Short simulation exercises to improve emergency department nurses self-efficacy for initial disaster management: Controlled before and after study

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Short simulation exercises to improve emergency department nurses' self-efficacy for initial disaster management: controlled before and after study

Abstract

Introduction: Head nurses at emergency departments often assume responsibility for managing the initial response to a major incident, and to create surge capacity.

Training is essential to enable these nurses to perform an effective disaster response. Evaluating the effects of such training is however complicated as real skill only can be demonstrated during a real major incident. Self-efficacy has been proposed as an alternative measure of training effectiveness.

Purpose: The aim of this study was to examine if short, small-scale computer-based simulation exercises could improve head emergency nurses' general and specific self-efficacy and initial incident management skills.

Method: A within-group pretest-posttest design was used to examine 13 head nurses' general and specific self-efficacy before and after an intervention consisting of three short computer based simulation exercises during a 1-hour session. Management skills were assessed using the computer simulation tool DigEmergo.

Results: The exercises increased the head nurses' general self-efficacy but not their specific self-efficacy. After completing the first two exercises they also exhibited improved management skills as indicated by shorter time to treatment for both trauma and in-hospital patients.

Conclusion: This study indicates that short computer based simulation exercises provide opportunities for head nurses to improve management skills and increase their general self-efficacy.

Key words: management, mass casualty incident, nurses, simulation training, surge capacity

Introduction

Following a major incident (MI) with multiple casualties there is an immediate need to increase the capacity to triage, treat and logistically manage the high influx of victims, particularly at geographically close trauma hospitals that will have little time to react before patients reach the emergency department (ED). This increase in capacity is generally referred to as surge capacity, and is created by managing resources and patient flow (Barbisch & Koenig, 2006). Overcrowded EDs and a constant lack of hospital beds are common in many hospitals, and this directly influences disaster preparedness by reducing surge capacity (Abir, 2013). Even a moderate-sized incident can affect the health care system to the extent that a small expansion in capacity requires activation of the disaster plan and optimal use of every resource (Bradt et al., 2009; Khorram et al., 2009; Lennqvist, 2012).

In the ED, nurses often assume responsibility for the management of emergency response and function in leadership roles, managing and coordinating health care and caregivers. ED coordinator nurses must be prepared to respond as local leaders, adapt nursing practices, and to coordinate with hospital command, medical officers and other staff to minimize adverse medical outcome caused by a MI (Gebbie & Qureshi, 2002; Jennings-Sanders, Frisch, & Wing, 2005; Smith, Farra, Dempsey, & Arms, 2015). In the Swedish healthcare system it is typically the head emergency nurse that receives the initial MI alert at the ED and initiate the hospital response according to the disaster response plan (Nilsson & Kristiansson, 2015).

61 According to the National Board of Health and Welfare in Sweden, the ability
62 of the healthcare system to handle MIs depends on appropriate planning with well-
63 trained and practised organizations. There is a growing body of evidence that shows
64 that training is essential for effective disaster response and for a rapid and correct
65 decision-making process in the stress and chaos of the moment (Auf den Heide, 2006;
66 Brannan, White, & Bezanson, 2008; Pattillo, 2006; Smith, 2015; Watters, 2015;
67 Wilkerson, 2008). MIs are rare events, which means that daily activities alone cannot
68 be relied on to provide the necessary experience needed to manage such large-scale
69 events. Simulation-based training is one method that has been increasingly used
70 within emergency and disaster management to achieve the required knowledge, skills
71 and experience. Simulation exercises can be an effective training method for teaching
72 emergency management by creating opportunities for repetitive practice and
73 facilitating different learning strategies in a safe and educational environment (Olson,
74 2012). Participants in a simulation exercise have the opportunity to test existing and
75 new coordination strategies and receive immediate feedback. This supports complex
76 decision making where different strategies for decisions in different scenarios can be
77 discussed in a cooperative learning environment (Lennqvist, 2015). Simulation
78 exercises are also used for individual management training on how to act according to
79 standard operation procedures to achieve an effective medical response to an MI.
80 Studies have shown that simulation-based training can enhance clinical learning,
81 confidence, motivation to learn, clinical performance, critical thinking, and self-
82 efficacy (Brannan et al., 2008; Okuadet et al., 2009; Pattillo, 2006; Smith, et al., 2015;
83 Stefanidis et al., 2012; Watters, 2015; Wilkerson et al., 2008). Some studies have
84 also used simulations to successfully increase trainees' knowledge of disaster

medicine and basic competence in performing mass casualty triage (Ingrassia et al., 2014; Nilsson et al., 2015).

It is important to ensure that simulation exercises really do improve the trainees' ability to perform accurately in an MI. In a literature review specifically on the efficiency of hospital staff MI training, Hsu et al. (2004) stated that there was insufficient evidence to support firm conclusions on the efficiency of any one specific training method. They concluded that more attention should be directed to evaluating the efficiency of MI training activities. One problem, however, is that the actual results of a MI training intervention only can be seen during a real MI, which are rare events. There are several confounding variables, such as time elapsed since training or staff turnover, that reduces the ability to draw firm conclusions about the efficiency of previous training. Instead, the typical measure used is training performance, with the assumption that increased skill at performing in the simulated scenario will translate to the real situation (Ford & Weissbein, 1997; Grossman & Salas, 2011). A simulator that correctly and efficiently enables learners to gain new knowledge is said to exhibit a high level of educational validity, which reflects both the learners understanding of the simulation and the real-world applicability of knowledge and skills learnt (Feinstein & Cannon, 2002). Another way to look at the effect of a training intervention is to measure the participants' self-efficacy. Self-efficacy can function as an indirect measure of the impact of training to improve skills in health care and is one way to understand the potential impact of an educational intervention on later clinical practice (Hsu, 2015; Artino, 2015).

Self-efficacy is the extent to which an individual believes him or herself to be capable of performing a specific behaviour in a specific situation (Bandura, 1997).

109 Specific self-efficacy is task-related and means the extent to which the individual
110 claims to be capable of performing a specific task. Self-efficacy can be affected in
111 four ways according to Bandura (1997): mastery experiences, social modelling, social
112 persuasion and psychological responses. Master responses means that experience
113 from previous similar situations increases self-efficacy. Social modelling considers
114 that by observing others successfully performing a task, the individual believes that
115 also he or she can do the same. Social persuasion means that an individual can be
116 verbally convinced that he or she has the capability to perform a specific behaviour in
117 a specific situation. The last source of self-efficacy, according to Bandura, is the
118 individual's own response and reaction to the situation. Mood, emotional status and
119 stress can affect an individual's self-efficacy. Anxiety, for example, can create a
120 physical discomfort that reduces self-efficacy (Bandura, 1997). Individuals with high
121 self-efficacy use more effective ways to solve problems because they believe in their
122 ability to handle the situation. Self-efficacy can thus be used as an indicator of the
123 ability to carry out a clinical behaviour (Cant & Cooper, 2010).

124 Simulated disaster exercises that allow participants to practice nursing
125 leadership skills can increase their working knowledge and perceived self-efficacy
126 related to emergency management through mastery experiences. Training can also
127 enhance self-efficacy in clinical situations and nurses' perceived abilities relating to
128 leadership and management of clinical scenarios (Watters, 2015; Smith, 2015). One
129 of the major effects of simulated exercises may be to develop self-confidence in
130 performance (Cant & Cooper, 2010). It is also the case that in an educational
131 situation, individuals with high self-efficacy learn more and perform better than those

with low self-efficacy (Bandura, 1997; Wood and Bandura, 1989). Thus, training to improve self-efficacy can be beneficial for subsequent training sessions.

The National Board of Health in Sweden recommends frequent and regular education, training and exercises as one way to enable head emergency nurses to deal with the managerial activities associated with MIs (SOSFS2013:22 §6-7). In order for such training to be realised there is an interest to explore small-scale training interventions with short time demands and minimal disruption on day-to-day healthcare operations. In line with the recommendations of Hsu et al. (2004) and Artino (2015), the efficiency of such training interventions should be investigated, for example by measuring its effect on trainee self-efficacy. The aim of the current study was therefore to examine if short, small-scale computer-based simulation exercises, using a prototype training system called DigEmergo, would improve head emergency nurses' self-efficacy and MI management skills. The study was named Simulation-based Training of Resource Management in the Emergency Room (STORMER).

Method

The study used a quantitative experimental method with a within-group design, in which participants' self-efficacy was measured using questionnaires before and after partaking in three simulated surge capacity scenarios. An *a priori* power analysis indicated a minimum participant sample of 12 to detect a large effect (Cohen, 1988).

Participants

13 registered head nurses at an emergency department at a small town hospital in Sweden participated in the study. The nurses who were invited to participate were

the individuals appointed to receive and manage the initial surge at the ED in the case of an MI. Two of the participants were men and 11 were women. The age of the participants varied from 31 to 63 years ($M = 41.5$, $SD = 9.8$) and their *nursing experience* varied from 2 to 42 years ($M = 13.9$, $SD = 11.7$). Years as a *registered nurse in an ED* varied from 1 to 15 years ($M = 5.5$, $SD = 4.6$), and experience as a *head nurse* varied from 1 to 10 years ($M = 4.0$, $SD = 3.2$).

Measures

The participants were asked to complete pre- and post-test questionnaires about their *general* and *specific* self-efficacy as well as their perception of their ability to organize and manage the initial response to an MI. General self-efficacy was measured using a validated version of the General Self-Efficacy Scale translated into Swedish (Löve, Moore, & Hensing, 2012). In this questionnaire the participants rated 10 statements using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) with a higher score indicating a greater level of self-efficacy. Specific self-efficacy was measured by six statements based on performance indicators for medical response at an ED developed by Nilsson (2012). The statements reflected the participants' estimated self-belief about their ability to cope with the task as an initial disaster manager at an ED. The indicators reflected specific management skills by considering the time taken to convey the alert to ED management and staff, time taken to create an adequate number of trauma and medical teams, time taken to activate the hospitals' disaster plan and time taken to establish contact with the hospital management. The six statements used the same 5-point Likert scale format as the general self-efficacy questionnaire.

178 To measure management skills, data on the number of patients taken care of
179 during each scenario and the time to treatment of in-hospital patients and trauma
180 patients were saved in the DigEmergo database. Time to treatment was defined as the
181 time, in seconds, from a patient being introduced on the screen to the time when the
182 patient was assigned a staff resource (e.g., nurse or doctor).

183 ***Procedure***

184 Prior to the test the participants were only aware that the whole procedure
185 would take 60 minutes, comprise three scenarios and that their management
186 performance would be measured. Each session started by having the participant read
187 and sign the written informed consent form, followed by a demographics
188 questionnaire and the self-efficacy pre-test questionnaire. The participant then
189 performed a 5-minute training session on how to use DigEmergo after which they
190 were asked to manage three consecutive, 10 minutes long, simulated MI scenarios.
191 The scenarios (a bus accident, a fire at an elderly care unit, and a train crash) were all
192 designed to clearly overwhelm the hospital's resources but to otherwise provide a
193 similar level of challenge. All scenarios featured a simulated ED with 25 beds divided
194 among 4 emergency trauma rooms and 12 ordinary examination rooms. Each scenario
195 was initiated by the presentation of an alert from the Emergency Call Centre (ECC)
196 with preliminary, and therefore incomplete, information about the MI. The number of
197 critically injured patients allocated to the hospital was always seven, with two arriving
198 within the 10 minutes of the scenario time. The number of in-hospital ED patients and
199 available staff varied from 9 to 19 and 14 to 23, respectively, to provide scenario
200 variation. The scenario order was balanced across participants to prevent order

effects. Each participant was asked to perform initial management in the scenario by handling the patient flow exactly as they would in real life. For each scenario the instructor verbally introduced a series of interventions, such as new information from the on-scene medical commander. The interventions were the same for all participants and followed a predetermined schedule. Immediately after the third scenario, the participants completed the post-test questionnaire. The entire session lasted 60 minutes.

Equipment

The DigEmergo simulation system used in this study was developed in a collaboration between the Centre of Teaching and Research in Disaster Medicine and Traumatology (KMC) and Linköping University based on the existing training system Emergo Train System (Rybing et al., 2015, 2016). The participants worked with DigEmergo on a 65” touchscreen with 1920x1080 resolution running on standard workstation Windows 7 PC. The ED and trauma patients were visualized on the screen according to the preprogramed standardized scenarios. By touching the screen, the participants could move the patients and staff around the ED, triage patients, initiate treatments, and transport patients to a number of destinations, e.g. a hospital ward or home. An earlier version of this software running on a 77” SmartBoard interactive whiteboard surface is shown in Figure 1. The DigEmergo system was moved to the actual ED at which the study took place and installed in a closed room adjacent to the clinical space.

[Insert Figure 1 here]

Ethical considerations

All local, regional, and national guidelines for ethical permission were followed. According to these guidelines no formal ethical approval process was required, but ethical consideration was still given with regard to the need for consent, the information requirement, confidentiality obligations and utilization requirement (World Medical Association, 2008). Before the simulation session, the study was explained to all participants individually and they were informed that participation in the study was voluntary and they had the option to discontinue at any time. All participants gave written informed consent for participation. In addition, participants were assured that participation or non-participation would in no way compromise their work situation at the ED. The participants attended the study either before or after their normal shift so as not to compromise ED staffing. Permission to carry out the study at the ED was given by the ED head manager.

Statistical analysis

One-way paired samples t-tests with a significance level of 0.05 were used to compare the pre- and post-test scores of self-efficacy. The t-test family of statistical tests are normally considered robust against violations of non-normal distributions (Maxwell, 2004). The predicted direction of effect was that general and specific self-efficacy would increase from pre- to post-test. One-way paired samples t-tests were also used to compare management skill differences between the first and the third scenario. Again the predicted effect was that management skill would improve from the first to the third scenario. 95% confidence intervals of the difference were used as

effect size measure. All the statistical analyses were performed using Statistical Package for Social Science, SPSS, V.22.

Results

All 13 study participant head nurses successfully completed each test session.

Self-efficacy

The one-way paired *t*-test on general self-efficacy showed that the mean post-test level was significantly higher than the pre-test $t(12) = 3.105, p = .0046$, 95% CI [1.2, 6.9]. The mean general self-efficacy score was 35.7 (SD = 5.06) for the pre-test and 39.8 (SD = 4.1) for the post-test, see Figure 2a.

There was no significant difference in the mean specific self-efficacy score $t(12) = 0.969, p = 0.175$, 95% CI [-0.96, 2.49]. The mean specific self-efficacy score was 22.6 (SD = 3.88) at the pre-test and 23.3 (SD = 3.1) at the post-test, see Figure 2b.

[Insert Figure 2a and b here]

Management skills

The paired sample *t*-test showed a significant decrease in time to treatment of trauma patients, i.e. those patients that arrived from the accident scene, between the first and third exercise session $t(12) = 2.654, p = 0.010$, 95% CI [-25.36, -2.49]. The mean time to treatment of trauma patient was 24 seconds (SD = 18) in the first exercise and 10 seconds (SD = 5) in the third, see Figure 3a.

There was also a significant decrease in time to treatment of in-hospital patients, i.e. those patients already in the hospital when the accident occurred, between the first and third scenario, $t(12) = 2.159$, $p = 0.025$, 95% CI [-116.7, -0.53]. The mean time to treatment of in-hospital patient in the first exercise was 164 seconds (SD = 67), and in the third exercise 106 seconds (SD = 56), see Figure 3b.

[Insert Figure 3a and b here]

The paired t -test on the number patients that were given care showed no significant difference between first simulation to the third, $t(12) = 1.7$, $p = 0.057$, 95% CI [-0.67, 5.44]. The mean number of patients taken care of in the first exercise was 9.0 (SD = 2.9) and in the third exercise it was 11.4 (SD = 3.6), see Figure 4.

[Insert figure 4 here]

[Insert tables here]

Discussion

The current study found that the short, computer-based simulation exercises using DigEmergo significantly increased head nurses' general self-efficacy and management skill as measured by time to treatment for both trauma and in-hospital patients. These findings imply that this training method could potentially be one way to enhance the confidence that the nurses have concerning task performance, their perseverance when obstacles are met, and their resilience in facing adverse situations.

Improving the head nurses' general self-efficacy through simulation exercises could make them more prepared to make decisions in a stressful situation and thereby manage the acute incoming surge in the ED during a MI more effectively.

The use of self-efficacy to measure the effect of simulation exercises on emergency head nurses is one way to understand the potential impact of an educational intervention on later clinical practice. However, it is important not to overestimate the association between reported self-efficacy and abilities. According to Bandura (1997), expectations alone do not produce a desired performance. However, given the appropriate skills and motivation, efficacy expectations are a major determinant of a person's choice of activities. In a training context, measurable performance indicators should therefore also be used in addition to self-efficacy measurements.

In the current study, this was done by using the data on time to treatment of in-hospital patients and trauma patients and the number of patients that received care. The results showed no statistically significant increase in the number of patients that received care, but did show a significant decrease in time to treatment of trauma patients and of in-hospital patient from the first session to the third. There are two basic ways to interpret this: 1) that the trainees have improved in their general skill of managing surge which will translate to more efficient handling during a real MI, or 2) that the trainees have improved specifically in their skill at running the simulator only and will be no better at handling a real MI. This is a question of transfer-of-training and simulation validity, i.e. if the skills trained in the simulator will transfer from the training context to the real context. It is not possible from this study alone to conclude anything about the simulation validity. Further studies are needed specifically aimed

at addressing the question of simulation validity. If the simulation, DigEmergo, can be shown to train the specific skills required during a real MI it can be said to have high validity. Together with the current study that show skill improvement, the combined results would demonstrate the system's usefulness as a training method for emergency medicine management skills.

The current study found no support for an increase in specific self-efficacy using this training method. This could be because the specific self-efficacy instrument used has not been independently tested and validated, and may thus not be measuring the correct underlying variables. There is currently no validated instrument to measure self-efficacy specifically related to the context of managing a MI. Another plausible explanation is that the national quality indicators for MI medical response that the instrument was based on (Nilsson et al., 2010) concerned tasks or skills that were not included and measured in the DigEmergo simulator. For instance, there is no "hospital management" to contact in the simulator, which was one of the statements in the specific self-efficacy questionnaire. Thus, the participants may not have been trained on these management skills, which would explain the lack of change in specific self-efficacy. In a study by Fry (2014) the emergency nurses' general self-efficacy was reported as high, although specific practical tasks, such as handling high patients numbers, caused this to fluctuate. This indicates the importance of identifying factors that affect self-efficacy and to include these factors in simulation exercises with the purpose of training and enhancing self-efficacy. Additional studies of other training methods should be conducted to validate a specific self-efficacy instrument for emergency medicine management, and to test other training strategies for improving nurses' specific self-efficacy.

338 The focus in this study was the *initial* response to an MI at an ED. The
339 scenarios used were about 10 minutes in length and run at near-real time. This
340 simulates only a small part of the initial hospital management of an MI, as the effects
341 might impact the hospitals' ability to deliver healthcare for days. The short scenario
342 time was used based on the purpose of the study, which was to investigate the use of
343 *short* simulation-based exercises on head nurse's self-efficacy and management skill.
344 The scenarios used in the current study could be complemented with equally short
345 scenarios that capture a different time period of the MI management process, e.g. the
346 second day, the start of the first hour immediately after the event, or other
347 departments. Longer sessions could also be used to capture performance over an
348 extended time; however, this creates a higher threshold for participation as it takes
349 more time from the nurses' day-to-day activities. A benefit of longer scenarios,
350 however, is the possibility to measure more variables, such as performance indicators
351 for decision-making and patient flow variables such as length of stay and patient
352 outcome.

353 It should also be noted that the effects of the training intervention were
354 measured immediately post-training. A longitudinal study is required to investigate
355 how well this effect holds over time. Burstein (2006) stated improving specific
356 functions in the health care system requires repeated training sessions because
357 knowledge that is not frequently used is forgotten. The use of simulation exercises is
358 valuable because it allows the nurses to repeatedly participate rare and critical events
359 in a safe environment with no direct risk to patients (Farra, 2015). The use of
360 computer simulations such as DigEmergo provides the opportunity to organize small
361 simulations with minimal impact on the hospital's day-to-day activities and can

facilitate frequent training of incident management skills. The use of computer-simulated exercises also has the advantage that the data from the simulations can be analysed directly after the exercise and the results are available for immediate debriefing (Burstein, 2006).

Conclusions

This study found support for the use of short computer-based simulation exercises as a method to train head nurses to improve management skills and increase their self-efficacy. Simulation-based training is known to increase skill and self-efficacy in a range of domains, and this work provides additional support for the use of short and small-scale simulation-based training as a mean to create opportunities for clinical staff to engage in such training with little impact on day-to-day activities.

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Figures

Figure 1. Student interacting with the DigiEmergo[®] system on a 85” SmartBoard.

Figure 2a. Mean and SD of head nurses General self-efficacy before and after the three simulation exercises.

Figure 2b. Mean and SD of head nurses Specific self-efficacy before and after the three simulation exercises.

Figure 3a. Mean and SD of time from trauma patient arriving in the ED to head nurse assigned staff to start the treatment of the patient in the first and third exercise.

Figure 3b. Mean and SD of time from exercise start to head nurse started treating in-hospital patient in the first and third exercise.

Figure 4. Mean and SD for number of patients taken care by the head nurse

during the first and the third exercise.