junior College of Nursing (R111-015).

Ethical statements

This study was approved by the Human Research Ethics Committee of Ditmanson Medical Foundation Chia-Yi Christian Hospital (IRB2022017).

Declaration of competing interest

The authors have no conflicts of interest to declare.

Data availability

The datasets generated and/or analyzed in the present study are not publicly available, but they can be obtained from the corresponding author on reasonable request.

References

- Chen, M.F., Tsai, C.C., 2022. The effectiveness of a thanks, sorry, love, and farewell board game in older people in Taiwan: a quasi-experimental study. *Int. J. Environ. Res. Public Health* 19, 3146. <https://doi.org/10.3390/ijerph19053146>.
- Chien, S.W., Shih, Y.T., Lee, P.Y., 2020. Fire risk identification and safety countermeasures in medical institutions and long-term care institutions. *J. Healthc. Qual.* 14 (3), 26–29.
- Chien, S.W., Shih, Y.T., Hsieh, S.F., 2022. Core issues regarding fire risk management and disaster prevention and mitigation strategies in medical institutions. *J. Healthc. Qual.* 16 (2), 68–73. <https://doi.org/10.53106/199457952022031602010>.
- Connor, Q., 2017. The impact of a gamified world on medical education. *Educ. Health* 30 (3), 256–257.
- Day-Black, C., Merrill, E.B., Konzelman, L., Williams, T.T., Hart, N., 2015. Gamification: an innovative teaching learning strategy for the digital nursing students in a community health nursing course. *ABNF J.* 26 (4), 90–94.
- Fu, K.T., 2014. The Research of Fire Safety Knowledge and Concept among Nurses and Undergraduate Nursing Students—a Case Study on the Fire Safety Education of the Nursing Home. Central Police University: Fire Science Department Thesis.
- Gauthier, A., Kato, P.M., Bul, K.C.M., Dunwell, I., Walker-Clarke, A., Lamer, P., 2019. Board games for health: a systematic literature review and meta-analysis. In: *Games for Health Journal: Research, Development, and Clinical Applications*, 8(2), pp. 85–100. <https://doi.org/10.1089/g4h.2018.0017>.
- Huang, C.C., 2021. Study on the Influence of Disaster Prevention Knowledge, Educational Propaganda on Participation Behavior: The Example of Xinying District Nursing Home. TransWorld University: Business Administration Department Thesis.
- Lee, J.S., 2021. Explore the Relationship among Personality Traits, Problem-Solving Ability and the Fire Emergency Response Behavior on the Staff in Postpartum Nursing Institutions. Asia University: Healthcare Administration Department Thesis.
- Liao, C.H., 2016. A Study of Knowledge, Attitude and Behavior for Long-Term Care Institutions' Employees by the Intervention of Fire Prevention Education. Central Taiwan University of Science and Technology: Central Taiwan University of Science and Technology.
- Lu, C.F., Wu, S.F., Shu, Y.F., Yeh, M.Y., 2018. Applying game-based learning in nursing education: empathy board game learning. *J. Nurs.* 65 (1), 96–103. [https://doi.org/10.6224/JN.201802.65\(1\).13](https://doi.org/10.6224/JN.201802.65(1).13).
- Luchi, K.C.G., Cardozo, L.T., Marcondes, F.K., 2019. Increased learning by using board game on muscular system physiology compared with guided study. *Adv. Physiol. Educ.* 43 (2), 149–154. <https://doi.org/10.1152/advan.00165.2018>.
- Ministry of Health and Welfare Taiwan Patient Safety Net, 2021. Taiwan patient-safety reporting system annual report 2020. Available from: https://www.patientsafety.mohw.gov.tw/files/file_pool/1/0m103598096120967374/2020%E5%B9%B4%E5%B9%B4%E5%BA%A6%E5%A0%B1%E8%A1%A8_online.pdf.
- Noda, S., Shiotsuki, K., Nakao, M., 2019. The effectiveness of intervention with board games: a systematic review. *Biopsychosoc. Med.* 13, 22. <https://doi.org/10.1186/s13030-019-0164-1>.
- Pan American Health Organization, 2018. WHO/PAHO hospital fire prevention and evacuation guide. Available from: [https://www.paho.org/disasters/dmdocuments/HospitalsDontBurn%20\(1\).pdf](https://www.paho.org/disasters/dmdocuments/HospitalsDontBurn%20(1).pdf).
- Wu, C.F., Su, S.C., 2019. Research on the successful factors of using board game in guided teaching. *Manag. Inf. Comput.* 8, 1–10.
- Xu, Y., Lau, Y., Cheng, L.J., Lau, S.T., 2021. Learning experiences of game-based educational intervention in nursing students: a systematic mixed-studies review. *Nurse Educ. Today* 107, 105139. <https://doi.org/10.1016/j.nedt.2021.105139>.