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Featured Article

# Effect of Repeated Simulation on the Quality of Trauma Care

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**KEYWORDS**
simulation;
learning;
experience;
ambulance;
prehospital emergency care;
trauma

**Abstract**

**Background:** Simulation participants are not dependent on learning during an actual clinical situation. This allows for a learning environment that can be constructed to meet the knowledge and experience needs of the participant. Simulations in a prehospital emergency are an ideal way to address these needs without risking patient safety.

**Method:** Nurses in prehospital emergency care (n = 63) participated in simulation interventions. During the simulation, the performed trauma care was assessed in two groups of participants with different frequency of simulation.

**Results:** Several statistically significant differences and clinical improvements were found within and between the groups. Differences were noted in specific assessments, examinations, care actions, and time from assessment to action.

**Conclusion:** The result suggested that repeated simulation may contribute to a clinical improvement in trauma care, and more frequent simulation may led to even greater improvements.

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This study examined the effect of participating in trauma simulation on trauma care skills of nurses in prehospital emergency care. The mortality among patients exposed to high-energy trauma is very high. The body is suddenly in an extremely stressful and fragile condition, in which many organ systems may fail concurrently. This aggravated and time-sensitive situation is frequently complicated by profuse bleeding and serious and extensive tissue damage. Caring for a highly vulnerable patient in

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this context is a complex and often demanding task for the nurse arriving at the scene. Therefore, simulation of high-energy trauma situations provides an opportunity to educate nurses as if on the scene, either before encountering the actual clinical work or after, as continuing education (Axelsson, Jimenez Herrera, & Bång, 2016).

**Key Points**

- To practice trauma care knowledge and skills with detailed objective assessment, can manifest the ABCDE knowledge of the nurse in prehospital emergency care.
- During repeated trauma simulation, there were statistically significant differences and clinical improvements of trauma care in the prehospital context.
- An individual objective assessment and a debriefing facilitating learning through reflections could ensure good-quality trauma care.

## Background

The nurse in the prehospital emergency care assesses and performs necessary life-saving interventions and care for the patient at the scene of the accident and during transportation to the hospital. The nurse's knowledge and prehospital emergency care skills are critical for patient survival and reduction of patient morbidity and mortality (Wilson et al., 2015). However, conducting care in the prehospital trauma context is challenging to manage, for example, limited information about the patient's medical history prevents a deeper knowledge and understanding of the patient's needs for care (Axelsson et al., 2016; Suserud, 2005).

Training in prehospital trauma care can be achieved by simulation. With simulation, the participants are no longer dependent on learning while in an actual trauma situation. Scenarios are constructed according to the participants' knowledge and experience level (Motola, Devine, Chung, Sullivan, & Issenberg, 2013). Thereby, skills are rehearsed and maintained although they are not frequently used in clinical practice (Dieckmann, 2009; Gallagher & Henn, 2014).

Benefits of simulation in health care are well documented and include improvement in psychomotor skills, communication skills, assessment, and management skills (Nestel & Bearman, 2015; Yuan, Williams, & Fang, 2012). Prior foci of research on simulated trauma care have revolved around simulation as a method for education, evaluation of staff performance, and evaluation of work environment (Abelsson, Rystedt, Suserud, & Lindwall, 2014). Airway, Breathing, Circulation, Disability, and Exposure (ABCDE) has, to our knowledge, rarely been researched.

The aim of the study was to examine the association between the frequency of trauma simulation and the effect of trauma simulation on the trauma care skills of nurses in prehospital emergency care. The hypothesis was that, after the simulation period, the trauma care skills in a group simulating four times during a six-month period would be better than the trauma care skills in a group simulating two times during the same period. In the research process, trauma care skills were represented by the scores on an instrument measuring clinical competence.

## Ethical Considerations

The study followed the ethical principals in accordance with the Declaration of Helsinki (2013), regarding anonymity and integrity. University institutional review board provided the ethical approval for this study. Each participant provided their consent. No unauthorised person had access to the material.

## Method

This study was an intervention study. Simulation of patients exposed to high-energy trauma was conducted in two separate groups. Group A completed each of their four simulation scenarios (i.e., scenarios 1, 2, 3, and 4) with one simulation occurring every eight weeks. Group B completed only the first and last simulation scenarios (i.e., scenarios 1 and 4) with a time interval of six months (Figure 1).

Simulations 1 and 4 is in the study described as the first and the last simulations. The frequency of which the simulations were conducted was determined in consultation with a prominent researcher in the field of simulation. Two separate evaluations were conducted, one during the first and one during the last simulation. The evaluations enabled a comparison of the two groups A and B. The purpose of having two groups was to explore whether the frequency of simulation was related to the participants' trauma care abilities. In this article, the reporting follows the guidelines according to Cheng et al. (2016).

| Scenario | | Group A | Group B |
|---|---|---|---|
| 1 | Severe injuries to extremities in the form of bilateral open femur fractures and closed pelvic fracture as a result of a fall of 4 meters. Patient bleeding extensively. | X | X |
| 2 | High spinal injury as a result of a dive head-first into the shallow end of the pool. Patient going into spinal shock. | X | |
| 3 | Two penetrating abdominal wounds as a result of a stab by a pair of scissors causing one open, bleeding, cavity and one cavity with intestines pressing out. | X | |
| 4 | Severe injuries to extremities in the form of bilateral open femur fractures, closed pelvic fracture and an open humerus fracture as a result of a motorcycle accident. Patient bleeding extensively. | X | X |

**Figure 1** Scenarios conducted during the four simulations.

## Participants

By using convenience sampling, participants were assigned to groups based on geographic location. A total of 81 nurses in prehospital emergency care were invited to participate in the study, of whom 63 completed the study. Twenty-seven participants were included in group A, and 36 participants were included in group B. They originated from five ambulance stations in three regions in Sweden. The participants were informed about the study by their station chief. Nurses who were willing to participate then contacted the researcher directly. The participants were in no way dependent on the researcher and were informed of the aim of the research before agreeing to join the study. All participants had some previous experience of simulation training. The registered nurses in the study have a three-year Bachelor degree at the university level. The specialist nurses have an additional one-year prehospital, anaesthetic, or intensive care specialist education. Eighteen participants did not complete the study. The reason was maternity/parental leave (n = 3) or no longer working in the EMS (n = 15), 12 in group A and 6 in group B. (Figure 2).

## Intervention

The participants performed the simulations in pairs. The pair assignment was based on which participants were on duty at the time of the simulations. The nurses were randomly assigned the primary or secondary role in the simulation. The primary nurse was instructed to assess and perform trauma care to the best of his/her ability as if the scenario occurred in a real-life situation (INACSL, 2016; Tariq, Sood, & Goodsman, 2015). The secondary nurse worked solely under the direction of the primary nurse and was asked not to take any independent actions nor make any suggestions for trauma care. The focus of the evaluation was the primary nurse.

The scenarios started with a call from dispatch about the current patient. The facilitator played the role of a person who had witnessed the accident and met the participants at the scene of the accident. The participants were also shown a picture of the scene of the accident. The patient was represented by a Resusci Anne Basic (Laerdal®, Stavanger) that was moulaged with the appropriate injuries. The trauma care was based on the Prehospital Trauma Life Support (PHTLS®) mnemonic concept ABCDE (PHTLS, 2014), used in the clinical prehospital setting in Sweden. During the scenario, the facilitator continually provided the nurses with patient's vital parameters and adjusted the patient outcome and vital parameters according to the interventions made by the primary nurse (Tariq et al., 2015). The scenario ended when the primary nurse stated that they were leaving the scene. The scenarios ranged from 2:00 to 11:00 minutes (mean 6). The facilitator concluded the simulation by leading a debriefing session, with the two nurses. This debriefing included theoretical knowledge and recommendations on specific care actions that participants may have overlooked (Alinier, Hunt, Gordon, & Harwood, 2006).

To ensure content validity, an anaesthetist and a trauma surgeon, both emergency physicians specialised in prehospital trauma care, assisted in the construction of the scenarios. Before the study, four nurses in prehospital emergency care who were not included in the study, pilot tested the patient scenarios. All simulations in the study were video-filmed, given that these situations were considered impossible to evaluate and rate correctly in real time. The scenarios took place on the garage floor in the participants' respective ambulance stations. No other

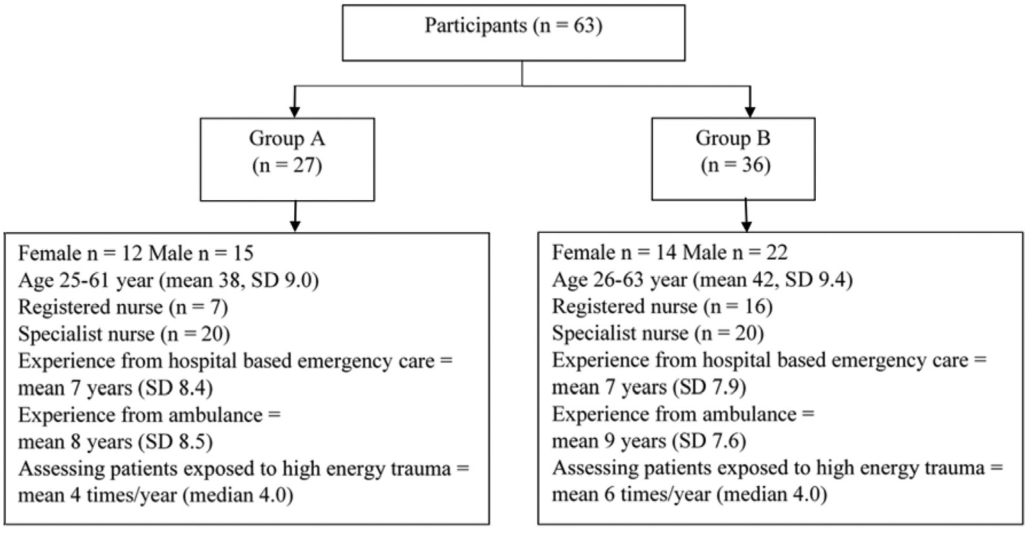


**Figure 2** Consort flow diagram presenting the background characteristics of the participants.

persons were present during the simulation nor the debriefings.

## Rating Scale and Rating Procedure

For evaluation of the simulation scenarios, the *Global Rating Scale* (*GRS*) *for the assessment of paramedic clinical competence* was used with consent from the developer (Tavares, Boet, Theriault, Mallette, & Eva, 2013). The GRS has been validated by paramedics in a prehospital emergency setting, reporting an interrater reliability (Kappa) of 0.75 to 0.94 and internal consistency (Cronbach's alpha coefficient) of 0.53 to 0.89 (Tavares et al., 2013, 2014). The GRS has seven dimensions, including situation awareness, history gathering, patient assessment, decision making, resource utilisation, communication, and procedural skill. Scoring is made using a 7-point Likert scale, 1 = unsafe, 2 = unsatisfactory, 3 = poor/weak, 4 = marginal, 5 = competent, 6 = highly competent, and 7 = exceptional. According to the developer of the instrument, a GRS score of one to three is classified as unsatisfactory and means that the participant has failed this dimension of the assessment. A score of four to seven is satisfactory and means a "pass." All seven dimensions are ultimately weighted to calculate an overall score for the overall clinical performance (Tavares et al., 2013). A total GRS score of 7 to 21 is regarded unsafe/weak total GRS score of 22 to 28 as marginal and a total GRS score of 29 to 49 as competent.

A supplementary flowchart, based on the concept ABCDE (PHTLS, 2014), was used. It allowed for a more detailed examination of the participants' trauma care on the specific dimension patient assessment. The flowchart consisted of examinations, assessments, and care actions that the participants were expected or obligated to perform. The content of the flowchart was marked with executed or not executed. The time until essential criteria were performed was also measured. The flowchart contributed to detailed and structured evaluation that improved the identification of appropriate as well as inappropriate behaviours. In addition, it decreased subjectivity on behalf of the rater which in turn enhanced the reliability of the assessments.

The content of the flowchart and the classification of the critical criteria were, to validate, reviewed by an emergency physician specialised in prehospital trauma care. Before the evaluation, the content of the flowchart was weighted, and certain assessments and care actions were classified as critical criteria (Tariq et al., 2015).

## Raters of Recordings

Two blinded independent raters, with 5 and 15 years of experience in simulation and evaluation of clinical implementations in prehospital emergency contexts, were asked to rate the recordings. The recorded material was deidentified and randomised prior to evaluation by the raters. The raters were introduced to the use of GRS and provided with detailed information on the patient scenarios and the criteria important for the evaluation, including the critical criteria for each patient. Both raters initially performed the evaluation, using both the GRS instrument and the flow chart, for the same 14 scenarios to test the interrater reliability (Streiner & Norman, 2008) that was 95% (i.e., five discordances in 98 items). The remaining recordings were divided randomly between the two raters and evaluated separately.

## Data Analysis

The descriptive and inferential analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS) v 24.0 (IBM Corporation, Armonk, New York). Descriptive analysis (central tendency and distribution) were used to describe the data, whereas inferential statistics (*z*-test, *t*-test, and McNermar) compared potential differences between the variables before and after the interventions and between groups. The level of significance used was set at $\alpha = 0.05$ (Field, 2013). To determine the extent to which differences between the first and the last evaluation could likely be attributed to the simulation, data were collected from each participant regarding additional training opportunities. Also, the frequency of actual real-life clinical experience with high-energy trauma care performed during the collection period was recorded.

# Results

The aim of the study was to examine the association between the frequency of trauma simulation and the effect of trauma simulation on the trauma care skills of nurses in

**Table 1** The Proportion of Participants Performing Specific Care Actions During First and Last Simulation

| Care Actions | A First | B First | A Last | B Last |
|---|---|---|---|---|
| Assessed level of consciousness on arrival | 89% | 86% | 89% | 78% |
| Opened mouth for inspection | 22% | 19% | 11% | 19% |
| Oropharyngeal airway | 63% | 75% | 52% | 64% |
| Stabilised the cervical spine by hand | 85% | 83% | 85% | 86% |
| Applied cervical collar | 89% | 97% | 78% | 92% |
| Assessed airway management | 56%*1 | 31%*1 | 52% | 47% |
| Assessed respiratory rate | 67% | 69% | 81% | 75% |
| Assessed level of consciousness | 15% | 17% | 15% | 28% |
| Spinal immobilisation | 85% | 86% | 85% | 78% |
| Followed the ABCDE algorithm | 70% | 72% | 74% | 72% |

*Note.* ABCDE = Airway, Breathing, Circulation, Disability, and Exposure.

* Statistically significant difference at 5% level analysed with *z*-test and McNermar. The number 1 indicates pairwise comparison.

**Table 2** The Proportion of Participants Performing Specific Care Actions During First and Last Simulation

| Care Actions | A First | B First | A Last | B Last |
|---|---|---|---|---|
| Inspection of chest | 67%*1 | 69%*2 | 85%*1 | 86%*2 |
| Breathing sounds | 56% | 42% | 56% | 61% |
| Examination thorax | 52% | 56% | 59% | 53% |
| Examination abdomen | 56% | 53% | 67% | 58% |
| Examination pelvis | 63% | 69% | 74%*3 | 47%*3 |
| Pupil reactions | 22% | 28% | 44% | 22% |
| Exposure | 30% | 31% | 52% | 47% |
| Examination head | 11% | 14% | 19% | 14% |

* Statistically significant difference at 5% level analysed with *z*-test and McNermar. The numbers 1 to 3 indicates pairwise comparison.

prehospital emergency care. Study evaluation indicated that assessments, examinations, and care actions were not consistently performed, even those that can be considered lifesaving interventions. Furthermore, the result showed that there were statistically significant differences in scores within groups and between groups.

Table 1 describes the proportion of participants performing care actions during the simulations. These care actions were evaluated as to whether they were performed or not, during the simulations. The participants, in neither group, rarely assessed the patient's level of consciousness. However, group B showed an increase.

Participants in both groups rarely inspected the patient's mouth, and group A decreased the number of inspections. A significant percentage of participants in both groups did, however, apply a cervical collar, and it increased at the last simulation (Table 1).

Table 2 summarises other care actions performed during first and last simulations. Examination of the patients' heads and the assessments of pupil reactions were seldom conducted in either group, not in the first neither the last simulation scenarios. It is noteworthy that this also applies to "exposure" that was performed to a low degree. On examination of the patients' pelvis, there was a statistically significant difference between the groups in the last simulation. Group A that had simulated four times had an increased percent of participants examining the patient's pelvis, whereas group B with two simulations had a decrease in the percentage of participants performing the pelvis examination (Table 2).

As seen in Table 3, the time before performing a lifesaving jaw thrust was long both in the first and the last simulations. Performing a jaw thrust is classified as a critical criterion, although five participants never performed this. Stopping the extensively bleeding of the legs is also classified as a critical criterion due to the life-threatening situation it posed. Regardless, 16 participants neither identified nor stopped the bleeding. There was a statistically significant improvement between first and last simulations in group A, on the time to apply oxygen mask on the patient. Also, at the last simulation, there was a statistically significant difference between the groups in regard to time to apply oxygen mask. About the time to the care action, "leaving the scene," there were statistically significant differences between first and last simulations in both groups A and group B (Table 3).

Table 4 shows the scores for the seven dimensions of GRS. It is noteworthy that the lowest total score increased from the first and the last simulations in both groups. The lowest score for group A was 18 in the first simulation,

**Table 3** Mean Response Time to Care Actions Classified as Critical Criteria

| Care Actions | A First | B First | A Last | B Last |
|---|---|---|---|---|
| Perform jaw thrust, mean (*SD*) | 29 seconds (23) | 41 seconds (51) | 28 seconds (24) | 28 seconds (30) |
| Minimum time to maximum time | 6-97 | 5-240 | 2-105 | 1-122 |
| Undertook no action | 4% (n = 1) | 6% (n = 2) | 4% (n = 1) | 3% (n = 1) |
| Apply oxygen mask, mean (*SD*) | 102 seconds*1 (74) | 125 seconds (88) | 63 seconds*1,*2 (40) | 99 seconds*2 (65) |
| Minimum time to maximum time | 3-320 | 26-375 | 18-190 | 20-250 |
| Undertook no action | 7% (n = 2) | 8% (n = 3) | 7% (n = 2) | 19% (n = 7) |
| Check radial pulse, mean (*SD*) | 65 seconds (35) | 101 seconds (103) | 80 seconds (38) | 82 seconds (63) |
| Minimum time to maximum time | 17-142 | 17-525 | 12-152 | 18-330 |
| Undertook no action | 15% (n = 4) | 8% (n = 3) | 7% (n = 2) | 3% (n = 1) |
| Stop bleeding leg, mean (*SD*) | 202 seconds (109) | 201 seconds (100) | 156 seconds (73) | 171 seconds (85) |
| Minimum time to maximum time | 31-439 | 64-470 | 33-639 | 42-365 |
| Undertook no action | 22% (n = 6) | 6% (n = 2) | 7% (n = 2) | 17% (n = 6) |
| Stop bleeding arm, mean (*SD*) | | | 148 seconds (59) | 178 seconds (91) |
| Minimum time to maximum time | | | 33-332 | 30-330 |
| Undertook no action | | | 22% (n = 6) | 25% (n = 9) |
| Leaving the scene, mean (*SD*) | 378 seconds*3 (143) | 412 seconds*4 (116) | 265 seconds*3 (83) | 220 seconds*4 (101) |
| Minimum time to maximum time | 164-639 | 210-660 | 144-444 | 128-525 |

* Statistically significant difference at 5% level analysed with a *t*-test. The numbers 1 to 4 indicates pairwise comparison.

**Table 4** Score Per Dimension and Total Score on the 7-Point Likert Scale

| Dimension | A First | B First | A Last | B Last |
|---|---|---|---|---|
| Situation awareness (*SD*) | 4.56 (1.00) | 4.31 (0.82) | 4.56 (0.698) | 4.17 (0.88) |
| Minimum score to maximum score | 3-6 | 2-5 | 3-6 | 3-7 |
| History gathering (*SD*) | 3.96 (1.11) | 4.17 (0.91) | 4.41*1 (0.89) | 3.92*1 (0.73) |
| Minimum score to maximum score | 3-6 | 2-5 | 3-6 | 3-6 |
| Patient assessment (*SD*) | 3.96*2 (1.10) | 4.08 (0.97) | 4.56*2 (1.00) | 4.39 (1.00) |
| Minimum score to maximum score | 2-6 | 1-6 | 3-7 | 3-7 |
| Decision making (*SD*) | 4.22 (1.20) | 4.14 (1.00) | 4.85 (0.864) | 4.47 (1.00) |
| Minimum score to maximum score | 2-6 | 1-6 | 3-7 | 3-7 |
| Resource utilisation (*SD*) | 4.26 (0.984) | 4.11 (0.95) | 4.67 (0.784) | 4.44 (0.73) |
| Minimum score to maximum score | 3-6 | 1-6 | 3-6 | 3-6 |
| Communication (*SD*) | 4.41 (1.00) | 4.31 (0.89) | 4.67 (1.00) | 4.53 (0.91) |
| Minimum score to maximum score | 2-6 | 2-6 | 3-7 | 3-7 |
| Procedural skill (*SD*) | 4.22 (0.974) | 3.92*3 (0.97) | 4.56 (0.892) | 4.44*3 (0.94) |
| Minimum score to maximum score | 3-6 | 1-5 | 3-6 | 3-7 |
| Total score (*SD*) | 29.96 (6.84) | 29.03 (5.75) | 32.26 (5.44) | 30.36 (5.35) |
| Minimum score to maximum score | 18-42 | 10-38 | 23-45 | 21-45 |

* Statistically significant difference at 5% level analysed with *z*-test and McNermar. The numbers 1 to 3 indicates pairwise comparison.

which is considered unsafe/weak, and 23 in the last simulation, which is considered marginal. The lowest score in Group B was 10 in the first simulation, which is considered unsafe/weak, to 21 in the last simulation, higher although still considered unsafe/weak. For the last simulation, there was a statistically significant difference in participants obtaining patients prior history between the both groups in the dimension "history gathering." In regard to patient assessment, there was a statistically significant improvement in proportions of participants conducting patient assessment from the first simulation in group A. Finally, on the dimension "procedural skill," there was a statistically significant improvement in share of participants' abilities of procedural skills (psychomotor skills, equipment use) between the first and last simulations in group B (Table 4). The total score of the GRS was not related to the number of years the participants had worked as nurses in prehospital emergency care (correlations coefficient −0.019).

## Discussion

As the results suggest, both group A, simulating four times during a six-month period, and group B, simulating twice during a six-month period, many of the assessments, examinations, and care actions were performed more frequently at the follow-up assessment.

In some cases, these improvements were statistically significant, and in other cases, there were tendencies towards improvements. This occurred more frequently in the group with more frequent simulation exercises, compared with the group with less frequent simulation exercises and could possibly suggests that more frequent simulation has a stronger effect on the learning of high-energy trauma skills. However, our study does not provide conclusive evidence regarding the specific effect of the frequency of simulation on the trauma skills of nurses in prehospital emergency care. Insufficient sample size may have contributed to this. The result shows that both frequencies of simulation interventions have a good effect on learning regarding certain care actions, but not all. The insufficient sample size of the study may at least partially be the reason for this. Alternatively, certain care actions are easier to "access" with simulation compared with others. The impact on the frequency of simulation on a range of care actions is important to clarify in further studies.

The time until participants stopped the bleeding of the patients' legs was shorter in both groups during the last simulation, which on the individual level can be directly lifesaving. The need to focus on preventing further blood loss or even exsanguination, in some extreme situations, even before securing an open airway, may save lives (Drew, Bennett, & Littlejohn, 2015). The use of a tourniquet as an initial intervention in the case of a major extremity haemorrhage is associated with a higher survival rate (Drew et al., 2015). It is noteworthy that the examination of the patients' head and the assessment of pupil reactions, despite the clinical improvement in group A, were seldom conducted by both groups in both the first and last simulations. According to Rubenson Wahlin (2016), this can be life threatening for the patient because patients suffering from severe trauma often also suffer from traumatic brain injuries. Because this, in turn, can have a major impact on the overall survival of the patient, it is vital to highlight this in the nurses' continuous trauma education.

The proportion of participants assessing the level of consciousness was as low as 19% in the last simulation in both groups. This is in line with the conclusions of

Rubenson Wahlin (2016); in their study, patients' level of consciousness was assessed in less than 40% of the cases. The importance of the assessment is to avoid under-triaging a patient with potentially serious injuries or over-triaging, which would strain trauma resources (Kupas, Melnychuk, & Young, 2016).

The proportion of participants applying a cervical collar increased in both groups, from the first to the last simulation. However, the use of cervical collars may not always be the best course of action (Sparke, Voss, & Benger, 2013). Intubation of the patient is made more difficult with the cervical collar (Schubl et al., 2016). The cervical collar has also been found to contribute to the lack of oxygen for the patient, due to the compression of the jugular vessels with decreasing venous returns (Leonard, Mao, & Jaffe, 2012). It is, therefore, a possibility that the research situation influenced the participants' decision. The participants know that the cervical collar is included in the PHTLS® concept and that the study was observing their trauma care that is supposed to be performed according to PHTLS®. It is also relevant to discuss.

Regarding time for leaving the scene, there were statistically significant improvements between first and last simulations in both group A and group B. The participants had a shorter stay at the scene of the accident during the last simulation that indicates that the interval in the simulation seemed to be enough in group B. Patients exposed to high-energy trauma require quick and competent care at the scene of the accident. The focus should be on the quality of care and not only on quick care. However, a haemodynamically unstable patient requires both high quality of care as well as rapid leave of the scene (Harmsen et al., 2015). Time to leave the scene in this study is associated with the total score of the GRS. Tendency for improvements was observed in both groups in the last simulation, somewhat more in group A. This suggests that participants, regardless of interventions, shortened the time at the scene of the accident and were more accurate in their care actions. Here, it is noteworthy that the time used on real-life scenes is generally markedly longer than in simulated scenarios (Van Dillen et al., 2016).

In the GRS dimensions, decision making, resource utilisation, and communication, there were improvements in care actions in both groups in the last simulation implying that the participants, regardless of intervention, had become more experienced with the situation as the primary nurse at the site and is the one making the decisions. The dimension resource utilisation consists of the ability to identify and use resources, such as the fire brigade, effectively (Tavares et al., 2013). The use of the fire brigade has prior been described as generating a sense of security for the nurse in prehospital emergency care (Abelsson and Lindwall, 2012). A well-functioning cooperation between all emergency care personnel at the accident site improves the chances of survival for the patient (Berlin and Carlström, 2015; Elmqvist et al., 2010).

## Limitations

In this study, time for securing the patient on the scoop stretcher was not included, nor was the time to insert an intravenous catheter. One limitation was that the ambulance crew often has access to fire brigade and police at the accident site. During the simulation, at the request of the participants, these resources were always 20 minutes away.

The nurses were randomly assigned the primary or secondary role in the simulation. This resulted in the primary nurse being a novice for existing circumstances, whereas the secondary nurse had experienced the scenario. It should be noted that the participants rarely realised it was the same simulated scenario.

The small sample size may have contributed to the fact that few statistically significant improvements were detected. With increased power, it may have been possible to detect differences, given that the results reveal a tendency towards higher scores in the last simulation. Further studies with more participants are needed.

One further limitation may be that nurses interested in trauma, and simulation of trauma care, were more likely to choose to participate in the study. This interest may indicate that they possessed slightly better knowledge of trauma care than others, who did not decide to participate, which can have affected the outcome.

## Conclusion

The study indicated statistically significant differences in scores within and between groups. The result suggested that repeated simulation may contribute to clinical improvements of the participants' trauma care at the individual level. This result suggests the need for further explorations of how learning in the trauma care setting may be best enabled by simulation.

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