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Research Article

Is There Any Difference Between Maneuver Simulation and Scenario Workshop Learning about Radiation Triage?

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Abstract

Background: Very little information on maneuver simulations (MS) effectiveness in radiation triage (RT) training is currently available.
Objectives: The present study aimed to compare the effect of MS and scenario workshops (SW) on rescuers' learning of RT.
Methods: This quasi-experimental study was conducted on rescuers in July 2020. For this purpose, two military medical centers were randomized into two groups, intervention (MS) and control (SW). The main tool was the researcher-made Radiation Triage Knowledge Questionnaire (RTKQ). In this respect, the pre-test was performed using the RTKQ questionnaire. The first post-test, two weeks following the intervention, was also done through the RTKQ and the objective structured clinical examination (OSCE), and the second post-test was conducted four weeks after the intervention, only via the RTKQ.
Results: In total, 30 rescuers with a mean age of 22 participated in this study. During the pre-test, the difference in knowledge between the two study groups (intervention and control) was not significant. In the first post-test, no significant difference was also observed in the levels of knowledge between MS and SW groups respectively (80.0 ± 8.9 vs. 79.3 ± 0.8), but the difference in skills between the study groups was significant (89.3 ± 10.3 vs. 61.3 ± 16.0). In the second post-test, there was a significant difference between the mean value of the levels of knowledge (76.0 ± 9.1 vs. 64.7 ± 10.9) and skills (written scenarios) (71.3 ± 9.9 vs. 54.0 ± 0.14) in two study groups.
Conclusions: Both training methods improved RT knowledge and skills, but MT was more effective than SW in boosting and maintaining knowledge and skills up to one month after the intervention. The utilization of MS in RT training was also accompanied by greater effectiveness.

Keywords: Radioactive Hazard Release, Radiation, Maneuver Simulation, Triage, Education

1. Background

Nowadays, using radiation sources to benefit humankind has become so common that there is no way to avoid it. Regrettably, the misuse of radiation and its potential accidents are regarded as serious threats challenging health care systems (1). From 1980 to 2013, 634 nuclear and radiation incidents were reported worldwide, resulting in 2584 casualties (2). During such accidents, there are often rising demands for medical resources and supplies, and the extent of the damage makes it difficult to provide relief (3). Effective preparedness for radiation events accordingly requires the understanding of the related physical damage, the range of accident victims, and the concept of successful resources allocation to save lives because up to a few days after such incidents, there is a lack of medical resources and equipment in the affected areas (4). Meanwhile, proper triage practice can significantly contribute to managing accidents and available resources and, consequently, reduce casualties by identifying patients needing immediate action (5). Triage is an integral part of responding to a crisis with a large number of casualties, aimed to provide the highest amount of relief to most people (6). Given the increase in casualties at the beginning of such accidents, there is the potential to save many lives and protect people from injuries by practicing proper strategies for triage and treatment because a large proportion of losses at this time can be attributable to wrong decisions (7). No familiarity with triage or the absence of emergency triage instructions can thus lead to irreparable damage. Therefore, it is of utmost importance to pay attention to triage training via effective methods. Of note, the role of rescuers and nurses as the largest components of the health care system is also vital for responding effectively to public health in the face of incidents that cause an ionizing radiation hazard release. Experience in dealing with radiation accidents has further revealed that rescuers and nurses need to better understand their roles in effective preparedness and response (8). As such incidents can bring about major crises, studies have demonstrated that rescuers and nurses can play an important role in the future management of these events (8, 9). They should also teach people preparedness skills for radiation emergencies by offering professional workshops and continuing education (10). Most organizations use traditional teaching methods like workshops to meet this critical issue, despite the importance of training to cope with such accidents. Since the primary approach to dealing with radiation events is the field method, theoretical knowledge is also required. Therefore, exploiting a method that helps theoretical development and leads to effective skills is necessary. Such active educational approaches are assumed to be the keys to defending against any military threats, terrorist attacks, natural disasters, and human and systematic errors. Due to their cost-effectiveness and the transfer of a large amount of information to learners in the shortest possible time, traditional educational methods have been widely used (11). However, these methods are likely to deprive learners of the opportunities to think and even lead to passive learning that is only associated with short-term learning. In addition, learners' individual differences and needs are not considered during traditional education, which can lead to no development of creative thinking and other cognitive skills (11, 12). Simulating is the action of imitating a model's dynamics and/or structure with its resulting element. In this sense, virtual simulation is one of the novel teaching methods which can help create a real-time simulated experience for learners to reach the highest possible level of preparedness in actual situations. However, this educational method faces numerous challenges, such as high costs, the need for advanced equipment, no realism in scenarios, and learner anxiety (13, 14). In addition to this type of simulation, operational maneuvers have high functionality since they do not require High Tech equipment such as a virtual reality. According to the related literature, it is difficult to choose the best teaching method to deal with radiation accidents, and it is important to reflect on the methods that improve preparedness in individuals (15).

2. Objectives

In this study, the effects of maneuver simulation (MS) as a training method along with scenario workshop (SW) on radiation triage (RT) knowledge and skills were compared in a community of rescuers.

3. Methods

This was a quasi-experimental study involving 60 rescuers at two military medical centers in Mashhad, Iran, in July 2020. Upon obtaining the approval of the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (IR.MUMS.NURSE.REC.1398.106), Both centers were randomized into two groups: MS (intervention) and SW (control) to prevent the dissemination of information. In total, 15 rescuers from each center were selected using the convenience sampling method based on the inclusion criteria, including: (1) the age range of 18 - 26 years; (2) no previous RT training; and (3) no hearing and visual problems, and the exclusion criteria, viz. (1) unwillingness to continue cooperation or non-participation in the training program. The initial analysis indicated that 12 individuals needed to be included in each group. Post-hoc analysis showed effect size is 2.08 and the power of the study is 0.99. (d = 2.08; α err prob = 0.05; Critical t = 2.04; Df = 28; Power (1-β err prob) = 0.99).

3.1. Research Tools

Radiation Triage Knowledge Questionnaire (RTKQ): The researcher-made RTKQ was comprised of three parts. The first part (11 items) dealt with demographic information (such as age, gender, education, etc.), and the second part (20 items) dealt with the levels of RT knowledge. With a scale score range of zero to 100, each question in the second part of the test had five scores (correct: 5 scores; wrong: 0 scores). The third part of the questionnaire (10 items in the form of 10 scenarios for radiation casualties) assessed RT skills in rescuers, wherein they had to choose the triage category appropriate to each scenario. For each correct answer, the score was 10, based on a scale ranging from zero to 100. The results obtained in the areas of knowledge or skills also ranged from zero to 49 (inadequate), 50 to 59 (borderline), 60 to 69 (moderate), and 70 to 100 (acceptable). The validity of this questionnaire was further determined based on content validity. In this regard, the questionnaire items were set based on educational goals and content. Then, to evaluate its relationship with the content, the RTKQ was submitted to 10 experts in this field, and the content validity index (CVI) was calculated. CVI was determined based on the items' relevance The acceptable CVI score for each item and the whole research tool was higher than 0.9. The external reliability of the questionnaire to assess the levels of RT Knowledge was also measured by the test-retest method using a pilot sample with a one-day interval.

Objective structured clinical examination (OSCE): The OSCE was completed by the OSCE test evaluator based on the triage category ascertained for the injured at each station by the rescuer. This checklist included five scenarios based on valid and reliable skill assessment tools for radiation accident victims. Each correct answer in this checklist had 20 points, ranging from zero to 100.

3.2. Intervention Group: MS

Day 1: Theoretical topics were initially used to explain the training program and its objectives and highlight the importance of preparedness and triage during radiation events.

Day 2: The theoretical topics of the first day were reminded. The theoretical topics of the first day were reminded. Rescuers were then introduced to MS and its rules and how to conduct maneuvers. The rescuers were then informed of the adjusted scenario as follows:

"Following the damage to the radioactive tanks at the radiology ward in your hospital, radioactive materials have leaked on the site. Two radiologic technologists and four other personnel have thus been contaminated or exposed to radiation. The area is accordingly divided into three spots identified with severe, moderate, and low damage based on physical damage, radiation severity, and dosimetry results. Two radiologic technologists have been exposed to radioactive skin contamination on the spot with severe damage. After transferring the injured to the low-risk spot, the rescuers remove the contamination at the mobile decontamination station and take the injured to the triage spot. Moreover, four other ward personnel are on the spot with moderate damage, and further analyses have shown that they are not contaminated with radioactive materials and have only been exposed to radiation. These injured individuals have accordingly been transferred to the triage spot."

The rescuers were dispatched to the scene in special clothing. This stage was performed with 15 individuals in two groups of seven and eight. Upon the presence of the first group at the maneuver site, its members, in groups of two and three, entered the accident scene with the necessary equipment and supplies and encountered six injured people who had symptoms and complications related to an ionizing radiation release. The rescuer received a triage card after examining the symptoms and taking the history of the injured persons. The completed triage cards were then collected and given to each triage worker for each injured individual. The researcher also assessed each casualty in the rescuer's presence and determined the proper triage category. The rescuers were also reminded of triage problems and errors, their questions were answered, and the major problems were resolved.

3.3. Control Group: SW

Day 1: Theoretical topics were initially used to explain the training program and its objectives, underscoring the importance of preparedness and triage during radiation events.

Day 2: The topics mentioned in the first phase were reminded. The learners were also introduced to the workshop rules and procedures. Then, 15 rescuers were divided into six groups of two individuals and one group of three individuals, and each group was given six written scenarios about radiation-related injuries. All six scenarios were identical for all groups. As a result of the symptoms that each injured person declared, the rescuers determined the appropriate triage category. The researchers subsequently asked each group to describe a scenario with the specified triage category. Afterward, the rescuers were informed of triage problems and errors, their questions were answered, and the problems were tackled (Table 1).

3.4. Outcomes

Pre-test: The pre-test was performed the day before the training with a researcher-made questionnaire (RTKQ) to simultaneously measure RT Knowledge in both groups.

Post-test 1: Two weeks after the intervention, the first post-test was performed in both groups using the RTKQ and the OSCE.

There were also five stations for the OSCE, and five standardized patients with different symptoms were recruited for each station. The time in each station was three minutes and a total of 15 minutes for the triage of five injured cases. The researcher conducted education for standardized patients. Five standardized patients who were more skilled in practicing the scenarios were accordingly selected from 10 volunteers who were able to play the role of the injured and received adequate training.

Post-test 2: Four weeks after the intervention, the second post-test was conducted with the RTKQ.

Data analysis was further performed using the SPSS Statistics software (ver. 20). To evaluate the homogeneity of both study groups in terms of quantitative variables and to compare the dependent variables between the groups at the pre-and post-intervention stages, the independent-samples *t*-test was used if the data had a normal distribution (Shapiro-Wilk test). On the other hand, the Mann-Whitney U test was utilized if the data were abnormal. The chi-square and Fisher's exact test were used to analyze the qualitative variables' data. In order to compare variables within each group at the pre-and post-intervention stages, paired-sample *t*-tests were applied if the distribution of the data was normal, and Wilcoxon signed-rank tests were used if it was not normal. The Friedman test was used to

Table 1. Intervention Stages

Sample Selection Based on Inclusion Criteria and Randomization	
Control: SW (n = 15)	Intervention: MS (n = 15)
Pre-test: RTKQ	Pre-test: RTKQ
Day 1 (8:00-16:00): Fukushima incident case report, basics of radiation and acute radiation syndrome (ARS), basics of safety and rescue, basics of RT	
Day 2 (8:00-16:00), SW: Reminding the theoretical content of the previous session, clarifying the workshop practice method, and delineating the final test and grading procedures; practicing the triage of pre-written scenarios; triaging six scenarios by each group of two or three rescuers; gathering scenarios and reviewing the performance of the rescuer; discussing possible triage errors	Day 2 (8:00-16:00), MS: Reminding the theoretical content of the previous session, clarifying the workshop practice method, and delineating the final test and grading procedures; practicing triage as an MS in the first group of seven rescuers; practicing triage as an MS in the second group of eight rescuers; eliminating possible errors, answering questions, and making necessary remarks
First post-test: Two weeks later (RTKQ - OSCE)	First post-test: Two weeks later (RTKQ - OSCE)
Second test: Four weeks later (RTKQ - Scenario Questions [SQ])	Second test: Four weeks later (RTKQ - Scenario Questions [SQ])

determine if three or more measurements from the same group of subjects are significantly different. All tests considered a 95% confidence interval (CI) with a significance level of 0.05.

4. Results

The study samples included 30 people, comprising 15 rescuers in the MS group and 15 in the SW group. None of the samples was excluded from the study. The mean age of the rescuers in the intervention group was 22.1 $\pm$ 2.8, and this value for the control group was 22.4 $\pm$ 2.7. All the rescuers were male, and 46.7% of them held high school diplomas. Also, 80.0% and 60.0% of the rescuers were single in the MS and SW groups, respectively. None of them had a history of dealing with radiation casualties. Moreover, 66.6% of those in the MS group and 53.3% of the cases in the control group had a history of RT ($P = 0.456$). In addition, 60.0% and 73.3% of the rescuers in the MS and SW groups were not familiar with RT, respectively ($P = 1.000$).

Knowledge Score between MS and SW groups: Data are presented in Table 2.

Intragroup knowledge score: The knowledge score in the first post-test compared to the pre-test was augmented by 42.3 $\pm$ 13.9 in the MS group and 40.3 $\pm$ 9.5 in the SW ($P = 0.966$). The knowledge score in the second post-test compared with the pre-test was also elevated by 38.3 $\pm$ 12.6 in the MS group and 25.7 $\pm$ 0.15 in the SW group ($P = 0.018$). Also, the knowledge score in the second post-test compared with the first post-test dropped by 4.0 $\pm$ 12.1 in the MS group and 14.7 $\pm$ 12.9 in the SW ($P = 0.080$). Based on the intragroup comparison, the Friedman test results demonstrated that the difference between the study stages in the MS group was significant ($P < 0.001$). The post hoc test results correspondingly showed that the difference between the first post-test and the pre-test ($P < 0.001$) and that between the second post-test and the pre-test ($P < 0.001$) were significant, whereas the difference between the second post-test and the first post-test was not significant ($P = 0.820$). In the SW group, the repeated-measures *t*-test results indicated a significant difference between the intervention stages ($P < 0.001$). The Bonferroni post hoc test also revealed significant differences between the first post-test and the pre-test ($P < 0.001$), the second post-test and the pre-test ($P < 0.001$), and the second post-test and the first post-test ($P = 0.002$) (Table 2).

Skill score between MS and SW groups: Data are presented in Table 2.

Intragroup skill score: During the second post-test, the skill score increased compared with the pre-test in the rescuer in the MS group by 43.3 $\pm$ 11.8 and in the SW group by 26.7 $\pm$ 14.5 ($P = 0.001$). In the intragroup comparison, the Wilcoxon signed-rank test results indicated a significant difference between the training stages in the MS and SW group ($P = 0.001$) (Table 3).

Research tool validity and reliability: The CVI of the total content of the RTKQ was 0.97, which was 0.99 for the OSCE. With regard to the total scores of the RTKQ, Spearman's rank correlation coefficient was calculated to be 0.77 between the first and second sessions.

5. Discussion

The study results revealed that MS and SW were effective in broadening the levels of RT knowledge and skills. In the following month, rescuers' knowledge during SW was also significantly reduced compared to MS. In addition, MS was more effective at enhancing rescuer skills than SW. This study is unique because few studies have been conducted in this field; however, several studies compare MS and SW in other fields. Despite the limitations of the studies, we had to use studies in other fields.

One month after training, the intergroup comparison results also showed a descending trend in knowledge in the SW group to the moderate level, and there was even a significant difference compared with the MS group. In

Table 2. Mean and SD of Rescuers' Knowledge Score Before and After Intervention in Study Groups [a]

Knowledge Score	Groups		Intergroup Test Results
	MS (n = 15)	SW (n = 15)	
Pre-test (%)	37.7 ± 6.5	39.0 ± 6.9	*t* = -0.5, df = 28; P = 0.590; independent-samples *t*-test
First post-test; 2-week (%)	80.0 ± 8.9	79.3 ± 8.0	Z = -0.1; P = 0.899; Mann-Whitney U test
Second post-test; 4-week (%)	76.0 ± 9.1	64.7 ± 10.9	*t* = 3.1, df = 28; P = 0.005; independent-samples *t*-test
Difference between first post-test and pre-test (%)	42.3 ± 13.9	40.3 ± 9.5	Z = -0.0; P = 0.966; Mann-Whitney U test
Difference between second post-test and pre-test (%)	38.3 ± 12.6	25.7 ± 15.0	*t* = 2.5, df = 28; P = 0.018; independent-samples *t*-test
Difference between second post-test and first post-test (%)	4.0 ± 12.1	14.7 ± 12.9	Z = -1.7; P = 0.080; Mann-Whitney U test
Intragroup test results	Chi = 24.1, df = 2; P < 0.001; Friedman test	F = 77.9, df = 28.2; P < 0.001; repeated measures *t*-test	

[a] Values are expressed as mean ± SD unless otherwise indicated.

Table 3. Mean and SD Of Rescuers' Skill Scores Before and After Intervention in Study Groups [a]

Skill Score	Groups		Intergroup Test Results
	MS (n = 15)	SW (n = 15)	
Pre-test (%)	28.0 ± 6.8	27.3 ± 5.9	Z = -0.2; P = 0.814; Mann-Whitney U test
First post-test OSCE score 2-week (%)	89.3 ± 10.3	61.3 ± 16.0	Z = -4.1; P < 0.001; Mann-Whitney U test
Second post-test; 4-week (%)	71.3 ± 9.9	54.0 ± 12.0	Z = -3.2; P = 0.001; Mann-Whitney U test
Difference between second post-test and pre-test (%)	43.3 ± 11.8	26.7 ± 14.5	Z = -3.2; P = 0.001; Mann-Whitney U test
Intragroup test results	Z = -3.5; P = 0.001; Mann-Whitney U test	Z = -3.4; P = 0.001; Mann-Whitney U test	

[a] Values are expressed as mean ± SD unless otherwise indicated.

other words, MS had retained the rescuer's knowledge for up to one month following the intervention. As cited in Ackermann, evaluating mannequin-based simulations in terms of acquiring and retaining cardiopulmonary resuscitation (CPR) knowledge and skills with a post-test design immediately after and three months following the intervention, simulations had been found effective in acquiring and retaining what had been learned up to three months after training (16), which was consistent with the present study in respect of training duration in MS. According to Alluri et al., comparing the effectiveness of mannequin- and lecture-based simulation training on medical students' knowledge of cardiology; immediately after training and five weeks later with a post-test design, the simulation was found to be more effective at developing and retaining long-term learning than lectures, which was in line with the present study (17). Flood and Higbie also concluded that participation in post-lecture simulations could be useful in bridging educational gaps and enhancing cognitive learning (18). Heidarzadeh et al. further performed mannequin-based simulations and lectured to examine the effects of cardiopulmonary examinations on students' knowledge and self-confidence. During the post-tests immediately and one week after training, mannequin-based simulations were even proven to be more effective at improving knowledge and self-confidence (19). Moreover, Seyedi et al. established that lectures and simulations could be equally effective in enhancing students' knowledge of biological agents during a post-test, two weeks after training (20), which was not in agreement with the present study. The most important reason for such discrepancy was the difference in statistical populations, subject matters, training presentation, and implementation methods.

Despite differences in subject matters, samples, and research designs, it was found that most of the studies supported the present study regarding MS's greater effectiveness than other traditional methods. Therefore, increasing the sustainability of training is challenging for educators when implementing such programs. The principle of learning by doing is also a fundamental principle of simulations, which aims to maintain content and apply skills in the future. Simulations also help rescuers and nurses gain the necessary clinical experience without having to deal with unusual events such as radiation accidents.

The RT skills in both study groups were assessed as homogeneous and inadequate during the pre-test. Both training methods significantly increased RT skills two weeks and one month after the intervention. Two weeks after training, the OSCE results also demonstrated that SM had significantly elevated RT skills compared with SW. The rising trend in RT skills in the MS group was also considered acceptable, but that was found moderate in the SW.

In addition, the comparison between both study groups, one month after training, showed that MS boosted RT skills to an acceptable level. However, in the SW group, the RT skills among the rescuers were assessed as inadequate, indicating further growth in the RT skills in the MS group, and a significant difference was observed as compared with the SW group. In other words, MS augmented RT skills and retained them for up to one month after training. In this respect, in the study by Shahbazi et al. on the effect of lecture- and rescue-based training with combat maneuvers on rescuers' general preparedness, the effectiveness and durability of most practical maneuvers up to one month later, compared with lectures, had been confirmed (21).

In Sadeghzadeh et al., the effect of software simulation on the elevation of functional learning in CPR and post-test diagnostic ability was also established immediately after training, which was in line with the present study, suggesting that simulation could improve the ability to recognize and learn practical skills by creating a safe and stress-free environment for repetition and practice during emergencies (22).

The results of the present study were also consistent with the findings reported by Faraji et al., stating that simulation could increase RT learning and performance immediately after training (23). In a review of articles related to simulation, Janighorban et al. determined that the efficiency of this procedure was higher than traditional education, and it was an important tool in clinical training (24). The simulation could further enhance many clinical skills in individuals and even have a high recall rate compared with other educational methods, making it possible to control the complexity of events (25, 26).

MS is unique in a way that is so close to the concept of learning by doing. It affects the cognitive, affective, and psychomotor domains of learning of RT. Although MS is a costly procedure, it may limit this educational method's applicability. Teachers must plan the MS steps intensively and usually need assistance to perform MS. In addition, the rescuer's mental state might have been affected vis. strengthened or reduced their performance during MS. Setting convincing crowd scenes is difficult and costly to present MS more realistic. Replications using the random sampling method could make the results much more valid. Therefore, it is recommended to repeat this study via random sampling methods. In addition, experts in the field of RT are few, and public awareness is thus needed in this sense (27).

5.1. Conclusions

Even though both training methods improved RT knowledge and skills, MS had not only proven to be effective in improving RT knowledge and skills among rescuers but also allowed them to retain most of what they had learned. Considering the active and comprehensive nature of the MS method, its use in significant radiation events can thus result in more familiarity with the facts of such incidents, better performance in the face of such events, learning upgrade and retention, and reduced casualties and financial damage in possible future events. Accordingly, utilizing MS as an effective method in RT training is recommended.

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Footnotes

Authors' Contribution: M. D. and S. R. M. developed the concept of study. M. D., S. R. M., and A. M. wrote the proposal. M. D. performed maneuver simulation. S. R. M. and A. M. performed the statistical analysis. M. D., S. R. M., and A. M. wrote and critically reviewed the final report. All authors confirmed the final draft.

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