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Original Article

The Value of Functional Exercise in Pediatric Mass-Casualty Incident Training

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Background: Hospital staff in Taiwan practice mass casualty incident (MCI) management through full-scale exercise (FSE). However, FSE is generally resource-intensive and time-consuming. As an alternative, functional exercise (FE) may be more cost-effective with a similar effect in certain aspects. Hence, we aimed to evaluate the FE value in MCI training. We investigated whether FE can increase the familiarity of pediatric MCI response and the effect in different groups.
Methods: A new emergency operation plan (EOP) of nontraumatic pediatric MCI was developed in 2018 for our Children's Hospital. An FE was conducted to assess the plan. In addition to the emergency department staff, head nurses, supervisors, and physicians of Children's Hospital also participated in the exercise. Pre- and post-exercise questionnaires were designed, and participants were asked to evaluate their familiarity with pediatric MCI response pre- and post-exercise. Participants' reading experience of the new EOP, previous training level, occupation position, and whether they were using a computer during the exercise were also noted in the questionnaires. Data were analyzed using paired *t*-test and Fisher's exact test.
Results: Among 49 participants, 16 participants completed the pre- and post-exercise questionnaires. The post-exercise familiarity score was found to be significantly higher than that of pre-exercise ($p < 0.05$). There were no significant differences among the relationships between familiarity increase and participants' reading experience of the new EOP, previous training level, occupation position, and whether they were using a computer during the exercise.
Conclusions: FE can significantly increase the familiarity of the hospital staff with pediatric MCI response and may be applied as a new training method of hospital disaster preparedness.

Key words: *disaster, mass casualty incident, functional exercise, pediatric, disaster training*

Introduction

An emergency preparedness exercise, as a proxy for an actual emergency or disaster, is a vital part of disaster preparedness, especially in the training of emergency services personnel.[1] In Taiwan, drills and full-scale exercises (FSEs) are commonly used by fire departments, hospitals, and government organizations.[2] However, these types of exercises are usually expensive to plan and execute, difficult to evaluate objectively,[3] and may not be able to provide adequate provisions to link the results of exercises to appropriate changes, including training and plans.[2] Mass-casualty incidents (MCIs) are among the common disasters that occur in Taiwan. Hospitals with emergency rooms (ERs) are usually mandated to conduct MCI exercise every year. FSEs are also the most common type of exercise in hospital MCI training, but they are usually resource-in-

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tensive and time-consuming. Previous research also indicated that evidence of the effectiveness of MCI training for hospital staff was limited.[4] In contrast, functional exercises (FEs) are not as commonly used in Taiwan, especially in hospital MCI preparedness and training. This type of exercise was reported to be an important link between disaster planning and response[5] and may be more cost-effective, with a similar effect to that of FSEs in some respects.

We believe that there is a greater value in FEs, especially in hospital MCI training. Because of their value, FEs should be further promoted in disaster preparedness. We assume that FEs can familiarize participants with MCI response. This type of exercise may offer a new means of preparing hospital staff, one with higher acceptance and satisfaction. To test this assumption, we conducted this study to investigate exercise effectiveness and other associated factors in different groups of participants.

Methods

In the authors' home hospital, the pediatric ER is located in the main building, but pediatric physicians and nurses work at the Children's Hospital, which is far away from the pediatric ER. Considering staff and other resource support for non-traumatic pediatric MCIs (NTPMCIs), a new emergency operation plan (EOP) was developed in 2018.

One seminar was conducted on March 2018 to introduce the EOP to hospital staff who might be involved in the NTPMCI response. A 1.5-hour FE with a scenario of mass pediatric food poisoning was conducted in May 2018. The objective of the exercise was to test the gaps and areas of improvement in the new EOP. Participants in the exercise included physicians and nurses from the emergency department, administrative staff, physicians and nurses from the pediatric department, and nurse leaders and supervisors. Participation in the exercise was not limited to seminar attendees.

During the exercise, participants were asked to play their usual daily roles. The hospital information system was used to mimic the real situation, but not every participant was asked to use a computer in the exercise. Twenty-five pediatric patients were simulated using paper cards to present patient information and symptoms to the participants. Participants needed to triage every mock patient according to this information. Other information, including vital signs, laboratory data, and image results, was given to the participants in different ways and time consumed to mimic the true hospital environment. An initial staff shortage and the time taken to transport support staff from the Children's Hospital were simulated in the exercise as well. Treatment was simulated by using paper stickers. Participants needed to determine their own duties in the exercise, the tests to be done, the treatment to be given, and the final discharge of these patients. Trained evaluators and MCI experts observed the whole exercise. A post-exercise debriefing was conducted by evaluators, who also provided feedback and led the discussion.

Anonymous questionnaires were administered before and after the exercise but before the debriefing. Consent was obtained verbally. Before and after the exercise, familiarity with non-traumatic pediatric MCI was self-assessed by participants using a 5-point Likert scale where 1 = very unfamiliar and 5 = very familiar. Besides familiarity, the pre-exercise questionnaire documented the participants' experience reading the new EOP, previous training level, and position. The post-exercise questionnaire documented the participants' impression of exercise and whether they used a computer in the exercise as well. The impression of the exercise was also assessed using a 5-point Likert scale where 1 = very bad and 5 = very good. Participants were also asked to rate their perception of the exercise using a Likert scale.

Participants who were involved in the whole exercise and finished both pre- and post-exercise questionnaires were included to determine the improvement in familiarity. Differences between pre- and post-exercise familiarity results were analyzed with a paired *t*-test. Fisher's exact test was used to analyze the correlation between the change in familiarity and experience reading the new EOP, previous training level, position, and whether a computer was used in the exercise. The change in familiarity was defined as the difference between pre- and post-exercise Likert scale scores for familiarity. An increase in familiarity was defined as a post-exercise Likert scale score higher than the same participant's pre-exercise scale score. The significance level was set at 0.05 (two-tailed). Descriptive analysis was used to assess participants' impressions of the exercise.

Ethical Statement

The study protocol was approved by the institu-

tional review board of the National Taiwan University Hospital. Oral informed consent was obtained from all subjects prior to enrollment.

Results

A total of 45 hospital staff members participated in the FE. Thirty participants finished the pre-exercise questionnaire and 25 finished the post-exercise questionnaire. Sixteen participants finished both pre- and post-exercise questionnaires, including three physicians, seven nurses, four head nurses, and two nurse supervisors (Fig. 1).

The mean self-assessed familiarity was 2.25 (standard deviation [SD] = 1.1) before the exercise and 3.68 (SD = 0.6) after exercise (Fig. 2). An increase in the familiarity score following the exercise was noted in 13 participants. In three participants, there was no change in the familiarity score after the exercise. There were no cases of a decrease in the familiarity score after the exercise. There was a significant improvement in the familiarity score after the FE, with $p < 0.05$ using a paired *t*-test.

With respect to EOP reading experience, 10 participants had read the EOP before the exercise. Familiarity increased in eight of these 10 participants, and no change was noted in two of the same 10 participants. Six participants had never read the EOP, but familiarity increased in five of them while in one there was no change (Fig. 3). According to Fisher's exact test, there was no significant difference ($p = 1$) of increasing familiarity between these two groups.

Nine participants did not have previous training experience. Familiarity increased in eight of these participants, and no change was noted in one participant. The remaining seven participants had more than one training session, and familiarity increased in five of these while in two there was no change (Fig. 4). When the change in familiarity of these two groups was compared by using Fisher's exact test, there was no significant difference ($p = 0.55$).

As for the participants' positions, only nursing staff were included for the purpose of comparison. Head nurses and nurse supervisors were grouped as nurse leaders for comparison with general nursing staff. Among the six nurse leaders, increasing familiarity was noted in five. Six of seven general nurses reported increased familiarity and one reported no change (Fig. 5). There was no significant difference ($p = 1$) between these two groups according to Fisher's exact test.

Nine participants used a computer in the exercise, and increasing familiarity was noted in seven of them while the remaining two reported no change.

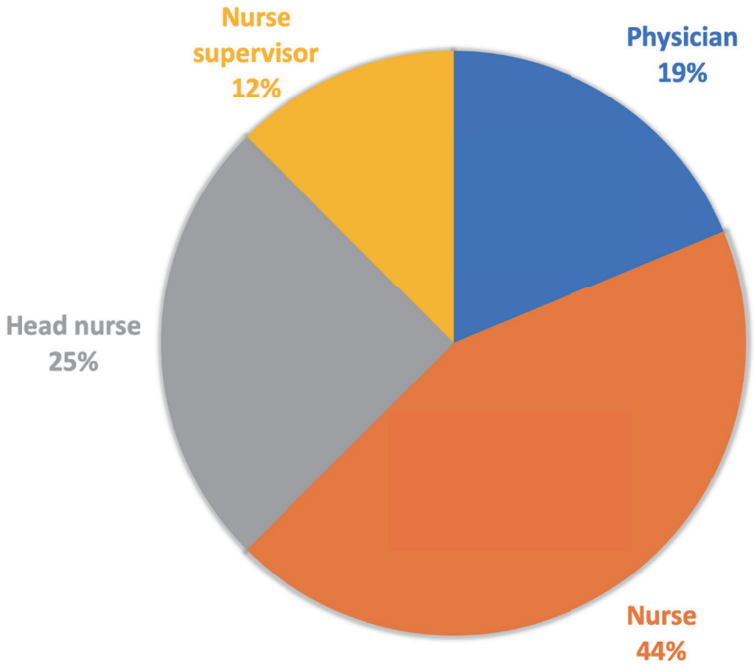

Fig. 1. Participants distribution.

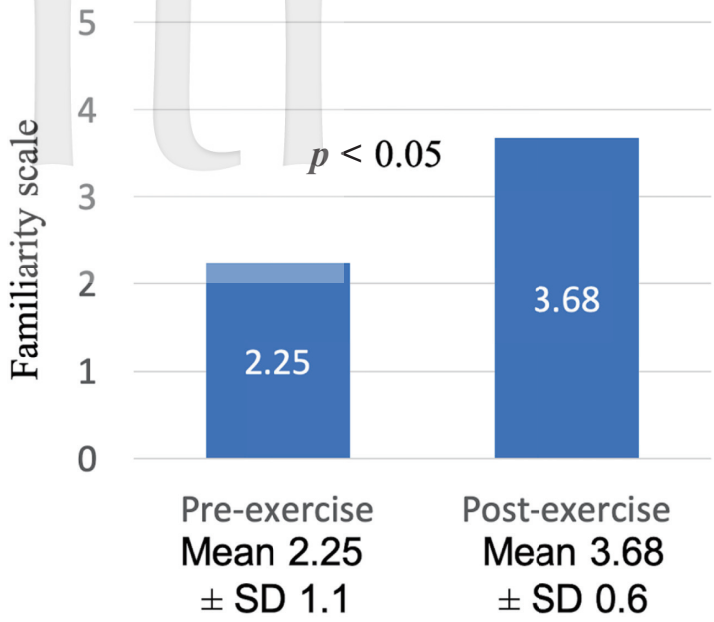

Fig. 2. Familiarity change.
SD: standard deviation.

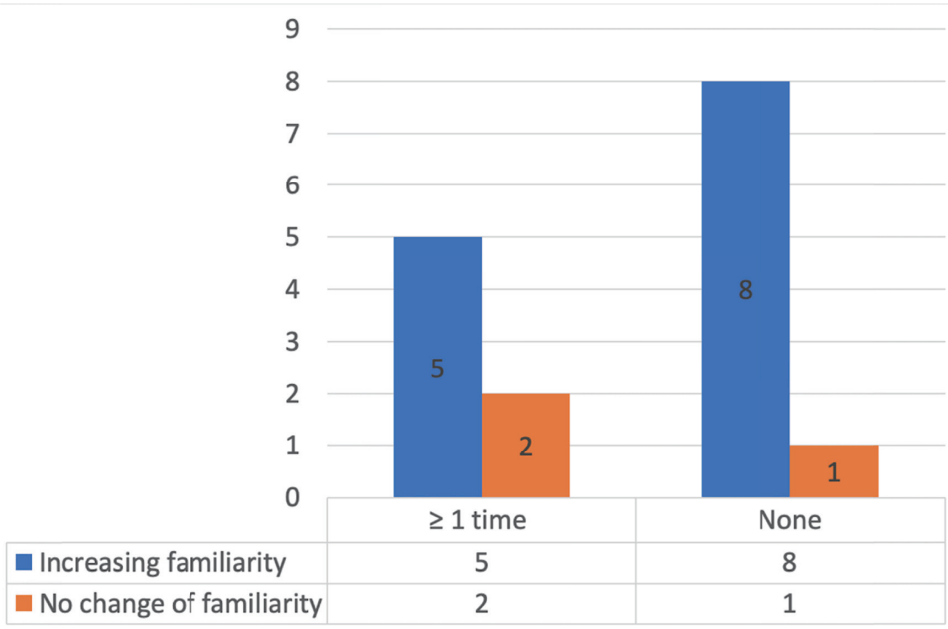

Fig. 3. Emergency operation plan (EOP) reading experience.

Seven participants did not use a computer, but six of them reported increased familiarity. The remaining participant did not report a change in familiarity (Fig. 6). A comparison of these two groups regarding the change in familiarity also revealed no significant difference ($p = 1$) according to Fisher's exact test.

Eleven of 16 (68.75%) participants rated their impression of the exercise as good to very good. The remaining five gave a rating of normal. No participants reported having a bad impression of the exercise.

Discussion

Disasters can cause significant damage to the

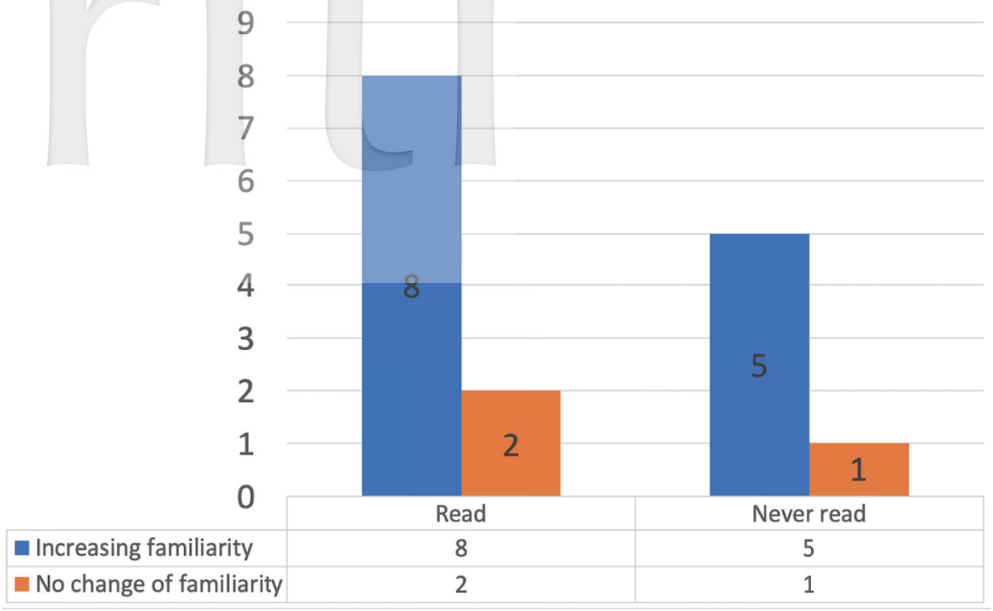

Fig. 4. Previous training experience.

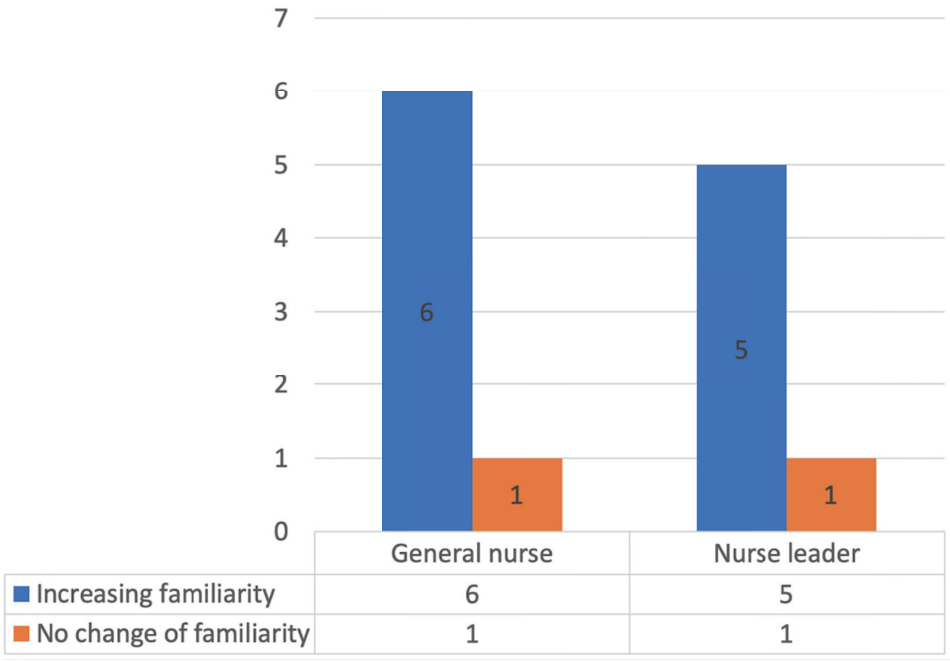

Fig. 5. Participants' occupation position.

community, as well as the hospitals therein. Hospitals are also cornerstones of health care in the community in the face of a disaster.[6] For a better disaster response, disaster management is crucial. There are four stages of disaster management, including mitigation, preparedness, response, and recovery. In the preparedness stage, developing an EOP and performing disaster exercises are two major components. Since health emergencies or disasters requiring a major response happen quite infrequently, organizations and staff need to practice the procedures and skills required for these events in order to be prepared to respond.[7] Training exercises probably provide the best methods of establishing disaster and major incident plans, apart from their actual occurrence.[2]

As a proxy of disaster,[8] the disaster exercise is

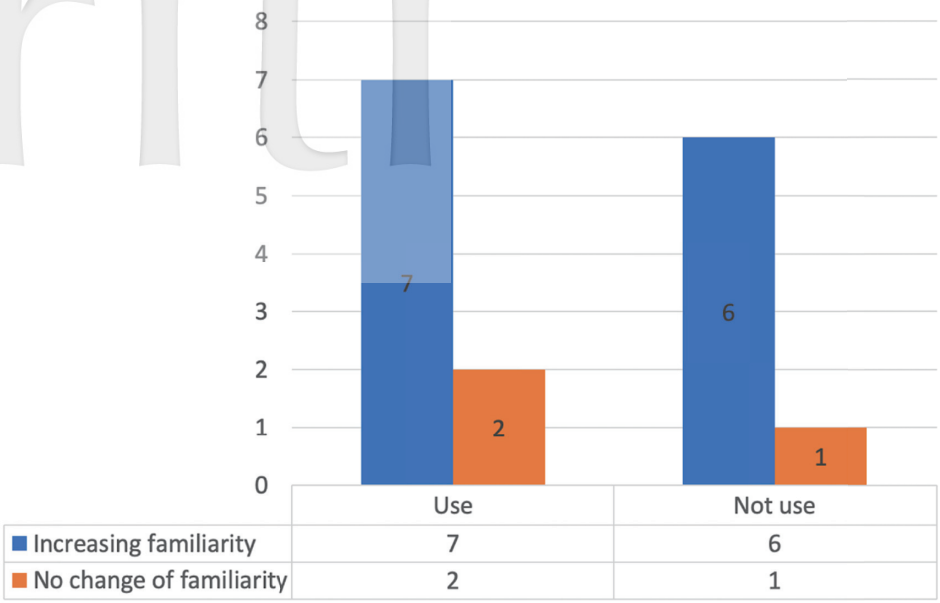

Fig. 6. Computer using.

frequently discussed and researched. Historically, disaster simulations (drills) have been the fundamental tools for evaluation and improvement of the local response capacity.[9] Exercises were reported to have multiple functions, including testing the overall response capability and training effectiveness, detecting difficulties in executing the strategy or tactics proposed in the plan,[10] testing and enhancing interlocal collaboration on emergency preparedness,[11] improving disaster plans,[12] measuring improvement in emergency plans and procedures, and identifying remaining gaps.[8] For health facilities and staff, exercises can also illustrate deficiencies in decision making and information systems, improve patient tracking and flow, prevent errors in treatment and triage, identify shortages in resources,[4] improve communication, knowledge and skills, empower work sites to be prepared for an emergency,[13] help to revise written emergency response plans,[8] familiarize staff with disaster procedures, identify problems in different components of the response, and provide the opportunity to apply lessons learned to disaster response.[4]

Although no one can ignore the importance of exercises in disaster preparedness, previous literature has cast doubt on their effectiveness.[7,10,14] Some studies pointed out a lack of direct evidence of improvement in hospital disaster response.[14] A comprehensive literature review by Hsu et al. found that the effectiveness of hospital disaster drills was difficult to determine, as there were little objective data in the literature, such as pre- and post-test knowledge scores or statistics showing significant improvement of patients over time.[4,15]

There are several types of disaster exercises, but they can be divided into two categories: discussion-based exercises and operation-based exercises. Discussion-based exercises include seminars, workshops, tabletop exercises (TTXs), and games. Operation-based exercises include drills, FEs, and FSEs.[16]

Discussion-based exercises can be used to familiarize participants with their plans, roles, and procedures or to allow participants to practice their roles and emergency plans by taking part in a facilitated discussion of simulated emergency situations. Operation-based exercises allow the testing of tools, plans, procedures, resources, technologies, inter-agency coordination, and command centers, under conditions closely matched to a real emergency event.[7]

Among these exercises, TTXs are commonly used and reported in disaster preparedness and studies. On the other hand, FEs are not so frequently conducted and studied. Previous studies indicated that FEs can measure strategic decisions regarding resources in relation to patient outcomes[17] and enhance the perceptions of response knowledge and teamwork.[10] Moreover, FEs were used to evaluate mass dispensing.[18] However, few studies discuss the use of FEs in hospital MCI training.

In our study, we chose NTPMCI to validate the value of FEs for several reasons. First, the participants were different. In past training and exercises in our hospital, the participants were ER and surgical unit staff. Staff from the pediatric department rarely participated in MCI exercises, which provided us an opportunity to determine the effect of FEs on participants from different backgrounds and specialties. Second, the EOP of NTPMCI was newly developed. Normally, an exercise, especially an operation-based exercise, is conducted after participants have read the EOP and even participated in a discussion-based exercise.[19] The pre-exercise survey disclosed that nearly half (14/30) of the participants in our exercise had not read the EOP before attending the exercise (results not shown). In this case, we can further analyze the relationship between exercise effectiveness and previous EOP reading experience. Third, pediatric patients were never emphasized in previous MCI training in our hospital. MCI is an important risk and a real threat to the quality of care,[15] and the vulnerability of children has been emphasized in disaster events, both natural and human-made.[20] To deal with this vulnerable group, special attention should be paid, even for ER staff who are familiar with MCI response. Fourth, exercises using simulation techniques can be used to evaluate and improve the preparedness of hospitals to manage an MCI[21] and test the participants' knowledge, skills, and abilities for MCI response.[5] However, the impact of the exercise on the participants in our study was still unclear.

We proposed that more benefits can be gained by performing exercises. Drills and FSEs were reported to be effective in training hospital staff,[4] but very few studies discussed the use of FEs in hospital MCI training. Previously reported MCI FEs focusing on pediatric victims revealed the usefulness of exercises for improving the hospital's ability to respond to the needs of pediatric victims and to enhance staff's perceived preparedness to care for the pediatric population.[22] However, that exercise was neither conducted on pediatric patients nor on non-traumatic events.

NTPMCIs are not common events, especially for responders not working in the ER.

Once this type of incident occurs, unfamiliar responders may be too panicked to properly deal with the event. Written plans are important, but they do not assure preparedness by themselves. Emergency plans become an illusion if they are not known and accepted by participants.[12] An important connection between planning and action is achieved by conducting exercises.[10] Therefore, increasing familiarity with the response through training to prepare health care providers is vital,[5] and we used participants' familiarization as the outcome measure.

The results of our study indicated that FE can familiarize participants with MCI response. Based on a literature review and our observations, we proposed several reasons to explain how FEs can familiarize participants. First, "hands on" exposure can provide a special FE experience. A unique character of operation-based exercise is operation, rather than discussion as in other type of exercises. Previous research also showed that new responder personnel have the opportunity for "hands on" exposure to emergency equipment, vehicles, procedures, and protocols and felt that they were learning. They also reported that their perception of the incident management system and teamwork improved after the exercise in all participants, despite the different levels.[10] An FSE using macrosimulation was also successfully used to train personnel who were unfamiliar with the working system.[23] Second, role playing in the exercise was proven effective in multidisciplinary health professional settings.[24] We also used role playing in this FE, which may be another potential means of increasing familiarity by learning and experience during the exercise. Third, a strong impression and high stress might contribute to familiarity. A three-hour interactive TTX that was fun for students was reported to increase their knowledge after the exercise.[24] A low-stress TTX environment was successfully used to familiarize emergency medical technicians in Taiwan with MCIs.[2] Compared with TTX, operation is performed in the FE with higher tension and stress on the participants. However, most of the participants had good and very good impressions of the exercise, which might further shape the participants' perceptions of the emergency management process.[10,25]

An additional reason for increasing familiarization is post-exercise debriefing. This reason could not be illustrated in this study because we conducted the post-exercise survey before the debriefing. During the exercise, participants focused their attention. Right after the exercise, the debriefing can allow the participants to discuss their opinions and concerns. Participants became more familiar with MCI response with this process, which was not limited to an FSE.[26] Expert feedback was instant during the debriefing, which can make a greater impression on participants. EOP

gaps and areas for improvement were also addressed at the post-exercise discussion, similar to other exercise results in previous literature.[13,27-29]

Improving understanding of the disaster plan, knowledge, and perception of preparedness were reported in the past as benefits of exercises,[12,15] but these exercises were conducted after a lecture or other training of the emergency plan and response. The exercise was usually conducted after planning and training.[10] Skryabina et al. reviewed exercise-related studies and found that even though most exercises were found to be beneficial to participants, these exercises were conducted after a lecture or video.[7]

The value of a drill on its own without any pre-exercise preparation was found to be limited to improving physicians' knowledge of anthrax bioterrorism.[7] However, our results indicated that familiarization can be increased regardless of pre-exercise training or reading the disaster plan. One possible explanation was cooperation in FEs with other participants. The other reason may be the observation of other participants action during FEs.

According to our results, no difference in increasing familiarity was found between staff in different positions. Both general staff and leaders can benefit from FEs. Unlike discussion-based exercise, every participant is involved in an FE. Although their work and duties were different, participants from all positions had something to do in the exercise. Moreover, our FE was conducted in the classroom, where participants could easily see each other. This may provide an additional advantage to familiarize participants with different positions because they can see what other participants are doing. A similar conclusion was reached in another study, which reported that FEs worked for police officers, firefighters, and civilian volunteers.[10]

In the authors' hospital, MCI response is highly dependent on computer use. In the exercise, using a computer may also have increased the participants' focus. We used to think that computer use during the exercise could increase familiarity, but results showed that the increase in familiarity level was not related to computer use. However, not every participant may have the chance or need to use a computer. With the results of this study, we can imply that FEs can still improve familiarity even without key operations of MCI response.

Other advantages of FEs can be observed in this research. First, our FE is cost-effective. TTXs and FSEs are costly,[8,12,30,31] but FEs can test decision making and operations with limited funding.[32] We spent less than 1,000 New Taiwan dollars (NTD) to complete the exercise. Second, our FE is not disruptive. FSEs can be more realistic than FEs, but they are disruptive to the normal workflow.[30] We conducted the exercise in the classroom and caused no disruption of hospital operation. Third, FEs can allow personnel from responder groups and agencies to develop working relationships with one another.[10] This also occurred in our exercise, where ER staff worked with Children's Hospital staff.

Despite the important findings, there are limitations to this study. FEs are not full-scale and have some limitations, and some of them were reflected by our exercise participants, such as a lack of realism. FSEs may still be mandatory for disaster preparedness, but preparatory limited-scale drills can improve preparedness for managing an MCI before a full-scale drill.[2] This exercise included fewer than 50 participants, in agreement with a previous report of poor participation rates.[15] The sample included in this research was small. More exercises and participants should be studied in the future. Most of the participants who finished both pre- and post- exercise questionnaires were nurses. More opinions of different occupation groups should be obtained. The familiarity level was measured by participants' self-perception, and this method is subjective. A more objective method may be considered for future evaluations.[5]

Conclusions

There is no strong evidence of the best method to train health care providers in disaster response.[33] Training programs have shifted from didactic or knowledge-based training to skill-based approaches in the USA in recent years.[13] This trend may indicate exercises as a mean of disaster training. Among the types of exercise, FEs are useful and can be a cost-effective way to familiarize health care providers with disaster response. FEs can be a new method of MCI training in the future and should be encouraged in every health facility.

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