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Anna Abelsson & Lars Lundberg

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Simulation as a means to develop firefighters as emergency care professionals

Anna Abelsson [a*] and Lars Lundberg [b,c]

[a]*School of Health Sciences, Jönköping University, Sweden;* [b]*Swedish Armed Forces Centre for Defence Medicine, Sweden;* [c]*PreHospen – Centre for Prehospital Research, University of Borås, Sweden*

Objective. The aim of this study was to evaluate the simulated emergency care performed by firefighters and their perception of simulation as an educational method. *Methods*. This study had a mixed method with both a quantitative and a qualitative approach. Data were collected by simulation assessment, a questionnaire and written comments. Descriptive analysis was conducted on the quantitative data whereas a qualitative content analysis was conducted on the qualitative data. Finally, a contingent analysis was used where a synthesis configured both the quantitative and the qualitative results into a narrative result. *Results*. The cognitive workload that firefighters face during simulated emergency care is crucial for learning. In this study, the severity and complexity of the scenarios provided were higher than expected by the firefighters. Clearly stated conditions for the simulation and constructive feedback were considered positive for learning. Patient actors induced realism in the scenario, increasing the experience of stress, in comparison to a manikin. *Conclusion*. Simulation in a realistic on-scene environment increases firefighters' cognitive ability to critically analyze problems and manage emergency care. Simulation of emergency care developed the firefighters as professionals.

Keywords: cognitive load; contingent analysis synthesis; emergency care; firefighter; simulation

1. Introduction

In order to tailor future training for firefighters to handle emergency care situations that they might encounter as first responders, it is essential to study the simulated training as well as how the firefighters perceive the educational methods used. The education for Swedish firefighters consists of 80 credits. This is a 2-year fire, rescue and safety education in which approximately 20 credits focus on prehospital emergency care [1]. All firefighters obtain basic emergency medical technician (B-EMT) education and continued annual training in emergency care at minor and major accident sites, medical emergencies, resuscitation, advanced cardiopulmonary resuscitation (CPR) and first aid.

In Sweden, firefighters are integrated into the prehospital medical personnel and obligated to provide immediate resuscitation essential for survival at all sites of accidents, and when called to patients with medical emergencies [2]. The fire brigade either assist the ambulance service or act as a substitute for the ambulance service when no ambulance is available. The fire brigade work in alliance with the ambulance service by assisting those people in need of emergency care in areas far from an ambulance service. All fire trucks are equipped with medical equipment and defibrillators, and the fire brigade's care actions are based on the ambulance organizations' directive of emergency care [3]. These directives are in turn based on concept education for prehospital emergency care [4].

A solid emergency care education for the first-responding personnel can be life-saving for some patients [2]. Simulation has become widely used in training of Emergency Medical Services (EMS) personnel in different skills [5–7]. Simulated learning is a complement to the learning in everyday work [8]. Through simulated emergency care, the firefighters can practice, learn and evaluate different care actions in a safe environment. The firefighter receives new knowledge regarding both theoretical and practical abilities, which according to Kolb [9] in turn evolves the person's experience. In the simulation, there is also a social process amplifying the learning situations. The exchange taking place between the participants develops a common understanding and therefore supports learning for both the experienced and the less experienced. To observe and to reflect with others also amplifies the learning situation [10].

Since the Swedish fire brigade is called upon in medical emergencies, the firefighters need solid emergency care training. Our hypothesis is that firefighters, despite much shorter medical training than other EMS staff, such as ambulance personnel, benefit from simulated emergency care training performed at an appropriate difficulty level.

*Corresponding author. Email: anna.abelsson@ju.se

1.1. Aim

The aim of this study was to evaluate the simulated emergency care performed by firefighters and their perception of simulation as an educational method.

2. Method

This study had a mixed method with both a quantitative and a qualitative approach. Data were collected by simulation assessment, a questionnaire and written comments. Descriptive analysis was conducted on the quantitative data, whereas a qualitative content analysis was conducted on the qualitative data. Finally, a contingent analysis was used where a synthesis configured both the quantitative and the qualitative results into a narrative result.

2.1. Participants

The participants in this study consisted of 72 firefighters, one female and 71 males, with age ranging from 26 to 66 years ($M = 42$, $Mdn = 41$). The number of service years in the fire brigade ranged from 1 to 43 years ($M = 18$, $Mdn = 15$). All participants received information about the study and were then asked to participate voluntarily. Inclusion criteria were firefighters employed for emergency response participating in scheduled practice.

2.2. Data collection

A total of 72 firefighters were organized into eight groups of 10–12 persons, representing a fire squad. Each fire squad participated in three different simulated major incidents per group. The participants were asked to carry out their work at the site, as they would in real life when the ambulance is not yet available. In each scenario, the firefighters would perform triage and care for injured patients according to the following care levels: priority 1 (P1), immediate need of care; priority 2 (P2), urgent need of care; priority 3 (P3), delayed care (Table 1). The patients were represented by patient actors with mock injuries. When patient 1 (scenario 1) and patient 5 (scenario 2) had a circulatory and respiratory arrest, the patient actor was switched to a manikin.

After each simulated scenario, the firemen and the instructors gathered in a room where a debriefing was held. The debriefing included an oral briefing of the contents of the exercise, e.g., medical care in connection with decontamination of chemical substances. At the end of the day, participants responded to a written questionnaire. The questionnaire consisted of six statements: (a) 'I experienced the emergency care simulation as realistic'; (b) 'I experienced a natural stress situation during emergency care simulation'; (c) 'I experienced simulated emergency care as an appropriate learning opportunity'; (d) 'The content and the difficulty were at an appropriate level'; (e) 'Simulated emergency care stimulated my problem-solving ability'; (f) 'I received good feedback on the medical emergency care that I provided'. A 7-point Likert scale was used: 1 = *strongly disagree*, 7 = *strongly agree*. The questionnaire also consisted of a text field where participants were free to write their own thoughts and comments.

Table 1. Patient case scenarios 1–3 prioritized and cared for by all eight teams.

Patient	Scenario	Priority
	Scenario 1	
1	Driver of the car sitting behind the steering wheel, belted, unconscious, with no evident breathing	P1
2	Backseat passenger, belted, agitated, abdominal injury with evisceration	P2
3	Driver of a truck, belted, conscious, severe pain due to a pelvic injury	P2
4	Person lying in the back of the truck, not belted, unconscious, airway obstruction	P1
	Scenario 2	
5	Person rescued from the smoke-filled house, unconscious, no evident breathing	P1
	Scenario 3	
6	Truck driver who has crashed with a pallet, unconscious, airway obstruction, lying in a puddle of corrosive liquid	P3 (need for decontamination)

2.3. Data analysis

Descriptive analysis (central tendency and distribution) was used to describe the quantitative data (simulation assessment and analysis of the questionnaire) and was conducted using IBM SPSS version 24.0. A qualitative content analysis according to Hsieh and Shannon [11] was performed on the qualitative data (written comments). The analysis started with the familiarizing of the written comments. This was performed by both authors to ensure reliability. In the first part, the written comments were read through repeatedly in order to reach an understanding of the substance of the data as a whole. The written comments were then read closely to identify meaning units that represented firefighters' perception of simulation as an educational method. The next step was to derive codes from the meaning units. Thereafter, the codes were abstracted and sorted into categories based on similarities and differences: patient actors and manikins; CPR; the instructor team. The relevance of the result was finally verified by the correlation between the aim of the research and the categories [11]. Finally, a contingent analysis synthesis of the quantitative and qualitative results into a narrative result was

carried out [12]. The contingent research analysis answers a research question regardless of qualitative or quantitative methods. The same research question was used for both the qualitative data and the quantitative data. A research synthesis, or an aggregation, of both results was then configured into a theoretical or, as in this study, a narrative result. The findings have a potential to lead to more comprehensive understanding, broader general knowledge and deeper understanding [12,13].

2.4. Ethical consideration

The study followed the ethical principles in accordance with the World Medical Association [14] about anonymity and integrity. Ethical approval was obtained from the fire chief of the region. Informed consent was obtained from each participant.

3. Results

The results are presented by the research methods used: the quantitative simulation assessment, the quantitative descriptive analysis of the questionnaire, the qualitative content analysis of the written comments and, finally, the contingent analysis synthesis of the whole result (Table 2).

3.1. The quantitative simulation assessment

Triage and emergency medical care were performed on the six different patient cases in the three scenarios by eight different fire squads, i.e., a total of 48 triage scenarios.

3.1.1. Scenario 1

Patient 1 – driver of the car sitting behind the steering wheel, belted, unconscious, with no evident breathing. Five fire squads (60%) correctly triage the patient as P1, with immediate extrication followed by resuscitation. The patient is undertriaged by three squads (40%), who do not identify the respiratory arrest and initially classify the patient as P2. However, all three squads identify the respiratory arrest when extricating the patient from the car and then initiate resuscitation.

Table 2. Model presenting the phase, procedure and product of the mixed method according to Sandelowski et al. [13].

Phase	Procedure	Product
(1, 2) Quantitative data collection	Simulation assessment ($n = 48$) Questionnaire ($n = 72$)	Numeric data
Quantitative data analysis	Central tendency and distribution	Descriptive statistics
(3) Qualitative data collection	Written comments ($n = 51$)	Texts
Qualitative data analysis	Qualitative content analysis	Code categories
(4) Integration of quantitative and qualitative results	Contingent analysis synthesis configured into a narrative result	Synthesis

Patient 2 – backseat passenger, belted, agitated, abdominal injury with evisceration. Six fire squads (75%) correctly triage the patient as P2 and wait until the driver (patient 1) is extracted (Figure 1). Meanwhile, a firefighter sits with the patient in the back seat. The other two squads (25%) overtriage the patient as P1. They extricate the driver (patient 1) and the passenger (patient 2) simultaneously, resulting in a slower extrication of the driver with a respiratory arrest.

Patient 3 – driver of a truck, belted, conscious, severe pain due to a pelvic injury. Six fire squads (75%) correctly triage the patient as P2. The other two squads (25%) overtriage the patient as P1, resulting in immediate extraction on suspicion of a life-threatening condition. The result of this overtriage is a delayed resuscitation of patient 4, who has a life-threatening airway obstruction.

Patient 4 – person lying in the back of the truck, not belted, unconscious, airway obstruction. All fire squads (100%) correctly triage and treat the patient as P1. An open airway

Figure 1. Extraction of patient 1 (scenario 1).

Figure 2. Extraction of patient 4 (scenario 1).

is established on site, and the patient is then extricated (Figure 2).

3.1.2. Scenario 2

Patient 5 – person rescued from the smoke-filled house, unconscious, no evident breathing. Seven fire squads (88%) correctly triage the patient as P1 due to the respiratory arrest and immediately start resuscitation. The patient is undertriaged by one squad (12%), who do not immediately identify the respiratory arrest, with a resulting delay in the onset of resuscitation.

3.1.3. Scenario 3

Patient 6 – truck driver who has crashed with a pallet, unconscious, airway obstruction, lying in a puddle of corrosive liquid. Six fire squads (75%) correctly triage the patient as P3 and initially put the patient in the recovery position and administer oxygen, simultaneously starting decontamination of the corrosive liquid (Figure 3). The other two squads (25%) do not triage the patient at all, who is left in a supine position without any medical observation or care during decontamination of the corrosive liquid.

3.2. The quantitative descriptive analysis of the questionnaire

The statement with the highest rank on the 7-point Likert scale was 'The content and the difficulty were at an appropriate level' ($M = 6.3$). This statement was never ranked lower than 4 by any single participant. The statement 'I experienced simulated emergency care as an appropriate learning opportunity' was also ranked high ($M = 6.2$). The statement with the lowest rank was 'I experienced a natural stress situation during emergency care simulation' ($M = 4.8$). This was the only statement which scored anywhere between 1 and 7 on the 7-point Likert scale (Table 3).

Figure 3. Administration of oxygen with the patient in the recovery position before decontamination of the corrosive liquid (patient 6, scenario 3).

Table 3. Ranking of the six statements on a 7-point Likert scale.

Statement	*M*	*Mdn*	Range
'I experienced the emergency care simulation as realistic'	5.7	6.0	3–7
'I experienced a natural stress situation during emergency care simulation'	4.8	5.0	1–7
'I experienced simulated emergency care as an appropriate learning opportunity'	6.2	6.1	2–7
'The content and the difficulty were at an appropriate level'	6.3	6.5	4–7
'Simulated emergency care stimulated my problem-solving ability'	5.6	5.9	2–7
'I received good feedback on the medical emergency care that I provided'	6.0	6.0	2–7

3.3. The qualitative content analysis of the written comments

The written comments were summarized into three categories: patient actors and manikins; CPR; the instructor team.

3.3.1. Patient actors and manikins

Emergency care exercises involving patient actors with mock injuries (moulage) was considered to add more realism to the learning than using manikins only. The use of

patient actors added an extra dimension of actuality. The participants were not able to take any short-cuts, which they could consider doing when working with manikins:

> You shape up when you meet real people. You treat people better than manikins.

A patient actor who responded to questions and actions prevented the firefighter from providing certain care actions without certain participation from the patient. The patient actors also provided different emotions, such as aggression, apathy and fear. This role-playing was considered to improve the simulation experience:

> There is more focus on the medical care when talking to a human being. You treat a person with dignity. That is not the case with the manikin.

To provide emergency care for a human being infers protecting and treating the body gently. It emerged that the human body is more difficult to handle because it is not stiff like a manikin, and therefore is more difficult to drag and carry. The mock injuries on the patients provided increased realism and learning since the participants could visually see the injuries, as they would have been able to in real life. It was considered positive that there was a variety of injuries.

3.3.2. Cardiopulmonary resuscitation

The need for CPR in scenarios 1 and 2 was considered positive since it was not initially expected. Due to the use of patient actors, the firefighters had disregarded the possibility that a cardiac arrest would occur. During CPR, the participants received continuous feedback, regarding the quality of compression and ventilation to optimize the CPR quality:

> It was great with the CPR in the middle of everything, also, that we got feedback on what we actually did in real time. Then you got the feeling for the quality of the compressions.

3.3.3. The instructor team

The instructor team was considered important in creating a positive educational experience. What was identified as important for the exercises was that the training team beforehand clearly stated the conditions for each moment of the exercise, e.g., that the ambulance is 20 min away, vehicles may be cut if necessary and similar practical conditions. It was described as valuable that all persons on the exercise site were clearly distinguished with vests of different colors. These colors highlighted the different roles, and the participants were able to quickly identify who participated in the scenario and who belonged to the instructor team:

> The fact that people on site had vests marked with different colors meant that I didn't need to look for who was involved in the scenario.

During the feedback sessions, the participants felt that feedback given in a constructive and polite way resulted in better learning. The feedback was perceived as exchanging thoughts on ways of working as opposed to being criticized for their ignorance. The participants described how the feedback triggered a positive feeling, which facilitated professional development. Even negative events or inaccuracies could improve learning by seeing the events in a neutral way and then discussing alternative approaches without pointing out any individual:

> We talked about what we had done and what we could have done better. It felt good. No one was singled out, we were all a team, including the instructors.

It was emphasized how important it was for instructors to take responsibility for events that had gone wrong in the simulation and that could be improved for future scenarios. This was considered to strengthen the participants' sense of practicing under fair conditions.

3.4. The contingent analysis synthesis of the whole result

The firefighters expressed how scenarios that were harder than their level of knowledge were the best way to learn. Of the 48 patient cases, 38 patient cases were triaged correctly, six out of 48 patients were undertriaged and four out of 48 patients were overtriaged. Constructive feedback in the form of a discussion, containing suggestions for improvement, was considered positive for learning and developed the firefighter as professionals. The fact that the conditions for each simulation exercise were clearly stated and that all involved persons were clearly distinguished with vests of different colors resulted in a suitable learning opportunity with the right conditions for practicing.

Simulating varying injury scenarios was found to stimulate the problem-solving ability of firefighters. The use of patient actors resulted in problems being solved as they would be at the site of the accident. The firefighters helped each other to triage patients in the different scenarios, as well as finding solutions to how patients could be extricated from the vehicles.

The patient actors had mock injuries that could be visually identified, resulting in improved realism. The actors' bodies were also more difficult to handle because they were soft, as opposed to a stiff manikin that could easily be dragged or carried. The participants described how they tried to avoid causing unnecessary pain to the actor during a move, which would not necessarily have been the case if they had acted against a manikin. The realism of the simulation resulted in a firefighter sitting inside the car with the injured and agitated patient. An acting patient actively stimulated the participation in the simulated emergency care, as opposed to a manikin that was more easily ignored. An acting patient who expressed emotions and pain was also described to increase the experience of stress during

simulation. The fact that there was a natural stress even in situations involving patient actors was shown when patient 4 (scenario 1) was carefully extricated, which required great effort. In scenario 2, patient 5 was afflicted with a sudden and unexpected circulatory and respiratory arrest that required immediate CPR. This stressful situation was promptly handled since all firefighters are well trained to provide CPR.

4. Discussion

The aim of the simulation of emergency care at the site of the accident is to improve firefighters' clinical competence and experience. The simulated settings in this study consisted of three different scenarios including six patients, all with a focus on emergency care. In an exercise, different conditions can be trained. Working with personal protective equipment provides, according to Kim et al. [15], decreased performance levels regarding life-saving interventions. It is therefore important that firefighters are allowed to perform their training in their personal protective clothing, in some cases also wearing their self-contained breathing apparatus as in this study. The staff's skills and experiences of emergency care are of great importance for ensuring good quality and safe care in an emergency [16]. It is therefore also important to provide training, and, more specifically, training adapted for personnel in the fire brigade.

Implicitly there are high demands and expectations on the firefighters' abilities. But high-risk situations and life-threatening events are infrequent in their daily work. Not being exposed to emergency care situations increases the need to practice and prepare for these situations [17,18]. Through simulation, skills that are rarely used are practiced and retained [8]. When simulating emergency care situations, staff are challenged to critically analyze problems and make decisions in a complex and rapidly changing environment. The availability of information is often limited or contradictory [19]. Simulation is therefore a fundamental part of training staff in emergency care settings [20]. The setting in this study is the regular working environment for the firefighters. The environment thus strengthens learning when knowledge is created in, for the firefighters, relevant situations [21,22]. When staff feel that the simulation is realistic, they can more easily understand the consequences of the care actions they choose to execute or not. It is possible to compare the simulated situation with what would happen in a real situation [22]. This emerged from the result of the firefighters paying attention to the injured persons as opposed to ignoring a manikin. The injured body was treated gently and with respect, as opposed to a stiff manikin that can be pulled and thrown.

The results showed how the firefighters wanted the scenarios to be above their level of competency. This is consistent with the learning that occurs when requirements are higher than the personal resources available. The person will experience positive stress that helps them to perform over their normal abilities [23]. It improves the possibility of learning for the individual [24]. If the stress, instead, becomes too much, it will result in cognitive overload. This means an impaired cognitive capacity of the individual. Cognitive overload during complex and demanding tasks leads to a reduced cognitive ability to process information, impaired performance and impaired learning [25,26]. If the instructor for a scenario can balance the stress level, the increase in stress can be used to give the individual an increased cognitive capacity [27]. In this study, the severity and complexity of the scenarios provided were higher than expected by the firefighters. The fact that the scenarios were balanced on the borderline between being manageable and too difficult resulted in a learning experience for the firefighters. It gave an increased ability to process information, to plan future actions, to adapt to the situation and to work in the team. Furthermore, it was revealed in the results that the right conditions for practicing and learning were experienced due to the clear information regarding prerequisites for the simulations. The positive feeling was experienced in the scenarios as the participants perceived the scenarios as fair. This, in turn, resulted in improving the cognitive ability to process information and function optimally during the simulation [24].

4.1. Example for implementation of simulated trauma care at a fire station

- Aim: to practice, learn and evaluate different care actions in a safe environment and on an appropriate difficulty level.
- Method: theoretical education, such as ABCDE, chemical injuries or CPR. Simulation of specific injuries and illnesses. Subsequent discussions with constructive feedback. The facilitator will provide the correct answers and solutions.
- Preconditions: clear instructions and directives for the simulations. Actors with mock injuries.
- Result: theoretical and practical learning creates competency and experience. Learning is enhanced by the simulated care conducted by several participants at the same time, enabling discussion and learning within the group.

4.2. Limitations

This simulated study, conducted in a safe environment, cannot mimic real-life emergency care situations the firefighters are exposed to. The firefighters had full focus on the task at hand and not what was happening in the environment. This would have been the case during a real emergency event. In this study, there was only one female participant, which is representative for the number of female firefighters in Sweden. The gender is unlikely to

have affected the result as all firefighters, regardless of gender, are employed for emergency response and perform the same tasks. Another limitation is that we have not determined how the degree of simulated knowledge relates to the degree of clinical knowledge of the firefighters as there is no accepted standard measurement between these two.

5. Conclusion

The cognitive load that firefighters face during simulated emergency care is crucial for learning. The firefighters in this study requested severe and complex scenarios, in order to learn. However, the workload should not make learning impossible. Clearly stated conditions for the simulation and constructive feedback were considered positive for learning. Patient actors induced realism in the scenario, increasing the experience of stress, in comparison to a manikin. Simulation of emergency care developed the firefighters as professionals.

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ORCID

Anna Abelsson http://orcid.org/0000-0002-1641-6321
Lars Lundberg http://orcid.org/0000-0003-0453-6913

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