

# BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email [info.bmjopen@bmj.com](mailto:info.bmjopen@bmj.com)

# BMJ Open

## Simulation training is an effective educational tool to teach the ABCDE primary assessment: a blinded longitudinal intervention study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032023
Article Type:	Research
Date Submitted by the Author:	29-May-2019
Complete List of Authors:	Drost- de Klerck, Amanda; Universitair Medisch Centrum Groningen, emergency department Olgers, Tycho; University Medical Center Groningen, Internal medicine, Emergency dept. van de Meeberg, Evelien; Universitair Medisch Centrum Groningen, emergency department Schonrock-Adema, Johanna; Universitair Medisch Centrum Groningen, emergency department ter Maaten, Jan; University Medical Center Groningen, Emergency Department, Department of internal medicine
Keywords:	ACCIDENT & EMERGENCY MEDICINE, EDUCATION & TRAINING (see Medical Education & Training), GENERAL MEDICINE (see Internal Medicine), MEDICAL EDUCATION & TRAINING

SCHOLARONE™  
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1  
2  
3 **Simulation training is an effective educational tool to teach**  
4 **the ABCDE primary assessment: a blinded longitudinal**  
5 **intervention study.**  
6  
7  
8  
9

10  
11  
12  
13  
14 *Amanda M Drost-de Klerck, Tycho J Olgers, Evelien K van de Meeberg, Johanna Schönrock-*  
15 *Adema, Jan C ter Maaten.*  
16  
17

18  
19  
20  
21  
22 *Emergency Department, University Medical Centre Groningen, Hanzeplein 1, 9713 GZ*  
23 *Groningen, The Netherlands, Amanda M Drost-de Klerck, Consultant Emergency Medicine.*  
24 *Emergency Department, University Medical Centre Groningen, Tycho J Olgers, Consultant*  
25 *Acute Internal Medicine. Emergency Department, University Medical Centre Groningen,*  
26 *Evelien K van de Meeberg, Consultant Emergency Medicine. University of Groningen,*  
27 *University Medical Centre Groningen, Institute for Medical Education, Johanna Schönrock-*  
28 *Adema, senior researcher. Emergency Department, University Medical Centre Groningen, Jan*  
29 *C ter Maaten, Full Professor Acute Internal Medicine.*  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44

45 **Word count: 2083**  
46  
47  
48

49 **Address for correspondence/request for reprints:**  
50

51 A.M. Drost-de Klerck  
52

53 Phone: +31503616161 / Fax: +31503611725  
54

55 Email: [a.drost@umcg.nl](mailto:a.drost@umcg.nl)  
56  
57  
58  
59  
60

### **Contributors**

AMDK and JCM have conceived the study and created the assessment form. AMDK, TJO, EKM and JCM collected the data. AMDK is guarantor and did the literature search, managed the data and performed data analysis and drafted the manuscript. JSA advised regarding to the data analysis. All authors contributed to the final manuscript, revision of the manuscript and final approval of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

### **Copyright/license for publication**

The corresponding author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to i) publish, reproduce, distribute, display and store the Contribution, ii) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution, iii) create any other derivative work(s) based on the Contribution, iv) to exploit all subsidiary rights in the Contribution, v) the inclusion of electronic links from the Contribution to third party material where-ever it may be located; and, vi) licence any third party to do any or all of the above."

### **Competing interests**

All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: no support from any organisation for the

1  
2  
3 submitted work; no financial relationships with any organisations that might have an interest  
4  
5 in the submitted work in the previous three years; no other relationships or activities that  
6  
7 could appear to have influenced the submitted work.  
8  
9

### 10 11 12 13 **Patient and public involvement**

14  
15 Participants of this study were not involved in the development of the research question,  
16  
17 design or outcome measures. Some participants of the study encouraged others to  
18  
19 participate, but they were all voluntarily included. The results of the study will be available  
20  
21 for the participants on request.  
22  
23  
24  
25

### 26 27 28 **Ethics approval**

29  
30 Ethics approval was not required because the study participants had signed up for a two day  
31  
32 course, the intervention, before they were asked to participate in the study. So, the  
33  
34 intervention was not on behalf of the study.  
35  
36  
37  
38  
39

### 40 41 42 **Transparency**

43  
44 We declare that the manuscript is honest, accurate and transparent. No important aspects  
45  
46 of the study have been omitted and discrepancies from the study as originally planned have  
47  
48 been explained.  
49  
50  
51

### 52 53 54 **Funding**

55  
56 The study was only funded by the Emergency Department of the University Medical Center  
57  
58 Groningen.  
59  
60

## ABSTRACT

**Objectives** To analyse the short- and long-term effectiveness of simulation training to acquire a structured Airway Breathing Circulation Disability Exposure (ABCDE) approach for medical emergencies; and to analyse which skills were learned and maintained best.

**Design** a blinded longitudinal intervention study.

**Setting** The skills center of the University Medical Centre Groningen.

**Participants** Thirty voluntary participants of a simulation-based course were included in this study. Their mean age was 27 years. Twenty-one female, nine male.

**Intervention** The intervention consisted of a two day ABCDE-teaching course for residents and non-residents. The course encompasses 24 simulations with a patient simulator in which participants perform primary assessments of acute ill patients.

Video recordings were taken of each participant performing a primary assessment, before (T1), directly after (T2) and three months after the intervention (T3).

**Main outcome measures** The performance on the primary assessment was measured by the mean total rank score, based on video recordings that were taken before (T1), directly after (T2) and three months after the intervention (T3). Two observers scored the videos using an assessment form, in random order and blinded to the measurement moment.

**Results** The Wilcoxon signed rank test showed that the performance on the primary assessment was much better directly after the course (mean total rank score T2 vs T1  $p < 0.000$ ) and this persisted till three months after the course for most skills. The skills that deteriorated 3 months after the course, remained significant better than before the course. Strikingly, most skills that decrease over time are skills related to communication and leadership.

**Conclusion**

1  
2  
3 Simulation training is an effective educational tool to teach doctors the ABCDE primary  
4 assessment. Communication skills decrease over time, so it could be useful to organize  
5  
6 refresher courses, team training or another kind of training with a focus on communication  
7  
8 and leadership.  
9  
10  
11  
12  
13  
14

### Strengths and limitations of this study

#### Strengths

- This is a longitudinal intervention study using the same environment for intervention and study.
- The observers rated the videos in random order and were blinded to the measurement moment.

#### Limitations

- A few skills were often scored as “does not apply”, which rendered the number of observations for those skills too few to analyse reliable differences. This was probably caused by the fact that scenarios contained a life threatening condition only in 3 of the 5 main items from the ABCDE. We think that this limitation wasn't of any influence on the results because when an item is scored often as “does not apply” it doesn't help to discriminate in quality of performance.
- The participants knew they were a study subject. We do not know if they have prepared for the study scenario. This might have influenced the study scores at T1 and T3.



**Key messages****What is already known on this subject?**

- Using a structured “Airway-Breathing-Circulation-Disability-Exposure” (ABCDE) approach in the primary assessment for early recognition and immediate treatment of life threatening conditions has become the standard approach in Medical Emergencies.
- Competence in the ABCDE approach is mainly trained using simulation training, while little research has been done to analyse the effectiveness of simulation training in acquiring this structural approach.

**What this study adds?**

- This is the first study investigating the effectiveness of simulation training aimed at teaching doctors a systematic primary assessment using the ABCDE approach.
- This study demonstrated that simulation training is effective in teaching the ABCDE approach.
- Strikingly, analysis of all separate skills showed that communications skills deteriorate the most over time.

## INTRODUCTION

### Background

In emergency medicine, assessing incoming patients in life threatening conditions following a structured approach is considered essential for successful resuscitation. A structured approach facilitates optimal use of time and resources for early recognition of deterioration, especially in the so-called 'golden hour', which refers to a time period of one hour or less following traumatic injury or medical emergency,[1, 2]. This golden hour during which resuscitation could be most beneficial has been recognized in several emergencies such as trauma, stroke, sepsis and shock,[3-5]. Using the structured approach "Airway-Breathing-Circulation-Disability-Exposure" (ABCDE) in the primary assessment for early recognition and immediate treatment of life threatening conditions has been the standard approach in trauma for decades and the use of the ABCDE primary assessment has also increased in other medical emergencies in recent years.

### Importance

Solid empirical evidence for the usefulness of the ABCDE approach and its clinical benefits to patients is limited,[5, 6]. Despite this, the Dutch inspection for healthcare (IGZ) requires that physicians treating non-trauma patients in the emergency department are ABCDE trained,[7].Therefore, completing an ABCDE course is mandatory for working on the ED. These courses usually contain lectures and simulation scenario training. Despite the wide use of simulation training for teaching the systematic ABCDE approach, little research has been done to analyse the effectiveness of simulation training in acquiring this structural approach. Simulation training has been proven to be effective for learning technical skills and maintaining skills that are not frequently used in daily practice, like airway management

1  
2  
3 and surgical skills,[8-10]. Simulation training can also improve communication, efficiency and  
4  
5 safety during teamwork,[11-13]. A few studies based on self-perceptions showed that  
6  
7 simulation training improved, participants confidence levels; they felt more competent in  
8  
9 applying the ABCDE approach and several other skills,[14-16].  
10  
11

12  
13 To our knowledge, it has not been investigated before whether simulation training actually  
14  
15 improves the doctors' skills in performing this structured approach.  
16  
17

18  
19  
20 Our study focused on the effectiveness of simulation training for learning the systematic  
21  
22 ABCDE approach. Our main goal was to analyse the short- and long-term effectiveness of  
23  
24 simulation training to acquire a structured ABCDE approach. Furthermore, we wanted to  
25  
26 analyse which skills and competences were acquired and maintained best.  
27  
28  
29  
30  
31  
32  
33  
34

## 35 **METHODS**

### 36 **Study design**

37  
38 We conducted an interventional cohort study. The intervention consisted of a two day  
39  
40 simulation-based ABCDE-teaching course for residents and non-residents. The  
41  
42 measurements through video recordings were obtained before (T1), directly after (T2) and  
43  
44 approximately three months after the intervention (T3).  
45  
46  
47

48  
49 Three simulation scenario's (I,II and III) with different medical emergencies were specifically  
50  
51 designed for this study, but were of comparable difficulty as the course simulation  
52  
53 scenario's. All simulations contained a life threatening condition in 3 of the 5 main items  
54  
55 from the ABCDE to offer variable and realistic scenarios with the same degree of difficulty.  
56  
57

58  
59 The simulations were offered in random order, to prevent bias caused by the type or  
60

1  
2  
3 difficulty of the simulation. This means that each participant received three different  
4  
5 simulations and the three simulations were equally divided over the three different time  
6  
7 measurements.  
8  
9

10 We developed an assessment form (Figure 1) to evaluate the participants' performance with  
11  
12 regard to skills and competences essential to medical emergencies. The assessment form  
13  
14 was divided in 5 categories according to the ABCDE structure. In each category, the skills or  
15  
16 competences could be rated on a 2 (agree, not agree) or 5-point scale (agree, partially agree,  
17  
18 partially not agree, not agree or does not apply).  
19  
20  
21  
22  
23  
24

### 25 **Intervention**

26  
27 The ABCDE course is a two-day course which exists for ten years now. It includes mainly  
28  
29 simulation training and two theoretical lectures about airway management and ALS.  
30  
31

32 Previous to this course, the participants receive a book with mandatory chapters describing  
33  
34 the ABCDE approach and various acute medical emergencies. The course encompasses 24  
35  
36 simulations with a patient simulator in which participants perform primary assessments of  
37  
38 acute ill patients. In 8 scenarios, they participate in the role as a physician; in the other  
39  
40 scenarios, they are in the role of “non-obstructing nurse” or observer.  
41  
42  
43

44 The participants receive a certificate if they pass the theoretical test and if they are,  
45  
46 according to the instructors, capable of performing a structured primary assessment of an  
47  
48 acute ill patient, with recognition and resuscitation of life-threatening conditions and clear  
49  
50 communication.  
51  
52  
53

### 54 **Study setting and population**

55  
56  
57  
58  
59  
60

1  
2  
3 We approached all participants of this two-day course to voluntarily participate in the study  
4  
5 between August 2012 and March 2014.  
6  
7

8 The study participants were invited to act in a simulation as physician at three different  
9  
10 moments, separate from the course. We instructed them to perform a primary assessment  
11  
12 following the ABCDE approach.  
13  
14

15 This study used the patient simulator Laerdal Resusci Anne SkillTrainer with an upgrade  
16  
17 Vitale Signs Sim Software Complete package, which is also used during the course. This  
18  
19 simulator features heart and lung sounds, chest excursions, pulses and can show all vital  
20  
21 signs on a separate monitor. With a separate computer, the sounds and vital signs can be  
22  
23 changed during the scenario, to simulate several acute medical conditions.  
24  
25

26  
27 During the video recordings, the simulator, materials and environment were the same as  
28  
29 during the course.  
30  
31  
32  
33  
34

### 35 **Study Protocol**

36  
37 The first recording (T1) was taken 1-2 weeks prior to the course. The second recording (T2)  
38  
39 was taken within 1 week after the course. The third and last recording (T3) was taken  
40  
41 approximately three months after the course.  
42  
43

44 The research team consisted of 5 physicians, who were also course instructors. They were all  
45  
46 instructed in detail to only facilitate the simulation and not help the participant in any way.  
47  
48

49 Two emergency physicians, who were also course instructors but who were not involved in  
50  
51 the recordings, independently rated the recorded primary assessments on the assessment  
52  
53 form (Figure 1). The observers rated the videos in random order and were blinded to the  
54  
55 measurement moment.  
56  
57  
58  
59  
60

## Measurements

The primary outcome of this study was the improvement in primary assessment scores of participants as a result of the ABCDE simulation training. We also investigated whether the skills acquired were maintained over a period of three months and which skills and competences were learned and maintained best.

## Data analysis

To perform the statistical analysis, IBM SPSS version 23.0 was used. In all analyses, a p-value of  $< 0.05$  was regarded as significant.

Each skill or competence on the assessment form had a lowest score of 0 and a highest score of 1, so the weight of each item was the same, independent of the 2 or 5 point scale (agree=1, partially agree=0.67, partially not agree=0.33, not agree=0).

Because some skills or competences were marked as not applicable, we calculate mean scores in each category (A, B, C, D, E and remaining items). In each category the maximal score to obtain was 1. Therefore the maximal total score to obtain on the primary assessment was 6.

The interobserver reliability between the scores given by the two observers for the three different time measurements was calculated using the Spearman's rank correlation test (for T1, T2 and T3 (resp. R 0.81, 0.61, and 0.80). This interobserver reliability was generally high enough to average the mean scores of the two observers for each participant at T1, T2 and T3 for use in further analyses.

We used the Friedman test for three related samples to compare the mean rank total score of the whole group on the primary assessment at T1, T2 and T3.

We used the Wilcoxon signed rank test to compare the mean rank total scores on the primary assessment and to compare each scored item separately between T1 and T2, between T2 and T3 and between T1 and T3, based on the performance of each individual participant.

## RESULTS

### Characteristics of study subjects

We enrolled thirty participants in this study. Twenty-one were female, nine were male. Their mean age was 27 years (range 24-35, SD 2.77), their mean work experience was 11 months (range 0-48, SD14.4).

The video recording of T3 of one participant was lost due to technical problems.

### Main results

The mean total scores on the primary assessment of the whole group at T1, T2 and T3 were 2.90, 5.06, and 4.67 respectively (Table 1 and Figure 2).

Table 1: Total scores on the primary assessment of the whole group at T1, T2 and T3

Time	Mean	SD	Median
1	2.90	0.88	2.79
2	5.06	0.48	5.22
3	4.67	0.75	4.70

Friedmans test showed that the mean rank total scores of the whole group on the primary assessment at T1, T2 en T3 were 1.14, 2.62 and 2.24, respectively. Wilcoxon signed rank test showed that the mean rank total score on the primary assessment at T2 (directly after the course) was significantly higher than the mean rank total score at T1 (before the course, table 2). The mean rank total score on the primary assessment at T3 (three months after the course) was significantly lower than the mean rank total score at T2, but remained significantly higher than the mean rank total score at T1 (Table 2).

Table 2: Wilcoxon rank test for the mean rank total score on the primary assessment

Difference	Significance
T1 < T2	P = 0.000
T2 > T3	P = 0.035
T3 > T1	P = 0.000

The separate skills or competences were almost all scored significantly higher at T2 than at T1 (36 out of 41). Only the score on “resuscitates adequately in the E” did not differ significantly between T1 and T2. The other 4 skills could not be analysed as they were scored too often as “does not apply” (Table 3).

The separate skills most often showed no significant difference between T2 and T3 (30 out of 41). The skills (7 out of 41), “mentions deviating findings in the C”, “recognizes life threatening conditions in the C”, “ mentions conclusions in the C”, “examines D completely”, “communicates clearly”, “shows confidence” and “shows good leadership” were scored



1  
2  
3 significantly lower at T3 than at T2, but significant higher than at T1 (Table 4). Again, the  
4  
5 other 4 skills could not be analysed as they were scored too often as “does not apply” (Table  
6  
7  
8 3).  
9  
10  
11  
12  
13

14 Table 3: Skills and competences that were not possible to analyse due to low numbers  
15

Skill/Competence
recognizes life-threatening conditions in the B
resuscitate adequately in the B
orders right additional diagnostics in the D
orders right additional diagnostics in the E

26  
27  
28  
29 Table 4: Wilcoxon signed rank test for separate skills and competences that decreased  
30  
31 between T2 and T3  
32

Skill/Competence	Difference	Significance
mentions deviating findings in the C	T2 > T3 and T1 < T3	P = 0.004 and P = 0.003
recognizes live-threatening conditions in the C	T2 > T3 and T1 < T3	P = 0.035 and P = 0.005
mentions conclusions in the C	T2 > T3 and T1 < T3	P = 0.044 and P = 0.002
examines the D completely	T2 > T3 and T1 < T3	P = 0.001 and P = 0.000
communicates clearly	T2 > T3 and T1 < T3	P = 0.010 and P = 0.000
shows confidence	T2 > T3 and T1 < T3	P = 0.019 and P = 0.000
shows good leadership	T2 > T3 and T1 < T3	P = 0.049 and P = 0.000

## DISCUSSION

Our study is the first to demonstrate the positive effect of teaching the ABCDE approach for medically ill patients using simulation. This effect persists even 3 months after completing the course although some decline in participant performance on the primary assessment was seen.

We found that most skills and competences are learned and maintained very well.

Strikingly, most skills (five out of seven) that decrease over time are skills related to communication and leadership (Table 4). This is illustrated by a decrease in time of “recognition of life threatening conditions in the C”, while the scores on the resuscitation skills did not decline. It is possible that the lower score reflect ‘not thinking out loud’ rather than failing to recognize a life threatening condition.

This decrease in communication suggests that focusing on communication and leadership by refresher courses or team training, after completing a simulation course, may be an important topic for physicians to maintain their skills. The positive effect of team training for these non-technical skills has already been shown,[11-13].

Another skill that does not yield scores as high as most other skills after three months, is a complete examination of the Disability. A possible explanation for this finding is that the participants decide on the level of consciousness of the patient, determined by the EMV (Glasgow coma score), whether it is necessary to examine certain components of the Disability. The performance of the EMV does not decrease over time. This finding is in line

1  
2  
3 with previous research from our group on primary assessment completeness showing that  
4  
5 during the primary assessment in the emergency department, residents and experienced  
6  
7 staff have equal, but not maximum ABCDE completeness scores (83 instead of 100),[17]. This  
8  
9 outcome may reflect that a score of 100 is not necessary to exclude potential life  
10  
11 threatening diseases or stabilize the patients.  
12  
13  
14  
15  
16

### 17 **Limitations**

18  
19  
20 It was not possible to assess all specific skills in each simulation due to reality of the  
21  
22 scenario. A few skills were often scored as “does not apply”, which rendered the number of  
23  
24 observations for those skills too few to analyse reliable differences. This was probably  
25  
26 caused by the fact that scenarios contained a life threatening condition only in 3 of the 5  
27  
28 main items from the ABCDE.  
29  
30

31  
32 We think that this limitation wasn't of any influence on the results because when an item is  
33  
34 scored often as “does not apply” it doesn't help to discriminate in quality of performance.  
35  
36 Finally, the participants knew they were a study subject. We do not know if they have  
37  
38 prepared for the study scenario. This might have influenced the study scores at T1 and T3.  
39  
40  
41  
42  
43  
44

### 45 **Conclusion**

46  
47 Simulation training is an effective educational tool to teach doctors to perform a structured  
48  
49 primary assessment using the ABCDE. Communication skills tend to decrease over time, so it  
50  
51 will be useful to organize refresher courses, team training or another kind of training with a  
52  
53 focus on communication and leadership.  
54  
55  
56  
57  
58  
59  
60

## Acknowledgements

We want to thank Kinge van der Heide for her help with the recordings. We want to thank Mirjam Doff-Holman and Martine Oosterloo for the assessment of all recordings.

## REFERENCES

1. Franklin C, Mathew J. Developing strategies to prevent in-hospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. *Crit Care Med* 1994;22:244-7.
2. McQuillan P, Pilkington S, Allan A, Taylor B, Short A, Morgan G, et al. Confidential inquiry into quality of care before admission to intensive care. *BMJ* 1998;316:1853-8.
3. Kumar A, Roberts D, Wood KE, Light B, Parrillo JE, Sharma S, et al. Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care Med* 2006;34:1589-96.
4. National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. *N Engl J Med* 1995;333:1581-7.
5. Soreide K. Three decades (1978-2008) of Advanced Trauma Life Support (ATLS) practice revised and evidence revisited. *Scand J Trauma Resusc Emerg Med* 2008;16:19,7241-16-19.
6. Jayaraman S, Sethi D, Chinnock P, Wong R. Advanced trauma life support training for hospital staff. *Cochrane Database Syst Rev* 2014;(8):CD004173. doi:CD004173.

1  
2  
3 7. Spoedeisende hulp: vanuit een stevige basis. Rapportage werkgroep levelindeling SEH.

4  
5 2009

6  
7  
8 <https://www.netwerkacutezorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH->

9  
10 [Vanuit-een-stevig-basis.pdf](#).

11  
12  
13 8. Ryu WHA, Dharampal N, Mostafa AE, Sharlin E, Kopp G, Jacobs WB, et al. Systematic  
14  
15 Review of Patient-Specific Surgical Simulation: Toward Advancing Medical Education. *J Surg*  
16  
17  
18 *Educ* 2017.

19  
20  
21 9. Price J, Naik V, Boodhwani M, Brandys T, Hendry P, Lam BK. A randomized evaluation of  
22  
23 simulation training on performance of vascular anastomosis on a high-fidelity in vivo model:  
24  
25 the role of deliberate practice. *J Thorac Cardiovasc Surg* 2011;142:496-503.

26  
27  
28 10. Kory PD, Eisen LA, Adachi M, Ribaud VA, Rosenthal ME, Mayo PH. Initial airway  
29  
30 management skills of senior residents: simulation training compared with traditional  
31  
32 training. *Chest* 2007;132:1927-31.

33  
34  
35 11. Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JD, van Wijk KP.  
36  
37 Interventions to improve team effectiveness: a systematic review. *Health Policy*  
38  
39 2010;94:183-95.

40  
41  
42 12. Hesselink G, Berben S, Beune T, Schoonhoven L. Improving the governance of patient  
43  
44 safety in emergency care: a systematic review of interventions. *BMJ Open*  
45  
46 2016;6:e009837,2015-009837.

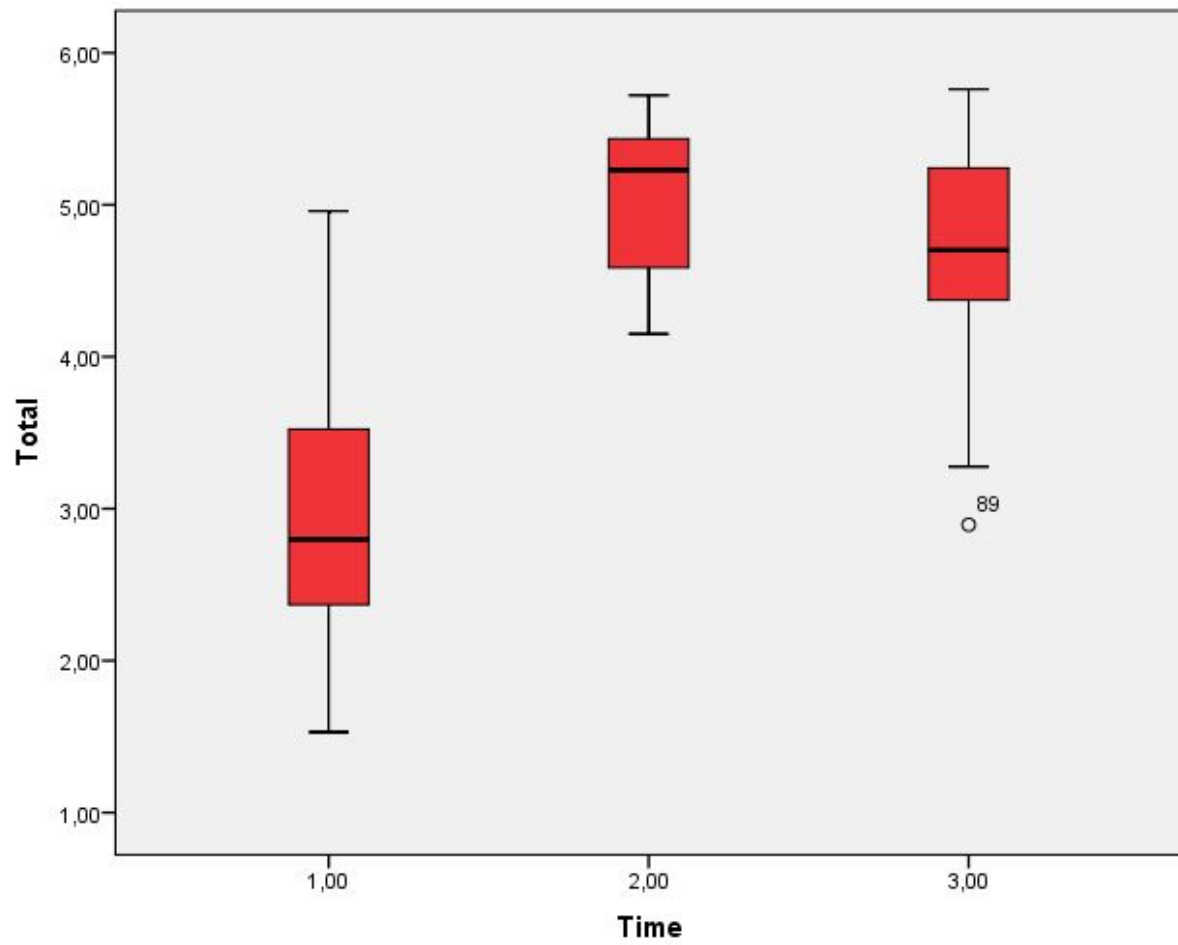
47  
48  
49 13. Shapiro MJ, Morey JC, Small SD, Langford V, Kaylor CJ, Jagminas L, et al. Simulation based  
50  
51 teamwork training for emergency department staff: does it improve clinical team  
52  
53 performance when added to an existing didactic teamwork curriculum?. *Qual Saf Health*  
54  
55  
56  
57  
58  
59  
60 *Care* 2004;13:417-21.

- 1  
2  
3 14. Willett TG, Kirlew M, Cardinal P, Karas P. An evaluation of the Acute Critical Events  
4  
5 Simulation (ACES) course for family medicine residents. *Can J Rural Med* 2011;16:89-95.  
6  
7  
8 15. Carling J. Are graduate doctors adequately prepared to manage acutely unwell patients?.  
9  
10 *Clin Teach* 2010;7:102-5.  
11  
12  
13 16. Pantelidis P, Staikoglou N, Paparoidamis G, Drosos C, Karamaroudis S, Samara A, et al.  
14  
15 Medical students' satisfaction with the Applied Basic Clinical Seminar with Scenarios for  
16  
17 Students, a novel simulation-based learning method in Greece. *J Educ Eval Health Prof*  
18  
19 2016;13:13.  
20  
21  
22  
23 17. Olgers TJ, Dijkstra RS, Drost-de Klerck AM, Ter Maaten JC. The ABCDE primary  
24  
25 assessment in the emergency department in medically ill patients: an observational pilot  
26  
27 study. *Neth J Med* 2017;75:106-11.  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 1: ABCDE Assessment Form

Primary assessment		
A	<ul style="list-style-type: none"> <li>- examines the airway</li> <li>- mentions threatened airway</li> <li>- applies airway maneuvers</li> <li>- applied oxygen</li> </ul>	agree / disagree agree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree/ d.n.a.
B	<ul style="list-style-type: none"> <li>- examines B completely (color, trachea, resp. rate, excursions, accessory muscle, percussion, auscultation, saturation)</li> <li>- gives nurse the right orders</li> <li>- mentions deviating findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostics</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitate adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7 - 8  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
C	<ul style="list-style-type: none"> <li>- examines C completely (acra, central pulse, heartrate, bloodpressure, cap.refill, CVD, heartsounds)</li> <li>- gives nurse the right orders</li> <li>- mentions deviating findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostics</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitate adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7  agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
D	<ul style="list-style-type: none"> <li>- examines D completely (EMV, pupils, meningitis, glucose)</li> <li>- applies EMC correctly</li> <li>- mentions deviating findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostics</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitate adequately</li> </ul>	1 - 2 - 3 - 4 agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
E	<ul style="list-style-type: none"> <li>- examines E completely (temperature, head-to toe)</li> <li>- gives nurse the right orders</li> <li>- mentions deviating findings</li> <li>- orders right additional diagnostics</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitate adequately</li> </ul>	1 - 2 agree / partially agree / partially disagree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
R E M A I N I N G	<ul style="list-style-type: none"> <li>- adequately asks for help</li> <li>- communicates clearly</li> <li>- summarizes adequately</li> <li>- draws the right conclusions</li> <li>- clinical reasoning is adequately</li> <li>- works structured</li> <li>- stays calm</li> <li>- shows confidence</li> <li>- shows good leadership</li> </ul>	agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree

Figure 2: Boxplot comparing Total score on primary assessment at T1, T2 and T3.





## Supplemental file: Wilcoxon signed rank test for all separate skills and competences

Wilcoxon		
Skill/Competence	Difference	Significance
examines the airway	T1<T2, T2=T3 and T1=T3	p=0.034, p=0.157 and p=0.206
mentions threatened airway	T1<T2, T2=T3 and T1<T3	p=0.008, p=1.000 and p=0.007
applies airway maneuvers	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.281 and p=0.001
applies oxygen	T1<T2, T2=T3 and T1<T3	p=0.006, p=0.739 and p=0.001
examines B completely	T1<T2, T2=T3 and T1<T3	p=0.001, p=0.210 and p=0.015
gives nurse the right orders in the B	T1<T2, T2=T3 and T1<T3	p=0.003, p=0.317 and p=0.003
mentions deviating findings in the B	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.119 and p=0.002
recognizes life-threatening conditions in B	T1<T2, T2=T3 and T1<T3	N= to low
orders right additional diagnostics in the B	T1<T2, T2=T3 and T1<T3	p=0.020 (n=15), p=1.000 (N=13) and p=0.031 N=14
mentions conclusions/interpretation in the B	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.192 and p=0.000
resuscitate adequately in the B	T1<T2, T2=T3 and T1<T3	N= to low
examines C completely	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.774 and p=0.001
gives nurse the right orders in the C	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.381 and p=0.000
mentions deviating findings in the C	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.004 and p=0.003
recognizes life-threatening conditions in C	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.035 and p=0.005
orders right additional diagnostics in the C	T1<T2, T2=T3 and T1=T3	p=0.016, p=0.083 and p=0.052
mentions conclusions/interpretation in the C	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.044 and p=0.002
resuscitate adequately in the C	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.637 and p=0.002
examines D completely	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.001 and p=0.000
applies EMV (Glasgow coma score) correctly	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.200 and p=0.021
mentions deviating findings in the D	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.117 and p=0.001
recognizes life-threatening conditions in D	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.108 and p=0.008
orders right additional diagnostics in the D	T1<T2, T2=T3 and T1<T3	N=to low
mentions conclusions/interpretation in the D	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.141 and p=0.000
resuscitate adequately in the D	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.230 and p=0.001
examines E completely	T1<T2, T2=T3 and T1<T3	p=0.003, p=0.465 and p=0.015
gives nurse the right orders in the E	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.059 and p=0.000
mentions deviating findings in the E	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.360 and p=0.000
orders right additional diagnostics in the E	T1<T2, T2=T3 and T1<T3	p=0.564 (N=5), N= to low

mentions conclusions/interpretation in the E	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.245 and p=0.000
resuscitate adequately in the E	T1<T2, T2=T3 and T1<T3	p=0.10 (N=13), p=0.139 (N=11), p=0.324 (N=13)
adequately asks for help	T1<T2, T2=T3 and T1<T3	p=0.005, p=0.768 and p=0.039
communicates clearly	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.010 and p=0.000
summarizes adequately	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.062 and p=0.000
draws the right conclusions	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.527 and p=0.000
clinical reasoning is adequately	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.398 and p=0.000
works structured	T1<T2, T2=T3 and T1<T3	p=0.000, p=0.490 and p=0.000
stays calm	T1<T2, T2=T3 and T1<T3	p=0.000, p=1.000 and p=0.000
shows confidence	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.010 and p=0.000
shows good leadership	T1<T2, T2>T3 and T1<T3	p=0.000, p=0.019 and p=0.000

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 4</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 7 and 8</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 8</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 8-9</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 9-10</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 9</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 8-10</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Page 11-12</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Page 8-11</b>
Study size	10	Explain how the study size was arrived at <b>(no effectsize known)</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 11-12</b> (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed <b>Page 11</b> (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy

(e) Describe any sensitivity analyses **Page 11 (interobserver reliability)**

For peer review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>Page 12</b> (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 11</b> (b) Indicate number of participants with missing data for each variable of interest <b>Page 12 and supplemental file</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <b>Page 12-14</b> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>Page 12-14, Table 1-4</b> (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 11 (interobserver reliability)</b>

**Discussion**

Key results	18	Summarise key results with reference to study objectives <b>Page 15-16</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>Page 16</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 15-16</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 16</b>

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>Page 3</b>
---------	----	---

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

1  
2 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE  
3 checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at  
4 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

For peer review only

# BMJ Open

## Use of simulation training to teach the ABCDE primary assessment: an observational study in a Dutch University Hospital with a 3-months follow up.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032023.R1
Article Type:	Original research
Date Submitted by the Author:	18-Sep-2019
Complete List of Authors:	Drost- de Klerck, Amanda; Universitair Medisch Centrum Groningen, emergency department Olgers, Tycho; University Medical Center Groningen, Internal medicine, Emergency dept. van de Meeberg, Evelien; Universitair Medisch Centrum Groningen, emergency department Schonrock-Adema, Johanna; Universitair Medisch Centrum Groningen, emergency department ter Maaten, Jan; University Medical Center Groningen, Emergency Department, Department of internal medicine
<b>Primary Subject Heading</b>:	Medical education and training
Secondary Subject Heading:	Emergency medicine
Keywords:	ACCIDENT & EMERGENCY MEDICINE, EDUCATION & TRAINING (see Medical Education & Training), GENERAL MEDICINE (see Internal Medicine), MEDICAL EDUCATION & TRAINING

SCHOLARONE™  
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

# Use of simulation training to teach the ABCDE primary assessment: an observational study in a Dutch University Hospital with a 3-months follow up.

*Amanda M Drost-de Klerck, Tycho J Olgers, Evelien K van de Meeberg, Johanna Schönrock-Adema, Jan C ter Maaten.*

*Emergency Department, University Medical Center Groningen, Hanzeplein 1, 9713 GZ Groningen, The Netherlands, Amanda M Drost-de Klerck, Consultant Emergency Medicine. Emergency Department, University Medical Center Groningen, Tycho J Olgers, Consultant Acute Internal Medicine. Emergency Department, University Medical Center Groningen, Evelien K van de Meeberg, Consultant Emergency Medicine. University of Groningen and University Medical Center Groningen, Institute for Medical Education, Johanna Schönrock-Adema, senior researcher. Emergency Department, University Medical Center Groningen, Jan C ter Maaten, Full Professor Acute Internal Medicine.*

**Word count:** 3116

**Address for correspondence/request for reprints:**

A.M. Drost-de Klerck

Phone: +31503616161 / Fax: +31503611725

Email: [a.drost@umcg.nl](mailto:a.drost@umcg.nl)

### Contributors

AMDK and JCM have conceived the study and created the assessment form. AMDK, TJO, EKM and JCM collected the data. AMDK is guarantor and did the literature search, managed the data and performed data analysis and drafted the manuscript. JSA advised regarding to the data analysis. All authors contributed to the final manuscript, revision of the manuscript and final approval of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

### Copyright/license for publication

The corresponding author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to i) publish, reproduce, distribute, display and store the Contribution, ii) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution, iii) create any other derivative work(s) based on the Contribution, iv) to exploit all subsidiary rights in the Contribution, v) the inclusion of electronic links from the Contribution to third party material where-ever it may be located; and, vi) licence any third party to do any or all of the above."

### Competing interests

All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: no support from any organisation for the

1  
2  
3 submitted work; no financial relationships with any organisations that might have an interest  
4  
5 in the submitted work in the previous three years; no other relationships or activities that  
6  
7 could appear to have influenced the submitted work.  
8  
9

### 10 11 12 **Ethics approval**

13  
14  
15 Ethics approval was not required because the study participants had signed up for a two-day  
16  
17 course, the intervention, before they were asked to participate in the study. So, the  
18  
19 intervention was not on behalf of the study.  
20  
21  
22

### 23 24 25 **Transparency**

26  
27 We declare that the manuscript is honest, accurate and transparent. No important aspects  
28  
29 of the study have been omitted and discrepancies from the study as originally planned have  
30  
31 been explained.  
32  
33  
34

### 35 36 37 **Funding**

38  
39 The study was only funded by the Emergency Department of the University Medical Center  
40  
41 Groningen.  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## ABSTRACT

**Objectives** To investigate short- and long-term effectiveness of simulation training to acquire a structured Airway Breathing Circulation Disability Exposure (ABCDE) approach for medical emergencies; and to examine which skills were learned and maintained best.

**Design** an observational intervention study with a 3-months follow-up.

**Setting** Skills centre of the University Medical Center Groningen.

**Participants** Thirty voluntary participants (mean age 27 years, 21 females, 9 males) of a simulation-based course.

**Intervention** A two-day ABCDE-teaching course for residents and non-residents. The course encompasses 24 simulations in which participants perform primary assessments of acute ill patients. Video recordings were taken of each participant performing a primary assessment, before (T1), directly after (T2) and three months after the intervention (T3).

**Main outcome measures** Physicians' performance in the ABCDE primary assessment at T1, T2 and T3. Two observers scored the primary assessments, blinded to measurement moment, using an assessment form to evaluate the performance with regard to skills essential for a structured ABCDE approach. The Friedman and Wilcoxon signed-rank test were used to compare physicians' performances on the subsequent measurement moments.

**Results** The mean rank scores on the primary assessment at T1, T2 and T3 were 1.14, 2.62 and 2.24, respectively (Table 1), and were significantly different, ( $p < 0.001$ ).

The mean rank scores on the total primary assessment directly after the course (T2 vs T1  $p < 0.001$ ) and three months after the course (T3 vs T1  $p < 0.001$ ) were significantly better than before the course. Certain skills deteriorated during the three months follow-up. Strikingly, most skills that decrease over time are Crew Resources Management (CRM)-skills.

## Conclusion

A course using simulation training is an effective educational tool to teach physicians the ABCDE primary assessment. Certain CRM-skills decrease over time, so we recommend organizing refresher courses, simulation team training or another kind of simulation training with a focus on CRM-skills.

### Strengths and limitations of this study

#### Strengths

- This is an observational intervention study measuring the 3-months effect of a simulation course.
- This study used the same environment for intervention and study.
- The observers were blinded to measurement moment during this study on participants' performance on the primary assessment using the ABCDE approach.

#### Limitations

- The fact that the observers might have been also the instructor of some study participants, may have influenced their ratings for a few participants, but potential bias was minimized by offering the videos in random order and blinded to measurement moment and our study focused on the outcomes at group level and not individual outcomes.
- There might be bias in the fact that we do not know if the participants have prepared for the study scenario at T1 and T3 (the Hawthorne effect), whereas preparation for T3 might result in an overestimation of the actual course effectiveness at follow-up, preparation at T1 might result in an underestimation of the effectiveness of the course on both T2 and T3.

## INTRODUCTION

### Background

In emergency medicine, assessing incoming patients in life-threatening conditions according to a structured approach is considered essential for successful resuscitation. The most widely used structured approach for early recognition and immediate treatment of life-threatening conditions is the “Airway-Breathing-Circulation-Disability-Exposure” (ABCDE) approach. The ABCDE approach is taught in the Advanced Trauma Life Support (ATLS) since 1978 and has been the standard approach in trauma since [1-3].

The use of the ABCDE primary assessment has also increased in other medical emergencies in recent years [4-7].

Using the ABCDE approach likely improves outcomes by helping health care professionals focus on the most life-threatening clinical problems and perform immediate resuscitation.

Although solid empirical evidence for the usefulness of the ABCDE approach and its clinical benefits to patients is limited[1, 2], the importance of early treatment in the so-called 'golden hour' – which refers to a time period of one hour or less following traumatic injury or medical emergency during which resuscitation could be most beneficial – has been recognized in several emergencies such as trauma, stroke, sepsis and shock [1-5, 8-11].

### Importance

The Dutch inspection for healthcare (IGZ) requires that physicians treating non-trauma patients in the emergency department are ABCDE qualified [12]. Therefore, completing an ABCDE course is mandatory for physicians who work at the Emergency Department (ED).

These courses usually contain lectures and simulation scenario training. Despite the wide use of simulation training for teaching the systematic ABCDE approach, little research has

1  
2  
3 been done to analyse the effectiveness of simulation training in acquiring this structural  
4  
5 approach. Simulation training has been proven to be effective for learning technical skills  
6  
7 and maintaining skills that are not frequently used in daily practice, like airway management  
8  
9 and surgical skills [13-15]. Simulation training can also improve communication, efficiency and  
10  
11 safety during teamwork [16-18]. A few studies based on self-perceptions showed that  
12  
13 simulation training improved participants' confidence levels; they felt more competent in  
14  
15 applying the ABCDE approach and several other skills [3, 19-21].  
16  
17

18  
19 To our knowledge, it has not been investigated before whether simulation training actually  
20  
21 improves physicians' skills in performing the structured ABCDE approach.  
22  
23  
24  
25

26  
27 Our study focused on the effectiveness of simulation training to acquire a structured ABCDE  
28  
29 approach. Our main goal was to analyse the short- and long-term effectiveness of simulation  
30  
31 training to acquire a structured ABCDE approach. We analysed the improvement in  
32  
33 physicians' primary assessment scores as a result of the ABCDE simulation training.  
34  
35

36  
37 We also investigated whether the skills acquired were maintained over a period of three  
38  
39 months and which skills and competences were learned and maintained best.  
40  
41  
42  
43  
44

## 45 **METHODS**

### 46 **Study design**

47  
48 We conducted an observational intervention study. The intervention consisted of a two-day  
49  
50 simulation-based ABCDE teaching course. The measurements through video recordings were  
51  
52 obtained before (T1), directly after (T2) and approximately three months after the  
53  
54 intervention (T3).  
55  
56  
57  
58  
59  
60

1  
2  
3 Three simulation scenarios (I, II and III) with different medical emergencies were specifically  
4 designed for this study. Scenario I was a case with pneumosepsis and hypoglycaemia, a  
5  
6 partially obstructed airway due to low consciousness and shock. Scenario II concerned a case  
7  
8 with obstructive shock caused by pulmonary embolism and an opioid overdose with altered  
9  
10 consciousness. Scenario III was a case with meningococcal sepsis with a partially obstructed  
11  
12 airway due to low consciousness, bronchospasm and shock. We have designed three  
13  
14 different and realistic scenarios with comparable difficulty by creating a life-threatening  
15  
16 condition which needs resuscitation in three of the five main items from the ABCDE.  
17  
18

19  
20 To prevent bias caused by the type or difficulty of the simulation, we varied the order in  
21  
22 which participants had to complete the three simulation scenarios in such a way that the  
23  
24 different scenario sequences were equally divided over T1, T2 and T3 (participant 1: T1  
25  
26 scenario A, T2 scenario B, T3 scenario C; participant 2: T1 scenario B, T2 scenario C, T3  
27  
28 scenario A; participant 3: T1 scenario C, T2 scenario A, T3 scenario B, etcetera). We made a  
29  
30 schedule in which the order of the scenarios was prescribed for each participant and  
31  
32 participants were divided over the schedule in order of inclusion.  
33  
34  
35  
36  
37  
38  
39

40 We developed an assessment form (Figure 1) to evaluate the participants' performance  
41  
42 regarding skills and competences essential to assess medical emergencies. The assessment  
43  
44 form was divided in six categories; five concerned the ABCDE structure and the sixth one  
45  
46 contained remaining items. The remaining items focus on some Crew Resources  
47  
48 Management (CRM) skills, like collaboration, communication, acknowledge own boundaries,  
49  
50 and leadership. In each category, the skills or competences could be rated on a two- (agree,  
51  
52 not agree, does not apply) or four-point scale (agree, partially agree, partially not agree, not  
53  
54 agree or does not apply). We have added the option "does not apply", because some skills  
55  
56 were not required in some simulation scenarios. In the categories B, C, D and E also the  
57  
58  
59  
60



1  
2  
3 number of examined items during the physical examination were scored. The following  
4  
5 items could be scored; in the B: skin color, trachea position, respiratory rate, thorax  
6  
7 excursions, breathing effort, lung percussion, lung auscultation and saturation; in the C:  
8  
9 circulation of extremities, central pulse, heart rate, blood pressure, capillary refill, central  
10  
11 venous pressure, heart sounds; in the D: Glasgow Coma Scale (EMV), pupils, neck stiffness,  
12  
13 glucose; in the E: temperature, head to toe examination (Figure 1).  
14  
15  
16  
17  
18  
19

## 20 **Intervention**

21  
22 The ABCDE course is a two-day course for non-residents and first year residents which exists  
23  
24 for ten years now. For most participants, it is a mandatory course that they need to pass  
25  
26 before they are allowed to work in the ED. The course consists mainly of simulation training  
27  
28 and two theoretical lectures about airway management and Advanced Life Support (ALS).  
29  
30 Previous to this course, the participants receive a book with chapters describing the ABCDE  
31  
32 approach and various acute medical emergencies.  
33  
34  
35

36  
37 The course focuses on learning to recognize and treat life-threatening conditions, but also  
38  
39 pays attention to some CRM-skills necessary for an efficient ABCDE approach.  
40  
41

42 This course is given in the skills centre in a room similar to a resuscitation room in the ED.

43  
44 The patient simulator used is a Laerdal Resusci Anne SkillTrainer with an upgrade Vitale Signs  
45  
46 Sim Software Complete package. This simulator features heart and lung sounds, chest  
47  
48 excursions, pulse and can show all vital signs on a separate monitor. With a separate  
49  
50 computer, the sounds and vital signs can be changed during the scenario, to simulate several  
51  
52 acute medical conditions.  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Each course group consists of six participants and two instructors. During the simulation  
4  
5 rounds the group is split in half and two scenarios are run simultaneously in two separate  
6  
7 rooms.  
8  
9

10 The course encompasses a total of 24 simulations with a patient simulator in which  
11  
12 participants perform the primary assessment of acute ill patients. In each scenario, the role  
13  
14 of physician, “non-obstructive nurse” and observer are assigned to the three participants.  
15  
16

17 One of the instructors operates the simulator and leads the debriefing afterwards.  
18  
19

20 In eight scenarios, the participants fulfil the role of physician; in the other scenarios, they  
21  
22 take up the role of “non-obstructing nurse” or observer.  
23  
24

25 The participants receive a certificate if they pass the theoretical test and if they are,  
26  
27 according to the instructors, capable of performing a structured primary assessment of an  
28  
29 acute ill patient, with recognition and resuscitation of life-threatening conditions and  
30  
31 adequate CRM-skills.  
32  
33

34 All course instructors are experts in the field of acute medicine, and experienced and  
35  
36 certified course instructors.  
37  
38  
39  
40  
41

## 42 **Study setting and population**

43

44 This study was conducted in the same skills centre as were the course took place. During the  
45  
46 video recordings, the simulator, materials and environment were also the same as during  
47  
48 the course.  
49  
50

51 We approached all participants prior to this two-day course by e-mail and invited them to  
52  
53 participate voluntarily in the study between August 2012 and December 2013. We  
54  
55 endeavoured to achieve a save response environment by a statement in the invitation e-mail  
56  
57 that declining to participate in the study would not influence their course results.  
58  
59  
60

1  
2  
3 The three measurement moments were scheduled in consultation with the participants,  
4  
5 separate from the course. For each measurement moment, study participants were  
6  
7 instructed to act in a simulation scenario as physician and to perform a primary assessment  
8  
9 according to the ABCDE approach. One of the researchers participated as “non-obstructive”  
10  
11 nurse and one researcher operated the simulator and computer.  
12  
13  
14  
15  
16

### 17 **Patient and public involvement**

18  
19  
20 Participants of this study were not involved in the development of the research question,  
21  
22 design or outcome measures. All participants of the study participated voluntarily.  
23  
24  
25

### 26 **Study Protocol**

27  
28  
29 The first recording (T1) took place one to two weeks prior to the course. The second  
30  
31 recording (T2) took place within one week after the course. The third recording (T3) took  
32  
33 place between three to four months after the course.  
34  
35

36  
37 The research team consisted of five physicians, who were also course instructors. They were  
38  
39 all instructed in detail to only facilitate the simulation and not help the participant in any  
40  
41 way.  
42  
43

44  
45 The observers were two emergency physicians, who were also course instructors, but who  
46  
47 were not part of the research team and therefore not involved in the recordings. The  
48  
49 observers received specific instructions how to score each item on the assessment form.  
50  
51 They independently rated the recorded primary assessments in random order and were  
52  
53 blinded to the measurement moment.  
54  
55  
56  
57  
58  
59  
60

## Measurements

Each skill or competence on the assessment form had a lowest score of 0 and a highest score of 1, so the weight of each item was the same, independent of the two- (0 = not agree, 1 = agree, not applicable = missing value) or four-point scale (agree=1, partially agree=0.67, partially not agree=0.33, not agree=0, not applicable = missing value) or the number of examined items during the physical examination.

Because some skills or competences were marked as not applicable, we calculated mean scores in each category (A, B, C, D, E and remaining items) based on the skills and competences which actually were applicable. In each category the maximal score to obtain was 1. Therefore, the maximal total score to obtain on the primary assessment for each scenario was 6 and the minimal score was 0.

## Data analysis

To perform the statistical analysis, IBM SPSS version 23.0 was used. In all analyses, a p-value of < 0.05 was regarded as significant.

The inter-observer reliability between the scores given by the two observers for the three different time measurements was calculated using the Spearman's rank correlation test (for T1, T2 and T3 (resp. R 0.81, 0.61, and 0.80). This inter-observer reliability was generally high enough to average the mean scores of the two observers for each participant at T1, T2 and T3 for use in further analyses.

We used the Friedman test for three related samples to analyse whether the total primary assessment scores of the entire group of participants differed between the three measurement moments. The Friedman test compares the mean rank scores at T1, T2 and

1  
2  
3 T3. The mean rank score is calculated by ranking the score of each participant on T1, T2 and  
4  
5 T3 and then calculating the mean rank of the entire group on T1, T2 and T3.  
6  
7

8 We used the Wilcoxon signed-rank test for two related samples to analyse whether the total  
9  
10 primary assessment scores of the entire group of participants differed between two  
11  
12 measurement moments and whether each skill or competence differed between two  
13  
14 measurement moments. The Wilcoxon signed-rank test also uses the mean rank scores.  
15  
16  
17

## 18 19 20 **RESULTS**

### 21 22 **Characteristics of study subjects**

23  
24 Between August 2012 and December 2013, 27 courses were given to six participants each.  
25  
26 From the total of 162 course participants 30 participants volunteered for this study. 21 were  
27  
28 female, nine were male. Their mean age was 27 years (range 24-35, SD 2.77), their mean  
29  
30 work experience was 11 months (range 0-48, SD14.4). Most participants did not have any  
31  
32 experience with simulation training at all (18 out of 30), some participants had done some  
33  
34 training in their own department, like ALS or Basic Life Support (BLS) (7 out of 30), from five  
35  
36 participants we do not know whether they had any experience with simulation training.  
37  
38  
39  
40 The video recording of T3 of one participant was lost due to technical problems.  
41  
42  
43  
44  
45  
46

### 47 48 **Main results**

49  
50 The mean scores on the total primary assessments were 2.90, 5.06, and 4.67 at T1, T2 and  
51  
52 T3 respectively (Table 1 and Figure 2). The maximal score possible was 6.  
53

54  
55 The mean rank scores of the entire group on the total primary assessments at T1, T2 en T3  
56  
57 were 1.14, 2.62 and 2.24, respectively (Table 1), and they were significantly different, ( $p <$   
58  
59 0.001).  
60

The mean rank score on the total primary assessment at T2 (directly after the course) was significantly higher than the mean rank score at T1 (before the course, table 1). The mean rank score on the total primary assessment at T3 (three months after the course) was significantly lower than the mean rank score at T2, but remained significantly higher than the mean rank score at T1 (Table 1).

Table 1: Scores on the total primary assessment of the whole group at T1, T2 and T3

Time	N	Mean	SD	Median	Mean rank score	Wilcoxon signed-rank test
1	30	2.90	0.88	2.79	1.14	T1 < T2, p<0.001
2	30	5.06	0.48	5.22	2.62	T2 > T3, p<0.05
3	29	4.67	0.75	4.70	2.24	T3 > T1, p<0.001

The separate skills or competences were almost all scored significantly higher at T2 than at T1 (36 out of 41). With respect to the remaining skills, four could not be included in our analyses as they were scored too often as “does not apply”, which rendered the number of observations for those skills < N=10, which was too low to ascertain differences in a reliable way. For only one skill – “resuscitates adequately in the E” – we did not find a significant difference between T1 and T2.

Most of the separate skills did not show significant differences between T2 and T3 (30 out of 41). The skills (7 out of 41), “mentions abnormal findings in the C”, “recognizes life threatening conditions in the C”, “mentions conclusions in the C”, “examines D completely”, “communicates clearly”, “shows confidence” and “shows good leadership” were scored significantly lower at T3 than at T2, but significantly higher than at T1 (Table 2).

Table 2: Outcomes for separate skills and competences that decreased between T2 and T3

Skill/Competence	Mean			SD			Wilcoxon signed-rank test		
	T1	T2	T3	T1	T2	T3	N=		
mentions abnormal findings in the C	0.52	0.94	0.82	0.33	0.11	0.18	29	T2 > T3 T1 < T3	p<0.01 p<0.01
recognizes live-threatening conditions in the C	0.50	0.95	0.84	0.42	0.15	0.31	28	T2 > T3 T1 < T3	p<0.05 p<0.01
mentions conclusions in the C	0.27	0.78	0.64	0.29	0.23	0.35	28	T2 > T3 T1 < T3	p<0.05 p<0.01
examines the D completely	0.36	0.87	0.70	0.34	0.17	0.26	29	T2 > T3 T1 < T3	p<0.01 p<0.001
communicates clearly	0.52	0.87	0.78	0.19	0.14	0.15	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows confidence	0.43	0.86	0.75	0.23	0.14	0.15	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows good leadership	0.54	0.89	0.82	0.22	0.13	0.13	29	T2 > T3 T1 < T3	p<0.05 p<0.001

## DISCUSSION

Our study is the first to show the effectiveness of a course using simulation to teach physicians the ABCDE approach for the assessment of medically ill patients. We found that the positive effect on performing a primary assessment according the ABCDE approach persisted even three months after completing the course.

Our findings corroborate outcomes of other studies showing that simulation training in health professions education was consistently associated with large effects on knowledge, skills and behaviour [22, 23]. Our findings are also in line with previous research showing that simulation training establishes, corrects, and confirms knowledge and skills of the ABCDE

1  
2  
3 approach and afterwards participants felt more competent in applying the ABCDE approach  
4  
5 [3, 19-21].  
6  
7

8 In the follow-up we found decline in participant performance on some skills of the primary  
9  
10 assessment. Strikingly, most skills that decrease over time are CRM-skills (Table 2). This is  
11  
12 illustrated by a decrease in time of “recognition of life-threatening conditions in the C”,  
13  
14 while the scores on the resuscitation skills did not decline. It is possible that this lower score  
15  
16 reflects ‘not thinking out loud’ rather than failing to recognize a life-threatening condition.  
17  
18 This decrease in CRM-skills suggests that focusing on CRM-skills by refresher courses or team  
19  
20 training, after completing a simulation course, may be an important topic for physicians to  
21  
22 maintain their skills. The positive effect of team training for these non-technical skills has  
23  
24 already been shown [16-18].  
25  
26  
27  
28  
29

30 Another skill that does not yield scores as high as most other skills after three months, is a  
31  
32 complete examination of the Disability. A possible explanation for this finding is that the  
33  
34 participants decide on the level of consciousness of the patient, determined by the EMV,  
35  
36 whether it is necessary to examine certain components of the Disability. The performance of  
37  
38 the EMV does not decrease over time. This finding is in line with previous research from our  
39  
40 group on primary assessment completeness showing that during the primary assessment in  
41  
42 the emergency department, residents and experienced staff have equal, but not maximum  
43  
44 ABCDE completeness scores (83 instead of 100) [7]. Fernandez et al. also showed that  
45  
46 professional lifeguards failed to fully perform the ABCDE sequence after simulation training  
47  
48 and spend more time in the Circulation step, because they spent more time in steps  
49  
50 considered most important [5].  
51  
52  
53  
54  
55

56 These outcomes may reflect that a score of 100 on the ABCDE approach is not necessary to  
57  
58 exclude potential life-threatening diseases or stabilize the patients.  
59  
60



## Limitations

It is not possible to define the impact of the book and the lectures that are also part of the course, on the measured improvements in performance on the primary assessment.

Outcomes from the regular course evaluation – not part of this study – indicated that the simulation training was the most powerful educational tool and accounted for most of the improvements. This feedback is in line with previous research showing that adding simulation training to a curriculum with lectures of medical students is associated with higher oral exam scores and higher overall course grades [22].

This study evaluated a course with instructors who are experts in the field of acute medicine, and experienced and certified course instructors. It is known that simulation-based education is most effective if guided by a safe and efficient debriefing and that debriefing can be challenging [23, 24]. We do not know if simulation training with debriefing by less experienced instructors may have less effect.

Another limitation of this study is that it was not possible to assess all specific skills in each simulation scenario, because they were often scored as “does not apply”. This limitation probably did not influence the results because items scored often as “does not apply” do not impact on discriminating in quality of performance.

The observers may have been the instructor during the course of some study participants and we cannot exclude that this may have influenced their ratings for some of them. This potential bias was minimized by offering the videos in random order and blinding the observers to measurement moment. Also, our study focused on the outcomes at group level and not individual outcomes.

1  
2  
3 Finally, the participants knew they were a study subject and when the recordings were  
4  
5 scheduled. We do not know if they prepared for the study scenarios. Modifying behaviour in  
6  
7 response to the awareness of being observed is known as the Hawthorne effect. This may  
8  
9 have influenced the study scores at T1 and T3, whereas preparation for T3 might result in an  
10  
11 overestimation of the actual course effectiveness at follow-up, preparation at T1 might  
12  
13 result in an underestimation of the effectiveness of the course on both T2 and T3.  
14  
15  
16  
17  
18  
19

## 20 **Conclusion**

21  
22 A course with simulation training is an effective educational tool to teach physicians to  
23  
24 perform a structured primary assessment using the ABCDE. This competence is largely  
25  
26 remained after three months. CRM-skills tend to decrease over time, so we recommend  
27  
28 organizing refresher courses, simulation team training or another kind of simulation training  
29  
30 with a focus on CRM-skills.  
31  
32  
33  
34  
35  
36

## 37 **Figure legend**

38  
39 Figure 1 Assessment form used by the observers.  
40  
41

42 Figure 2 Boxplot comparing mean score on primary assessment at T1, T2 and T3.  
43  
44  
45  
46

## 47 **Data sharing statement**

48  
49 Unpublished statistical data will be available on request to the corresponding author.  
50  
51  
52  
53

## 54 **Acknowledgements**

55  
56 We want to thank Kinge van der Heide for her help with the recordings. We want to thank  
57  
58 Mirjam Doff-Holman and Martine Oosterloo for the assessment of all recordings.  
59  
60

**REFERENCES**

- 1 Soreide K. Three decades (1978-2008) of Advanced Trauma Life Support (ATLS) practice revised and evidence revisited. *Scand J Trauma Resusc Emerg Med* 2008;16:19,7241-16-19 doi:10.1186/1757-7241-16-19 [doi].
- 2 Jayaraman S, Sethi D, Chinnock P, et al. Advanced trauma life support training for hospital staff. *Cochrane Database Syst Rev* 2014;(8):CD004173. doi:CD004173 doi:10.1002/14651858.CD004173.pub4 [doi].
- 3 Abellsson A, Rystedt I, Suserud B, et al. Learning High-Energy Trauma Care Through Simulation. *CLIN SIMULATION NURS* 2018;17:1-6 doi:10.1016/j.ecns.2017.11.009.
- 4 Thim T, Krarup NHV, Grove EL, et al. Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. *Int J Gen Med* 2012;5:117-21 doi:10.2147/IJGM.S28478.
- 5 Fernández-Méndez F, Otero-Agra M, Abelairas-Gómez C, et al. ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross sectional simulation study. *PLoS ONE* 2019;14 doi:10.1371/journal.pone.0212080.
- 6 Ilgen JS, Sherbino J, Cook DA. Technology-enhanced simulation in emergency medicine: a systematic review and meta-analysis. *Acad Emerg Med* 2013;20:117-27 doi:10.1111/acem.12076 [doi].
- 7 Olgers TJ, Dijkstra RS, Drost-de Klerck AM, et al. The ABCDE primary assessment in the emergency department in medically ill patients: an observational pilot study. *Neth J Med* 2017;75:106-11.
- 8 Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. *Crit Care Med* 1994;22:244-7.
- 9 McQuillan P, Pilkington S, Allan A, et al. Confidential inquiry into quality of care before admission to intensive care. *BMJ* 1998;316:1853-8.

1  
2  
3 10 Kumar A, Roberts D, Wood KE, et al. Duration of hypotension before initiation of effective  
4 antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care*  
5 *Med* 2006;34:1589-96 doi:10.1097/01.CCM.0000217961.75225.E9 [doi].  
6  
7

8  
9 11 National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue  
10 plasminogen activator for acute ischemic stroke. *N Engl J Med* 1995;333:1581-7  
11 doi:10.1056/NEJM199512143332401 [doi].  
12  
13

14  
15 12 Spoedeisende hulp: vanuit een stevige basis. Rapportage werkgroep levelindeling SEH.  
16 2009

17  
18 [https://www.netwerkacutezorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-](https://www.netwerkacutezorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf)  
19 [Vanuit-een-stevig-basis.pdf](https://www.netwerkacutezorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf).  
20  
21

22  
23 13 Ryu WHA, Dharampal N, Mostafa AE, et al. Systematic Review of Patient-Specific Surgical  
24 Simulation: Toward Advancing Medical Education. *J Surg Educ* 2017 doi:S1931-  
25 7204(16)30269-0 [pii].  
26  
27

28  
29 14 Price J, Naik V, Boodhwani M, et al. A randomized evaluation of simulation training on  
30 performance of vascular anastomosis on a high-fidelity in vivo model: the role of deliberate  
31 practice. *J Thorac Cardiovasc Surg* 2011;142:496-503 doi:10.1016/j.jtcvs.2011.05.015 [doi].  
32  
33

34  
35 15 Kory PD, Eisen LA, Adachi M, et al. Initial airway management skills of senior residents:  
36 simulation training compared with traditional training. *Chest* 2007;132:1927-31 doi:S0012-  
37 3692(15)52468-9 [pii].  
38  
39

40  
41 16 Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JD, et al. Interventions to  
42 improve team effectiveness: a systematic review. *Health Policy* 2010;94:183-95  
43 doi:10.1016/j.healthpol.2009.09.015 [doi].  
44  
45

46  
47 17 Hesselink G, Berben S, Beune T, et al. Improving the governance of patient safety in  
48 emergency care: a systematic review of interventions. *BMJ Open* 2016;6:e009837,2015-  
49 009837 doi:10.1136/bmjopen-2015-009837 [doi].  
50  
51

52  
53 18 Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency  
54 department staff: does it improve clinical team performance when added to an existing  
55 didactic teamwork curriculum?. *Qual Saf Health Care* 2004;13:417-21 doi:13/6/417 [pii].  
56  
57

58  
59 19 Willett TG, Kirlew M, Cardinal P, et al. An evaluation of the Acute Critical Events  
60 Simulation (ACES) course for family medicine residents. *Can J Rural Med* 2011;16:89-95.

1  
2  
3 20 Carling J. Are graduate doctors adequately prepared to manage acutely unwell patients?  
4 *Clin Teach* 2010;7:102-5 doi:10.1111/j.1743-498X.2010.00341.x [doi].  
5  
6

7 21 Pantelidis P, Staikoglou N, Pappas G, et al. Medical students' satisfaction with the  
8 Applied Basic Clinical Seminar with Scenarios for Students, a novel simulation-based learning  
9 method in Greece. *J Educ Eval Health Prof* 2016;13:13 doi:10.3352/jeehp.2016.13.13 [doi].  
10  
11  
12

13 22 Frallicciardi A, Fried J, Regan T, et al. A comparison of traditional lecture to simulation  
14 based cases for emergency medicine education among fourth year medical students. *Acad*  
15 *Emerg Med* 2012;19:S386 doi:10.1111/j.1553-2712.2012.01332.x.  
16  
17  
18

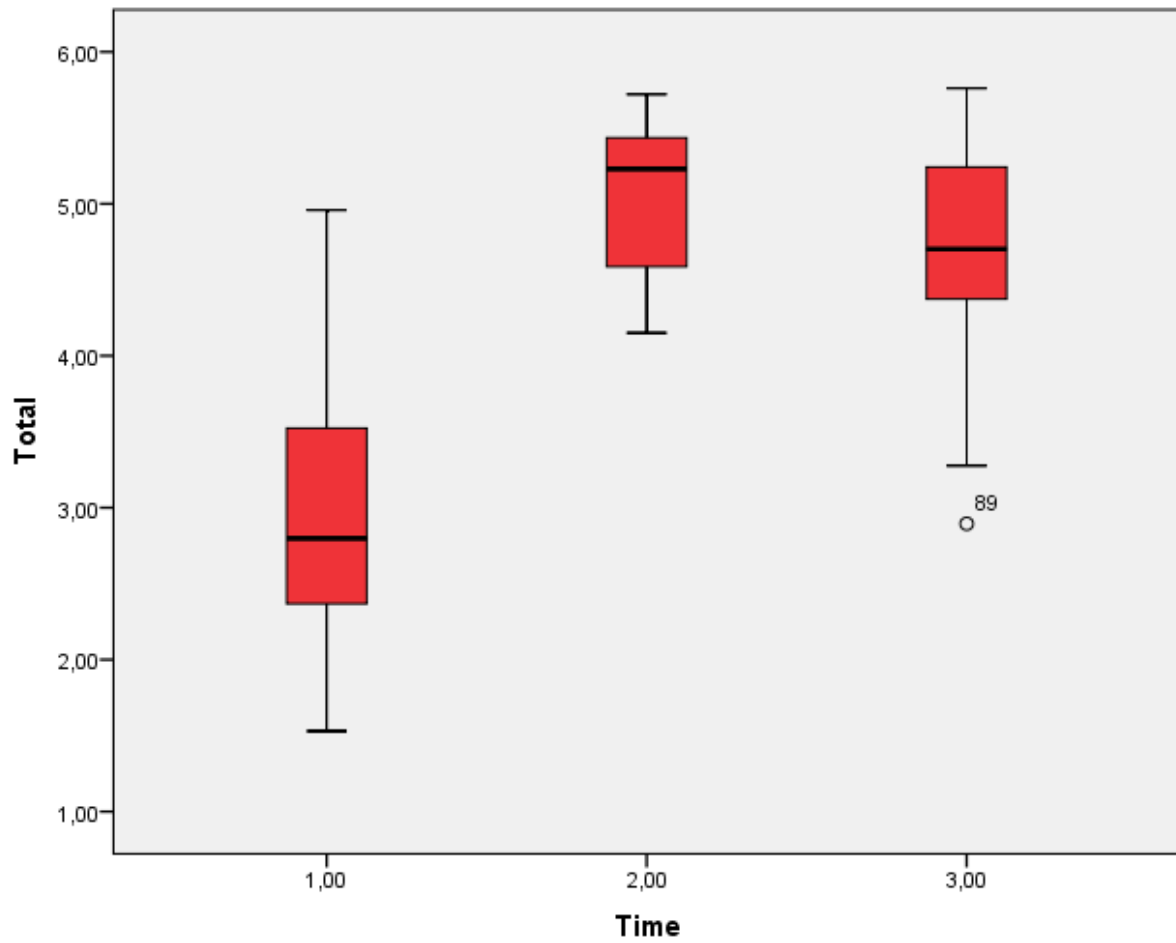
19 23 Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health  
20 professions education: a systematic review and meta-analysis. *JAMA* 2011;306:978-88  
21 doi:10.1001/jama.2011.1234 [doi].  
22  
23  
24

25 24 Grant VJ, Robinson T, Catena H, et al. Difficult debriefing situations: A toolbox for  
26 simulation educators. *Med Teach* 2018;40:703-12 doi:10.1080/0142159X.2018.1468558.  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 1 Assessment form used by the observers.

Primary assessment		
A	<ul style="list-style-type: none"> <li>- examines the airway</li> <li>- mentions obstructed airway</li> <li>- applies airway maneuvers</li> <li>- applies oxygen</li> </ul>	agree / disagree agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a.
B	<ul style="list-style-type: none"> <li>- examines B completely (color, trachea, resp. rate, excursions, breathing effort, percussion, auscultation, saturation)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7 - 8  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
C	<ul style="list-style-type: none"> <li>- examines C completely (circulation of extremities, central pulse, heart rate, blood pressure, cap.refill, CVP, heart sounds)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7  agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
D	<ul style="list-style-type: none"> <li>- examines D completely (Glasgow Coma Scale, pupils, neck stiffness, glucose)</li> <li>- applies EMC correctly</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4  agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
E	<ul style="list-style-type: none"> <li>- examines E completely (temperature, head to toe)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
R E M A I N I N G	<ul style="list-style-type: none"> <li>- asks for help adequately</li> <li>- communicates clearly</li> <li>- summarizes adequately</li> <li>- draws the right conclusions</li> <li>- clinical reasoning is adequate</li> <li>- works structured</li> <li>- stays calm</li> <li>- shows confidence</li> <li>- shows good leadership</li> </ul>	agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree

Figure 2 Boxplot comparing mean score on total primary assessment at T1, T2 and T3.



## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 4</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 6 and 7</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 7</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 7-9</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 9-10</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 7-11</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 7-12</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Page 7-12</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Page 7-12</b>
Study size	10	Explain how the study size was arrived at <b>(no effectsize known)</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 12-13</b> (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed <b>Page 12</b> (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed



1  
2 *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy  
3

---

4 (e) Describe any sensitivity analyses **Page 12 (interobserver reliability)**  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

For peer review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>Page 13</b> (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 13</b> (b) Indicate number of participants with missing data for each variable of interest <b>Page 13 and supplemental file Outcome</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <b>Page 13-15</b> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>Page 13-15, Table 1 and 2</b> (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 12 (interobserver reliability)</b>

**Discussion**

Key results	18	Summarise key results with reference to study objectives <b>Page 15-16</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>Page 17-18</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 15-18</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 15-18</b>

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>Page 3</b>
---------	----	---

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

1  
2 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE  
3 checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at  
4 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

For peer review only

# BMJ Open

## Use of simulation training to teach the ABCDE primary assessment: an observational study in a Dutch University Hospital with a 3-months follow up.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032023.R2
Article Type:	Original research
Date Submitted by the Author:	28-Dec-2019
Complete List of Authors:	Drost- de Klerck, Amanda; Universitair Medisch Centrum Groningen, emergency department Olgers, Tycho; University Medical Center Groningen, Internal medicine, Emergency dept. van de Meeberg, Evelien; Universitair Medisch Centrum Groningen, emergency department Schonrock-Adema, Johanna; Universitair Medisch Centrum Groningen, emergency department ter Maaten, Jan; University Medical Center Groningen, Emergency Department, Department of internal medicine
<b>Primary Subject Heading</b>:	Medical education and training
Secondary Subject Heading:	Emergency medicine
Keywords:	ACCIDENT & EMERGENCY MEDICINE, EDUCATION & TRAINING (see Medical Education & Training), GENERAL MEDICINE (see Internal Medicine), MEDICAL EDUCATION & TRAINING

SCHOLARONE™  
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

# Use of simulation training to teach the ABCDE primary assessment: an observational study in a Dutch University Hospital with a 3-months follow up.

*Amanda M Drost-de Klerck, Tycho J Olgers, Evelien K van de Meeberg, Johanna Schönrock-Adema, Jan C ter Maaten.*

*Emergency Department, University Medical Center Groningen, Hanzeplein 1, 9713 GZ Groningen, The Netherlands, Amanda M Drost-de Klerck, Consultant Emergency Medicine. Emergency Department, University Medical Center Groningen, Tycho J Olgers, Consultant Acute Internal Medicine. Emergency Department, University Medical Center Groningen, Evelien K van de Meeberg, Consultant Emergency Medicine. University of Groningen and University Medical Center Groningen, Institute for Medical Education, Johanna Schönrock-Adema, senior researcher. Emergency Department, University Medical Center Groningen, Jan C ter Maaten, Full Professor Acute Internal Medicine.*

**Word count:** 3414

**Address for correspondence/request for reprints:**

A.M. Drost-de Klerck

Phone: +31503616161 / Fax: +31503611725

Email: [a.drost@umcg.nl](mailto:a.drost@umcg.nl)

### **Contributors**

AMDK and JCM have conceived the study and created the assessment form. AMDK, TJO, EKM and JCM collected the data. AMDK is guarantor and did the literature search, managed the data and performed data analysis and drafted the manuscript. JSA advised regarding to the data analysis. All authors contributed to the final manuscript, revision of the manuscript and final approval of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

### **Copyright/license for publication**

The corresponding author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to i) publish, reproduce, distribute, display and store the Contribution, ii) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution, iii) create any other derivative work(s) based on the Contribution, iv) to exploit all subsidiary rights in the Contribution, v) the inclusion of electronic links from the Contribution to third party material where-ever it may be located; and, vi) licence any third party to do any or all of the above."

### **Competing interests**

All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: no support from any organisation for the

1  
2  
3 submitted work; no financial relationships with any organisations that might have an interest  
4  
5 in the submitted work in the previous three years; no other relationships or activities that  
6  
7 could appear to have influenced the submitted work.  
8  
9

### 10 11 12 13 **Ethics approval**

14  
15 Ethical approval was waived by our medical ethics committee (METc UMC Groningen) as this  
16  
17 research is educational research. We have received an independent review board  
18  
19 declaration from our medical ethics committee, which declares that this study fulfills all the  
20  
21 requirements for patient anonymity and is in agreement with regulations of our University  
22  
23 Hospital.  
24  
25  
26  
27  
28  
29

### 30 31 **Transparency**

32  
33 We declare that the manuscript is honest, accurate and transparent. No important aspects  
34  
35 of the study have been omitted and discrepancies from the study as originally planned have  
36  
37 been explained.  
38  
39  
40  
41

### 42 43 **Funding**

44  
45 The study was only funded by the Emergency Department of the University Medical Center  
46  
47 Groningen.  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



## ABSTRACT

**Objectives** To investigate short- and long-term effectiveness of simulation training to acquire a structured Airway Breathing Circulation Disability Exposure (ABCDE) approach for medical emergencies; and to examine which skills were learned and maintained best.

**Design** an observational study with a 3-months follow-up.

**Setting** Skills centre of the University Medical Center Groningen.

**Participants** Thirty voluntary participants (21 females & 9 males;  $27 \pm 2.77$  years) of a simulation-based course.

**Intervention** A two-day ABCDE-teaching course for residents and non-residents. The course encompasses 24 simulations in which participants perform primary assessments of acute ill patients. Video recordings were taken of each participant performing a primary assessment, before (T1), directly after (T2) and three months after the intervention (T3).

**Main outcome measures** Physicians' performance in the ABCDE primary assessment at T1, T2 and T3. Two observers scored the primary assessments, blinded to measurement moment, using an assessment form to evaluate the performance with regard to skills essential for a structured ABCDE approach. The Friedman and Wilcoxon signed-rank test were used to compare physicians' performances on the subsequent measurement moments.

**Results** The mean rank scores on the total primary assessment at T1, T2 and T3 were 1.14, 2.62 and 2.24, respectively, and were significantly different, ( $p < 0.001$ ).

The mean rank scores on the total primary assessment directly after the course (T2 vs. T1  $p < 0.001$ ) and three to four months after the course (T3 vs. T1  $p < 0.001$ ) were significantly better than before the course. Certain skills deteriorated during the follow-up. Strikingly, most skills that decrease over time are Crew Resources Management (CRM)-skills.

## Conclusion

A course using simulation training is an effective educational tool to teach physicians the ABCDE primary assessment. Certain CRM-skills decrease over time, so we recommend organizing refresher courses, simulation team training or another kind of simulation training with a focus on CRM-skills.

### Strengths and limitations of this study

#### Strengths

- This is an observational intervention study measuring the 3-months effect of a simulation course.
- This study used the same environment for intervention and study.
- The observers were blinded to measurement moment during this study on participants' performance on the primary assessment using the ABCDE approach.

#### Limitations

- The fact that the observers might have been also the instructor of some study participants, may have influenced their ratings for a few participants, but potential bias was minimized by offering the videos in random order and blinded to measurement moment, analysis showed a generally high inter-observer reliability and our study focused on the outcomes at group level and not individual outcomes.
- There might be bias in the fact that we do not know if the participants have prepared for the study scenario at T1 and T3 (the Hawthorne effect), whereas preparation for T3 might result in an overestimation of the actual course effectiveness at follow-up, preparation at T1 might result in an underestimation of the effectiveness of the course on both T2 and T3.

## INTRODUCTION

### Background

In emergency medicine, assessing incoming patients in life-threatening conditions according to a structured approach is considered essential for successful resuscitation. The most widely used structured approach for early recognition and immediate treatment of life-threatening conditions is the “Airway-Breathing-Circulation-Disability-Exposure” (ABCDE) approach. The ABCDE approach is taught in the Advanced Trauma Life Support (ATLS) since 1978 and has been the standard approach in trauma since [1-3].

The use of the ABCDE primary assessment has also increased in other medical emergencies in recent years [4-7].

Using the ABCDE approach likely improves outcomes by helping health care professionals focus on the most life-threatening clinical problems and perform immediate resuscitation.

Although solid empirical evidence for the usefulness of the ABCDE approach and its clinical benefits to patients is limited[1, 2], the importance of early treatment has been recognized in several emergencies such as trauma, stroke, sepsis and shock [1-5, 8-11].

### Importance

The Dutch inspection for healthcare requires that physicians treating non-trauma patients in the emergency department are ABCDE qualified [12]. Therefore, completing an ABCDE course is mandatory for physicians who work at the Emergency Department (ED). These courses usually contain lectures and simulation scenario training. Despite the wide use of simulation training for teaching the systematic ABCDE approach, little research has been done to analyse the effectiveness of simulation training in acquiring this structural approach.

Simulation training has been proven to be effective for learning technical skills and

1  
2  
3 maintaining skills that are not frequently used in daily practice, like airway management and  
4  
5 surgical skills [13-15]. Simulation training can also improve communication, efficiency and  
6  
7 safety during teamwork [16-18]. A few studies based on self-perceptions showed that  
8  
9 simulation training improved participants' confidence levels; they felt more competent in  
10  
11 applying the ABCDE approach and several other skills [3, 19-21].  
12  
13

14  
15 To our knowledge, it has not been investigated before whether simulation training actually  
16  
17 improves physicians' skills in performing the structured ABCDE approach.  
18  
19

20  
21  
22 Our study focused on the effectiveness of simulation training to acquire a structured ABCDE  
23  
24 approach. Our main goal was to analyse the short- and long-term effectiveness of simulation  
25  
26 training to acquire a structured ABCDE approach. We analysed the improvement in  
27  
28 physicians' primary assessment scores as a result of the ABCDE simulation training.  
29  
30 We also investigated whether the skills acquired were maintained over a period of three  
31  
32 months and which skills and competences were learned and maintained best.  
33  
34  
35  
36  
37  
38  
39

## 40 **METHODS**

### 41 **Study design**

42  
43 We conducted an observational intervention study. The intervention consisted of a two-day  
44  
45 simulation-based ABCDE teaching course. The measurements through video recordings were  
46  
47 obtained before (T1), directly after (T2) and 3-4 months after the intervention (T3).  
48  
49

50  
51 Three simulation scenarios (A, B and C) with different medical emergencies were specifically  
52  
53 designed for this study. Scenario A was a case with pneumosepsis and hypoglycaemia, a  
54  
55 partially obstructed airway due to low consciousness and shock. Scenario B concerned a case  
56  
57 with obstructive shock caused by pulmonary embolism and an opioid overdose with altered  
58  
59  
60

1  
2  
3 consciousness. Scenario C was a case with meningococcal sepsis with a partially obstructed  
4  
5 airway due to low consciousness, bronchospasm and shock. We have designed three  
6  
7 different and realistic scenarios with comparable difficulty by creating a life-threatening  
8  
9 condition which needs resuscitation in three of the five main items from the ABCDE.  
10  
11

12 To prevent bias caused by the type or difficulty of the simulation, we varied the order in  
13  
14 which participants had to complete the three simulation scenarios in such a way that the  
15  
16 different scenario sequences were equally divided over T1, T2 and T3 (participant 1: T1  
17  
18 scenario A, T2 scenario B, T3 scenario C; participant 2: T1 scenario B, T2 scenario C, T3  
19  
20 scenario A; participant 3: T1 scenario C, T2 scenario A, T3 scenario B, etcetera). We made a  
21  
22 schedule in which the order of the scenarios was prescribed for each participant and  
23  
24 participants were divided over the schedule in order of inclusion.  
25  
26  
27  
28  
29

30 We developed an assessment form (Figure 1) to evaluate the participants' performance  
31  
32 regarding skills and competences essential to assess medical emergencies. The assessment  
33  
34 form was divided in six categories; five concerned the ABCDE structure and the sixth one  
35  
36 contained remaining items. The remaining items focus on some Crew Resources  
37  
38 Management (CRM) skills, like collaboration, communication, acknowledge own boundaries,  
39  
40 and leadership. In each category, the skills or competences could be rated on a two- (agree,  
41  
42 not agree, does not apply) or four-point scale (agree, partially agree, partially not agree, not  
43  
44 agree or does not apply). We have added the option "does not apply", because some skills  
45  
46 were not required in some simulation scenarios. In the categories B, C, D and E also the  
47  
48 scored. The following items could be scored; in the B: skin color, trachea position,  
49  
50 respiratory rate, thorax excursions, breathing effort, lung percussion, lung auscultation and  
51  
52 saturation; in the C: circulation of extremities, central pulse, heart rate, blood pressure,  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 capillary refill, central venous pressure, heart sounds; in the D: Glasgow Coma Scale (EMV),  
4  
5 pupils, neck stiffness, glucose; in the E: temperature, head to toe examination (Figure 1).  
6  
7  
8  
9

## 10 **Intervention**

11  
12 The ABCDE course is a two-day course for non-residents and first year residents which exists  
13  
14 for ten years now. For most participants, it was a mandatory course that they need to pass  
15  
16 before they were allowed to work in the ED. The course consisted mainly of simulation  
17  
18 training and two theoretical lectures about airway management and Advanced Life Support  
19  
20 (ALS). Previous to this course, the participants received a book with chapters describing the  
21  
22 ABCDE approach and various acute medical emergencies.  
23  
24  
25  
26

27 The course focused on learning to recognize and treat life-threatening conditions, but also  
28  
29 paid attention to some CRM-skills necessary for an efficient ABCDE approach.  
30  
31

32 This course was given in the skills centre in a room similar to a resuscitation room in the ED.  
33

34 The patient simulator used was a Laerdal Resusci Anne SkillTrainer with an upgrade Vitale  
35  
36 Signs Sim Software Complete package. This simulator features heart and lung sounds, chest  
37  
38 excursions, pulse and can show all vital signs on a separate monitor. With a separate  
39  
40 computer, the sounds and vital signs can be changed during the scenario, to simulate several  
41  
42 acute medical conditions.  
43  
44  
45

46 Each course group consisted of six participants and two instructors. During the simulation  
47  
48 rounds the group was split in half and two scenarios were run simultaneously in two  
49  
50 separate rooms.  
51  
52

53 The course encompassed a total of 24 simulations with a patient simulator in which  
54  
55 participants perform the primary assessment of acute ill patients. In each scenario, the role  
56  
57  
58  
59  
60

1  
2  
3 of physician, “non-obstructive nurse” and observer were assigned to the three participants.

4  
5 One of the instructors operated the simulator and led the debriefing afterwards.

6  
7  
8 In eight scenarios, the participants fulfilled the role of physician; in the other scenarios, they  
9  
10 carried out the role of “non-obstructing nurse” or observer.

11  
12  
13 The participants received a certificate if they passed the theoretical test and if they were,  
14  
15 according to the instructors, capable of performing a structured primary assessment of an  
16  
17 acute ill patient, with recognition and resuscitation of life-threatening conditions and  
18  
19 adequate CRM-skills.

20  
21  
22 All course instructors have to follow a formalized educational program to become an  
23  
24 instructor: First they have to pass the course as participant and have to work in the field of  
25  
26 emergency medicine or acute care. Second they need to follow a two-day generic instructor  
27  
28 course specifically developed for simulation training. Then they have to act as assistant-  
29  
30 trainer for at least two courses and they need to write a report reflecting on their own role  
31  
32 as instructor. Finally they are observed by an experienced instructor to become certified. As  
33  
34 instructor, they have to teach the course least twice a year to stay competent and they need  
35  
36 to follow the course-specific instructors day each year.  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

### 47 **Study setting and population**

48  
49 This study was conducted in the same skills centre as were the course took place. During the  
50  
51 video recordings, the simulator, materials and environment were also the same as during  
52  
53 the course.  
54

55  
56 We approached all participants prior to this two-day course by e-mail and invited them to  
57  
58 participate voluntarily in the study between August 2012 and December 2013. We  
59  
60

endeavoured to achieve a safe response environment by a statement in the invitation e-mail that declining to participate in the study would not influence their course results.

The three measurement moments were scheduled in consultation with the participants, separate from the course. For each measurement moment, study participants were instructed to act in a simulation scenario as physician and to perform a primary assessment according to the ABCDE approach. One of the researchers participated as “non-obstructive” nurse and one researcher operated the simulator and computer.

### **Patient and public involvement**

Participants of this study were not involved in the development of the research question, design or outcome measures. All participants of the study participated voluntarily they knew all information about the investigation and they could withdraw from the study at any moment, all provided verbal consent.

### **Study Protocol**

The first recording (T1) took place one to two weeks prior to the course. The second recording (T2) took place within one week after the course. The third recording (T3) took place between three to four months after the course.

The research team consisted of five physicians, who were also course instructors. They were all instructed in detail to only facilitate the simulation and not help the participant in any way.

The observers were two emergency physicians, who were also course instructors, but who were not part of the research team and therefore not involved in the recordings. The observers received specific instructions how to score each item on the assessment form.



1  
2  
3 They independently rated the recorded primary assessments in random order and were  
4  
5 blinded to the measurement moment.  
6  
7  
8  
9  
10  
11  
12

### 13 **Measurements**

14  
15 Each skill or competence on the assessment form had a lowest score of 0 and a highest score  
16  
17 of 1, so the weight of each item was the same, independent of the two- (0 = not agree, 1 =  
18  
19 agree, not applicable = missing value) or four-point scale (agree=1, partially agree=0.67,  
20  
21 partially not agree=0.33, not agree=0, not applicable = missing value). This was the same for  
22  
23 the number of examined items during the physical examination  
24  
25

26  
27 Because some skills or competences were marked as not applicable, we calculated mean  
28  
29 scores in each category (A, B, C, D, E and remaining items) based on the skills and  
30  
31 competences which actually were applicable. In each category the maximal score to obtain  
32  
33 was 1. Therefore, the maximal total score to obtain on the primary assessment for each  
34  
35 scenario was 6 and the minimal score was 0.  
36  
37  
38  
39  
40  
41

### 42 **Data analysis**

43  
44 To perform the statistical analysis, IBM SPSS version 23.0 was used. In all analyses, a p-  
45  
46 value of < 0.05 was regarded as significant.  
47  
48

49  
50 The inter-observer reliability between the scores given by the two observers for the three  
51  
52 different time measurements was calculated using the Spearman's rank correlation test (for  
53  
54 T1, T2 and T3 (resp. R 0.81, 0.61, and 0.80). This inter-observer reliability was generally high  
55  
56 enough to average the mean scores of the two observers for each participant at T1, T2 and  
57  
58 T3 for use in further analyses.  
59  
60

1  
2  
3 We used the Friedman test for three related samples to analyse whether the total primary  
4 assessment scores of the entire group of participants differed between the three  
5  
6 measurement moments. The Friedman test compares the mean rank scores at T1, T2 and  
7  
8 T3. The mean rank score is calculated by ranking the score of each participant on T1, T2 and  
9  
10 T3 and then calculating the mean rank of the entire group on T1, T2 and T3.  
11  
12

13  
14  
15 We used the Wilcoxon signed-rank test for two related samples to analyse whether the total  
16 primary assessment scores of the entire group of participants differed between two  
17  
18 measurement moments and whether each skill or competence differed between two  
19  
20 measurement moments. The Wilcoxon signed-rank test also uses the mean rank scores.  
21  
22  
23 Finally, we applied the Holm correction to reduce the possibility of getting a statistically  
24  
25 significant result (Type I error) when performing multiple tests.  
26  
27  
28  
29  
30  
31

## 32 **RESULTS**

### 33 **Characteristics of study subjects**

34  
35  
36 Between August 2012 and December 2013, 27 courses were given to six participants each.  
37  
38 From the total of 162 course participants 30 participants volunteered for this study. 21 were  
39  
40 female, nine were male. Their mean age was 27 years (range 24-35, SD 2.77), their mean  
41  
42 work experience was 11 months (range 0-48, SD14.4). Most participants did not have any  
43  
44 experience with simulation training at all (18 out of 30), some participants had done some  
45  
46 training in their own department, like ALS or Basic Life Support (BLS) (7 out of 30), from five  
47  
48 participants we do not know whether they had any experience with simulation training.  
49  
50  
51 The video recording of T3 of one participant was lost due to technical problems.  
52  
53  
54  
55  
56  
57  
58

### 59 **Main results**

The mean rank scores of the entire group on the total primary assessments at T1, T2 en T3 were 1.14, 2.62 and 2.24, respectively (Table 1), and they were significantly different, ( $p < 0.001$ ).

The mean rank score on the total primary assessment at T2 (directly after the course) was significantly higher than the mean rank score at T1 (before the course, table 1). The mean rank score on the total primary assessment at T3 (three months after the course) was significantly lower than the mean rank score at T2, but remained significantly higher than the mean rank score at T1 (Table 1).

Table 1: Scores on the total primary assessment of the whole group at T1, T2 and T3

Time	N	Median	Mean rank score	Wilcoxon signed-rank test
1	30	2.79	1.14	T1 < T2, $p < 0.001$
2	30	5.22	2.62	T2 > T3, $p < 0.05$
3	29	4.70	2.24	T3 > T1, $p < 0.001$

The separate skills or competences were almost all scored significantly higher at T2 than at T1 (34 out of 41). With respect to the remaining skills, four could not be included in our analyses as they were scored too often as “does not apply”, which rendered the number of observations for those skills  $< N=10$ , which was too low to ascertain differences in a reliable way. For only three skills – “examines the airway”, “orders additional diagnostics in the B” and “resuscitates adequately in the E” – we did not find a significant difference between T1 and T2.

Most of the separate skills did not show significant differences between T2 and T3 (30 out of 41). Some skills (7 out of 41) were scored significantly lower at T3 than at T2, but significantly higher than at T1 (Table 2).

Table 2: Outcomes for separate skills and competences that decreased between T2 and T3

Skill/Competence	Wilcoxon signed-rank test		
	N=		
mentions abnormal findings in the C	29	T2 > T3 T1 < T3	p<0.01 p<0.01
recognizes live-threatening conditions in the C	28	T2 > T3 T1 < T3	p<0.05 p<0.01
mentions conclusions in the C	28	T2 > T3 T1 < T3	p<0.05 p<0.01
examines the D completely	29	T2 > T3 T1 < T3	p<0.01 p<0.001
communicates clearly	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows confidence	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows good leadership	29	T2 > T3 T1 < T3	p<0.05 p<0.001

## DISCUSSION

Our study is the first to show the effectiveness of a course using simulation to teach physicians the ABCDE approach for the assessment of medically ill patients. We found that the positive effect on performing a primary assessment according the ABCDE approach persisted even 3-4 months after completing the course.

Our findings corroborate outcomes of other studies showing that simulation training in health professions education was consistently associated with large effects on knowledge, skills and behaviour [22, 23]. Our findings are also in line with previous research showing that

1  
2  
3 simulation training establishes, corrects, and confirms knowledge and skills of the ABCDE  
4  
5 approach and afterwards participants felt more competent in applying the ABCDE approach  
6  
7  
8 [3, 19-21].  
9

10 In the follow-up we found decline in participant performance on some skills of the primary  
11  
12 assessment. Strikingly, most skills that decrease over time are CRM-skills (Table 2). This is  
13  
14 illustrated by a decrease in time of “recognition of life-threatening conditions in the C”,  
15  
16 while the scores on the resuscitation skills did not decline. It is possible that this lower score  
17  
18 reflects ‘not thinking out loud’ rather than failing to recognize a life-threatening condition.  
19  
20 This decrease in CRM-skills suggests that focusing on CRM-skills by refresher courses or team  
21  
22 training, after completing a simulation course, may be an important topic for physicians to  
23  
24 maintain their skills. The positive effect of team training for these non-technical skills has  
25  
26 already been shown [16-18].  
27  
28  
29  
30  
31

32 Another skill that does not yield scores as high as most other skills after three months, is a  
33  
34 complete examination of the Disability. A possible explanation for this finding is that the  
35  
36 participants decide on the level of consciousness of the patient, determined by the EMV,  
37  
38 whether it is necessary to examine certain components of the Disability. The performance of  
39  
40 the EMV does not decrease over time. This finding is in line with previous research from our  
41  
42 group on primary assessment completeness showing that during the primary assessment in  
43  
44 the emergency department, residents and experienced staff have equal, but not maximum  
45  
46 ABCDE completeness scores (83 instead of 100) [7]. Fernandez et al. also showed that  
47  
48 professional lifeguards failed to fully perform the ABCDE sequence and spend more time in  
49  
50 the Circulation step, because they spent more time in steps considered most important [5].  
51  
52 These outcomes may reflect that a score of 100 on the ABCDE approach is not necessary to  
53  
54 exclude potential life-threatening diseases or stabilize the patients.  
55  
56  
57  
58  
59  
60

## Limitations

It is not possible to define the impact of the book and the lectures that are also part of the course, on the measured improvements in performance on the primary assessment.

Outcomes from the regular course evaluation – not part of this study – indicated that the simulation training was the most powerful educational tool and accounted for most of the improvements. This feedback is in line with previous research showing that adding simulation training to a curriculum with lectures of medical students is associated with higher oral exam scores and higher overall course grades [22].

This study evaluated a course with instructors who are experts in the field of acute medicine, and experienced and certified course instructors. It is known that simulation-based education is most effective if guided by a safe and efficient debriefing and that debriefing can be challenging [23, 24]. We do not know if simulation training with debriefing by less experienced instructors may have less effect.

During the study we have deliberately chosen for a researcher participating as “non-obstructive nurse” in the measurement to minimize potential bias caused by help from the “non-obstructive nurse”. The researcher knew the research questions and was instructed in detail to only follow instructions from the participant and not help in any way.

We did not schedule the researchers and operators with an equal distribution over the measurement moments, but all five researchers rotated between roles of the nurse and operator on own initiative. We therefore think that the bias of the non-obstructive nurse influencing the participant is negligible.

Another limitation of this study is that it was not possible to assess all specific skills in each simulation scenario, because they were often scored as “does not apply”. The amount of not

1  
2  
3 applicable rated items was between 0-3 in ten items, between 3-10 in five items, between  
4  
5 10-20 and in four items the not applicable rated items was > 20. This limitation probably did  
6  
7 not influence the results because items often scored as “does not apply” do not impact  
8  
9 discriminating in quality of performance.  
10  
11

12 The sample size was chosen without power analysis, because we didn't know the expected  
13  
14 effect. This relative small sample size of 30 participants already showed large significant  
15  
16 differences. In our statistical analysis we accounted for a small sample size by using the  
17  
18 Wilcoxon signed-rank test.  
19  
20  
21

22 The observers may have been the instructor during the course of some study participants  
23  
24 and we cannot exclude that this may have influenced their ratings for some of them. This  
25  
26 potential bias was minimized by offering the videos in random order and blinding the  
27  
28 observers to the measurement moment. Also, our study focused on the outcomes at group  
29  
30 level and not individual outcomes and the inter-observer reliability was generally high.  
31  
32  
33

34 The measurement moment of T3 varied between 3-4 months after T2. We do not know if  
35  
36 this range of one month between T2 and T3 have caused a variation in performance at T3.  
37  
38

39 Some participants had experience with simulation training. These participants might have  
40  
41 had a higher score on T1 what might have caused an underestimation of the difference  
42  
43 between T1 and T2.  
44  
45

46 Finally, the participants knew they were a study subject and when the recordings were  
47  
48 scheduled. We do not know if they prepared for the study scenarios. Modifying behaviour in  
49  
50 response to the awareness of being observed is known as the Hawthorne effect. This may  
51  
52 have influenced the study scores at T1 and T3, whereas preparation for T3 might result in an  
53  
54 overestimation of the actual course effectiveness at follow-up, preparation at T1 might  
55  
56 result in an underestimation of the effectiveness of the course on both T2 and T3.  
57  
58  
59  
60

## Conclusion

A course with simulation training is an effective educational tool to teach physicians to perform a structured primary assessment using the ABCDE. This competence is largely remained after three months. CRM-skills tend to decrease over time, so we recommend organizing refresher courses, simulation team training or another kind of simulation training with a focus on CRM-skills.

## Figure legend

Figure 1 Assessment form used by the observers.

Figure 2 Boxplot comparing mean score on primary assessment at T1, T2 and T3.

## Data sharing statement

Unpublished statistical data will be available on request to the corresponding author.

## Acknowledgements

We want to thank Kinge van der Heide for her help with the recordings. We want to thank Mirjam Doff-Holman and Martine Oosterloo for the assessment of all recordings.

## REFERENCES

1 Soreide K. Three decades (1978-2008) of Advanced Trauma Life Support (ATLS) practice revised and evidence revisited. *Scand J Trauma Resusc Emerg Med* 2008;16:19,7241-16-19 doi:10.1186/1757-7241-16-19 [doi].

2 Jayaraman S, Sethi D, Chinnock P, et al. Advanced trauma life support training for hospital staff. *Cochrane Database Syst Rev* 2014;(8):CD004173. doi:CD004173 doi:10.1002/14651858.CD004173.pub4 [doi].



- 1  
2  
3 3 Abellsson A, Rystedt I, Suserud B, et al. Learning High-Energy Trauma Care Through  
4 Simulation. *CLIN SIMULATION NURS* 2018;17:1-6 doi:10.1016/j.ecns.2017.11.009.  
5  
6  
7 4 Thim T, Krarup NHV, Grove EL, et al. Initial assessment and treatment with the Airway,  
8 Breathing, Circulation, Disability, Exposure (ABCDE) approach. *Int J Gen Med* 2012;5:117-21  
9 doi:10.2147/IJGM.S28478.  
10  
11  
12  
13 5 Fernández-Méndez F, Otero-Agra M, Abelairas-Gómez C, et al. ABCDE approach to victims  
14 by lifeguards: How do they manage a critical patient? A cross sectional simulation study.  
15 *PLoS ONE* 2019;14 doi:10.1371/journal.pone.0212080.  
16  
17  
18  
19 6 Ilgen JS, Sherbino J, Cook DA. Technology-enhanced simulation in emergency medicine: a  
20 systematic review and meta-analysis. *Acad Emerg Med* 2013;20:117-27  
21 doi:10.1111/acem.12076 [doi].  
22  
23  
24  
25 7 Olgers TJ, Dijkstra RS, Drost-de Klerck AM, et al. The ABCDE primary assessment in the  
26 emergency department in medically ill patients: an observational pilot study. *Neth J Med*  
27 2017;75:106-11.  
28  
29  
30  
31 8 Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing  
32 responses of physicians and nurses in the hours before the event. *Crit Care Med*  
33 1994;22:244-7.  
34  
35  
36  
37 9 McQuillan P, Pilkington S, Allan A, et al. Confidential inquiry into quality of care before  
38 admission to intensive care. *BMJ* 1998;316:1853-8.  
39  
40  
41  
42 10 Kumar A, Roberts D, Wood KE, et al. Duration of hypotension before initiation of effective  
43 antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care*  
44 *Med* 2006;34:1589-96 doi:10.1097/01.CCM.0000217961.75225.E9 [doi].  
45  
46  
47  
48 11 National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue  
49 plasminogen activator for acute ischemic stroke. *N Engl J Med* 1995;333:1581-7  
50 doi:10.1056/NEJM199512143332401 [doi].  
51  
52  
53  
54 12 Spoedeisende hulp: vanuit een stevige basis. Rapportage werkgroep levelindeling SEH.  
55 2009  
56 [https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-](https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf)  
57 [Vanuit-een-stevig-basis.pdf](https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf).  
58  
59  
60

1  
2  
3 13 Ryu WHA, Dharampal N, Mostafa AE, et al. Systematic Review of Patient-Specific Surgical  
4 Simulation: Toward Advancing Medical Education. *J Surg Educ* 2017 doi:S1931-  
5 7204(16)30269-0 [pii].  
6  
7

8  
9 14 Price J, Naik V, Boodhwani M, et al. A randomized evaluation of simulation training on  
10 performance of vascular anastomosis on a high-fidelity in vivo model: the role of deliberate  
11 practice. *J Thorac Cardiovasc Surg* 2011;142:496-503 doi:10.1016/j.jtcvs.2011.05.015 [doi].  
12  
13

14  
15 15 Kory PD, Eisen LA, Adachi M, et al. Initial airway management skills of senior residents:  
16 simulation training compared with traditional training. *Chest* 2007;132:1927-31 doi:S0012-  
17 3692(15)52468-9 [pii].  
18  
19

20  
21 16 Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JD, et al. Interventions to  
22 improve team effectiveness: a systematic review. *Health Policy* 2010;94:183-95  
23 doi:10.1016/j.healthpol.2009.09.015 [doi].  
24  
25

26  
27 17 Hesselink G, Berben S, Beune T, et al. Improving the governance of patient safety in  
28 emergency care: a systematic review of interventions. *BMJ Open* 2016;6:e009837,2015-  
29 009837 doi:10.1136/bmjopen-2015-009837 [doi].  
30  
31

32  
33 18 Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency  
34 department staff: does it improve clinical team performance when added to an existing  
35 didactic teamwork curriculum?. *Qual Saf Health Care* 2004;13:417-21 doi:13/6/417 [pii].  
36  
37

38  
39 19 Willett TG, Kirlew M, Cardinal P, et al. An evaluation of the Acute Critical Events  
40 Simulation (ACES) course for family medicine residents. *Can J Rural Med* 2011;16:89-95.  
41  
42

43  
44 20 Carling J. Are graduate doctors adequately prepared to manage acutely unwell patients?.  
45 *Clin Teach* 2010;7:102-5 doi:10.1111/j.1743-498X.2010.00341.x [doi].  
46  
47

48  
49 21 Pantelidis P, Staikoglou N, Pappas G, et al. Medical students' satisfaction with the  
50 Applied Basic Clinical Seminar with Scenarios for Students, a novel simulation-based learning  
51 method in Greece. *J Educ Eval Health Prof* 2016;13:13 doi:10.3352/jeehp.2016.13.13 [doi].  
52  
53

54  
55 22 Frallicciardi A, Fried J, Regan T, et al. A comparison of traditional lecture to simulation  
56 based cases for emergency medicine education among fourth year medical students. *Acad  
57 Emerg Med* 2012;19:S386 doi:10.1111/j.1553-2712.2012.01332.x.  
58  
59  
60

1  
2  
3 23 Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health  
4 professions education: a systematic review and meta-analysis. *JAMA* 2011;306:978-88  
5 doi:10.1001/jama.2011.1234 [doi].  
6  
7

8  
9 24 Grant VJ, Robinson T, Catena H, et al. Difficult debriefing situations: A toolbox for  
10 simulation educators. *Med Teach* 2018;40:703-12 doi:10.1080/0142159X.2018.1468558.  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

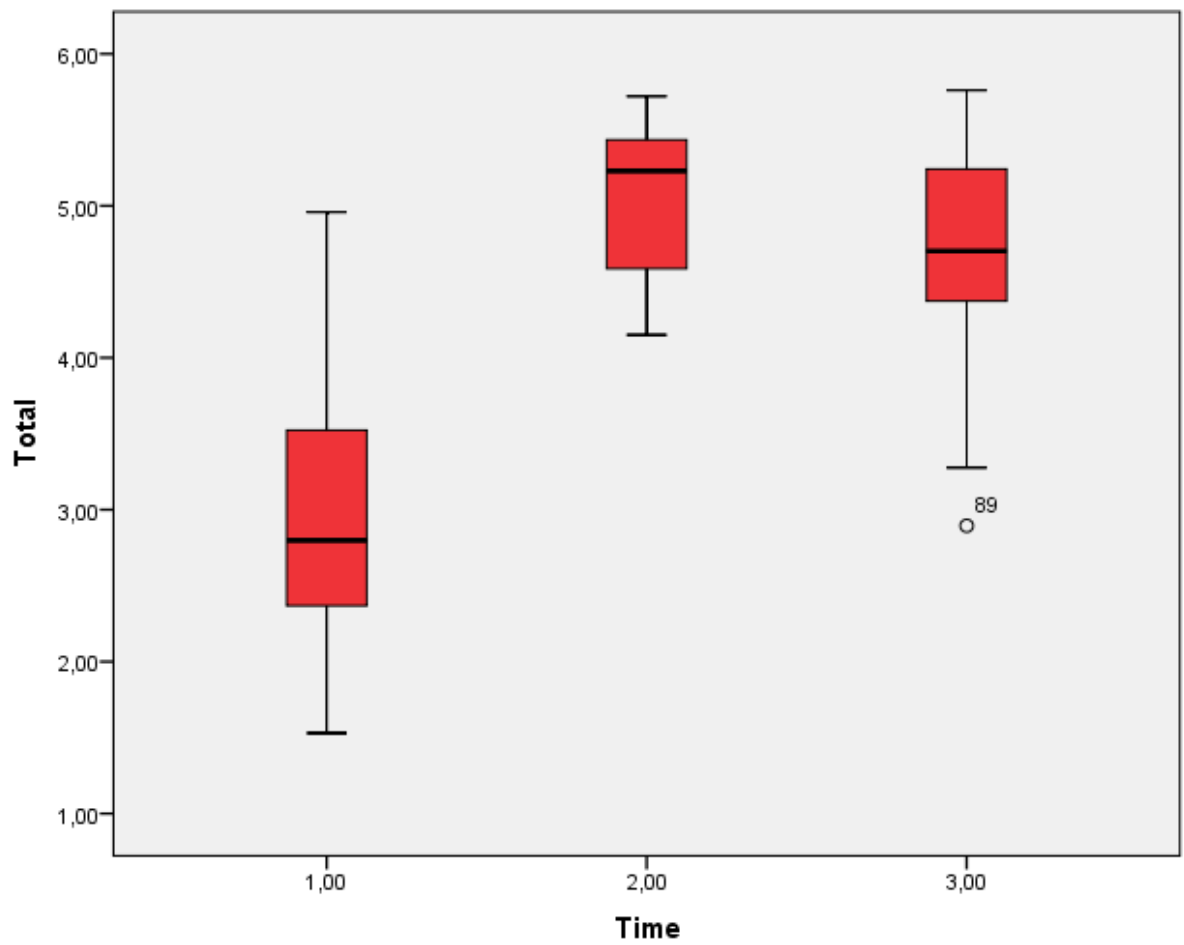
For peer review only

Figure 1 Assessment form used by the observers.

Primary assessment		
A	<ul style="list-style-type: none"> <li>- examines the airway</li> <li>- mentions obstructed airway</li> <li>- applies airway maneuvers</li> <li>- applies oxygen</li> </ul>	agree / disagree agree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree/ d.n.a.
B	<ul style="list-style-type: none"> <li>- examines B completely (color, trachea, resp. rate, excursions, breathing effort, percussion, auscultation, saturation)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7 - 8  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
C	<ul style="list-style-type: none"> <li>- examines C completely (circulation of extremities, central pulse, heart rate, blood pressure, cap.refill, CVP, heart sounds)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
D	<ul style="list-style-type: none"> <li>- examines D completely (Glasgow Coma Scale, pupils, neck stiffness, glucose)</li> <li>- applies EMC correctly</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4  agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
E	<ul style="list-style-type: none"> <li>- examines E completely (temperature, head to toe)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 agree / partially agree / partially disagree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
R	- asks for help adequately	agree / partially agree / partially disagree / disagree
E	- communicates clearly	agree / partially agree / partially disagree / disagree
M	- summarizes adequately	agree / partially agree / partially disagree / disagree
A	- draws the right conclusions	agree / partially agree / partially disagree / disagree
I	- clinical reasoning is adequate	agree / partially agree / partially disagree / disagree
N	- works structured	agree / partially agree / partially disagree / disagree
I	- stays calm	agree / partially agree / partially disagree / disagree
N	- shows confidence	agree / partially agree / partially disagree / disagree
G	- shows good leadership	agree / partially agree / partially disagree / disagree

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 2 Boxplot comparing mean score on total primary assessment at T1, T2 and T3.



www only

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 4</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 6 and 7</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 7</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 7-9</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 9-10</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 7-11</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 7-12</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Page 7-12</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Page 7-12</b>
Study size	10	Explain how the study size was arrived at <b>(no effectsize known)</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 12-13</b> (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed <b>Page 12</b> (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy

---

(e) Describe any sensitivity analyses **Page 12 (interobserver reliability)**

For peer review only

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>Page 13</b> (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 13</b> (b) Indicate number of participants with missing data for each variable of interest <b>Page 13 and supplemental file Outcome</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <b>Page 13-15</b> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>Page 13-15, Table 1 and 2</b> (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 12 (interobserver reliability)</b>

**Discussion**

Key results	18	Summarise key results with reference to study objectives <b>Page 15-16</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>Page 17-18</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 15-18</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 15-18</b>

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>Page 3</b>
---------	----	---

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

For peer review only

# BMJ Open

## Use of simulation training to teach the ABCDE primary assessment: an observational study in a Dutch University Hospital with a 3-4 months follow up.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032023.R3
Article Type:	Original research
Date Submitted by the Author:	04-Feb-2020
Complete List of Authors:	Drost- de Klerck, Amanda; Universitair Medisch Centrum Groningen, emergency department Olgers, Tycho; University Medical Center Groningen, Internal medicine, Emergency dept. van de Meeberg, Evelien; Universitair Medisch Centrum Groningen, emergency department Schonrock-Adema, Johanna; Universitair Medisch Centrum Groningen, emergency department ter Maaten, Jan; University Medical Center Groningen, Emergency Department, Department of internal medicine
<b>Primary Subject Heading</b>:	Medical education and training
Secondary Subject Heading:	Emergency medicine
Keywords:	ACCIDENT & EMERGENCY MEDICINE, EDUCATION & TRAINING (see Medical Education & Training), GENERAL MEDICINE (see Internal Medicine), MEDICAL EDUCATION & TRAINING

SCHOLARONE™  
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1  
2  
3 **Use of simulation training to teach the ABCDE primary**  
4 **assessment: an observational study in a Dutch University**  
5 **Hospital with a 3-4 months follow up.**  
6  
7  
8  
9

10  
11  
12  
13  
14 *Amanda M Drost-de Klerck, Tycho J Olgers, Evelien K van de Meeberg, Johanna Schönrock-*  
15  
16 *Adema, Jan C ter Maaten.*  
17

18  
19  
20  
21  
22 *Emergency Department, University Medical Center Groningen, Hanzeplein 1, 9713 GZ*  
23  
24 *Groningen, The Netherlands, Amanda M Drost-de Klerck, Consultant Emergency Medicine.*  
25  
26 *Emergency Department, University Medical Center Groningen, Tycho J Olgers, Consultant*  
27  
28 *Acute Internal Medicine. Emergency Department, University Medical Center Groningen,*  
29  
30 *Evelien K van de Meeberg, Consultant Emergency Medicine. University of Groningen and*  
31  
32 *University Medical Center Groningen, Institute for Medical Education, Johanna Schönrock-*  
33  
34 *Adema, senior researcher. Emergency Department, University Medical Center Groningen, Jan*  
35  
36 *C ter Maaten, Full Professor Acute Internal Medicine.*  
37  
38  
39  
40  
41  
42  
43

44 **Word count: 3537**  
45  
46  
47

48  
49 **Address for correspondence/request for reprints:**  
50

51 A.M. Drost-de Klerck  
52

53 Phone: +31503616161 / Fax: +31503611725  
54

55  
56 Email: [a.drost@umcg.nl](mailto:a.drost@umcg.nl)  
57  
58  
59  
60

## ABSTRACT

**Objectives** To investigate short- and long-term effectiveness of simulation training to acquire a structured Airway Breathing Circulation Disability Exposure (ABCDE) approach for medical emergencies; and to examine which skills were learned and maintained best.

**Design** an observational study with a 3-4 months follow-up.

**Setting** Skills centre of the University Medical Center Groningen.

**Participants** Thirty voluntary participants (21 females & 9 males;  $27 \pm 2.77$  years) of a simulation-based course.

**Intervention** A two-day ABCDE-teaching course for residents and non-residents. The course encompasses 24 simulations in which participants perform primary assessments of acute ill patients. Video recordings were taken of each participant performing a primary assessment, before (T1), directly after (T2) and three to four months after the intervention (T3).

**Main outcome measures** Physicians' performance in the ABCDE primary assessment at T1, T2 and T3. Two observers scored the primary assessments, blinded to measurement moment, using an assessment form to evaluate the performance with regard to skills essential for a structured ABCDE approach. The Friedman and Wilcoxon signed-rank test were used to compare physicians' performances on the subsequent measurement moments.

**Results** The mean ranks on the total primary assessment at T1, T2 and T3 were 1.14, 2.62 and 2.24, respectively, and were significantly different, ( $p < 0.001$ ).

The mean ranks on the total primary assessment directly after the course (T2 vs. T1  $p < 0.001$ ) and three to four months after the course (T3 vs. T1  $p < 0.001$ ) were significantly better than before the course. Certain skills deteriorated during the follow-up. Strikingly, most skills that decrease over time are Crew Resources Management (CRM)-skills.

## Conclusion

A course using simulation training is an effective educational tool to teach physicians the ABCDE primary assessment. Certain CRM-skills decrease over time, so we recommend organizing refresher courses, simulation team training or another kind of simulation training with a focus on CRM-skills.

### Strengths and limitations of this study

#### Strengths

- This is an observational intervention study measuring the 3-months effect of a simulation course.
- This study used the same environment for intervention and study.
- The observers were blinded to measurement moment during this study on participants' performance on the primary assessment using the ABCDE approach.

#### Limitations

- The fact that the observers might have been also the instructor of some study participants, may have influenced their ratings for a few participants, but potential bias was minimized by offering the videos in random order and blinded to measurement moment, analysis showed a moderate to high inter-observer reliability and our study focused on the outcomes at group level and not individual outcomes.
- There might be bias in the fact that we do not know if the participants have prepared for the study scenario at T1 and T3 (the Hawthorne effect), whereas preparation for T3 might result in an overestimation of the actual course effectiveness at follow-up, preparation at T1 might result in an underestimation of the effectiveness of the course on both T2 and T3.

## INTRODUCTION

### Background

In emergency medicine, assessing incoming patients in life-threatening conditions according to a structured approach is considered essential for successful resuscitation. The most widely used structured approach for early recognition and immediate treatment of life-threatening conditions is the “Airway-Breathing-Circulation-Disability-Exposure” (ABCDE) approach. The ABCDE approach is taught in the Advanced Trauma Life Support (ATLS) since 1978 and has been the standard approach in trauma since [1-3].

The use of the ABCDE primary assessment has also increased in other medical emergencies in recent years [4-7].

Using the ABCDE approach likely improves outcomes by helping health care professionals focus on the most life-threatening clinical problems and perform immediate resuscitation.

Although solid empirical evidence for the usefulness of the ABCDE approach and its clinical benefits to patients is limited[1, 2], the importance of early treatment has been recognized in several emergencies such as trauma, stroke, sepsis and shock [1-5, 8-11].

### Importance

The Dutch inspection for healthcare requires that physicians treating non-trauma patients in the emergency department are ABCDE qualified [12]. Therefore, completing an ABCDE course is mandatory for physicians who work at the Emergency Department (ED). These courses usually contain lectures and simulation scenario training. Despite the wide use of simulation training for teaching the systematic ABCDE approach, little research has been done to analyse the effectiveness of simulation training in acquiring this structural approach.

Simulation training has been proven to be effective for learning technical skills and

1  
2  
3 maintaining skills that are not frequently used in daily practice, like airway management and  
4  
5 surgical skills [13-15]. Simulation training can also improve communication, efficiency and  
6  
7 safety during teamwork [16-18]. A few studies based on self-perceptions showed that  
8  
9 simulation training improved participants' confidence levels; they felt more competent in  
10  
11 applying the ABCDE approach and several other skills [3, 19-21].  
12  
13

14  
15 To our knowledge, it has not been investigated before whether simulation training actually  
16  
17 improves physicians' skills in performing the structured ABCDE approach.  
18  
19

20  
21  
22 Our study focused on the effectiveness of simulation training to acquire a structured ABCDE  
23  
24 approach. Our main goal was to analyse the short- and long-term effectiveness of simulation  
25  
26 training to acquire a structured ABCDE approach. We analysed the improvement in  
27  
28 physicians' primary assessment scores as a result of the ABCDE simulation training.  
29  
30 We also investigated whether the skills acquired were maintained over a period of three to  
31  
32 four months and which skills and competences were learned and maintained best.  
33  
34  
35  
36  
37  
38  
39

## 40 **METHODS**

### 41 **Study design**

42  
43 We conducted an observational intervention study. The intervention consisted of a two-day  
44  
45 simulation-based ABCDE teaching course. The measurements through video recordings were  
46  
47 obtained before (T1), directly after (T2) and 3-4 months after the intervention (T3).  
48  
49

50  
51 Three simulation scenarios (A, B and C) with different medical emergencies were specifically  
52  
53 designed for this study. Scenario A was a case with pneumosepsis and hypoglycaemia, a  
54  
55 partially obstructed airway due to low consciousness and shock. Scenario B concerned a case  
56  
57 with obstructive shock caused by pulmonary embolism and an opioid overdose with altered  
58  
59  
60



1  
2  
3 consciousness. Scenario C was a case with meningococcal sepsis with a partially obstructed  
4  
5 airway due to low consciousness, bronchospasm and shock. We have designed three  
6  
7 different and realistic scenarios with comparable difficulty by creating a life-threatening  
8  
9 condition which needs resuscitation in three of the five main items from the ABCDE.  
10  
11

12 To prevent bias caused by the type or difficulty of the simulation, we varied the order in  
13  
14 which participants had to complete the three simulation scenarios in such a way that the  
15  
16 different scenario sequences were equally divided over T1, T2 and T3 (participant 1: T1  
17  
18 scenario A, T2 scenario B, T3 scenario C; participant 2: T1 scenario B, T2 scenario C, T3  
19  
20 scenario A; participant 3: T1 scenario C, T2 scenario A, T3 scenario B, etcetera). We made a  
21  
22 schedule in which the order of the scenarios was prescribed for each participant and  
23  
24 participants were divided over the schedule in order of inclusion.  
25  
26  
27  
28

29 We developed an assessment form (Figure 1) to evaluate the participants' performance  
30  
31 regarding skills and competences essential to assess medical emergencies. The assessment  
32  
33 form was divided in six categories; five concerned the ABCDE structure and the sixth  
34  
35 contained remaining items. The remaining items focus on some Crew Resources  
36  
37 Management (CRM) skills, like collaboration, communication, acknowledge own boundaries,  
38  
39 and leadership. In each category, the skills or competences could be rated on a two- (agree,  
40  
41 not agree, does not apply) or four-point scale (agree, partially agree, partially not agree, not  
42  
43 agree or does not apply). We have added the option "does not apply", because some skills  
44  
45 were not required in some simulation scenarios. In the categories B, C, D and E also the  
46  
47 number of examined items during the physical examination was scored. The following items  
48  
49 could be scored; in the B: skin color, trachea position, respiratory rate, thorax excursions,  
50  
51 breathing effort, lung percussion, lung auscultation and saturation; in the C: circulation of  
52  
53 extremities, central pulse, heart rate, blood pressure, capillary refill, central venous  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 pressure, heart sounds; in the D: Glasgow Coma Scale (EMV), pupils, neck stiffness, glucose;  
4  
5 in the E: temperature, head to toe examination (Figure 1).  
6  
7  
8  
9

## 10 **Intervention**

11  
12 The ABCDE course is a two-day course for non-residents and first year residents which exists  
13  
14 for ten years now. For most participants, it was a mandatory course that they need to pass  
15  
16 before they were allowed to work in the ED. The course consisted mainly of simulation  
17  
18 training and two theoretical lectures about airway management and Advanced Life Support  
19  
20 (ALS). Previous to this course, the participants received a book with chapters describing the  
21  
22 ABCDE approach and various acute medical emergencies.  
23  
24  
25

26  
27 The course focused on learning to recognize and treat life-threatening conditions, but also  
28  
29 paid attention to some CRM-skills necessary for an efficient ABCDE approach.  
30  
31

32 This course was given in the skills centre in a room similar to a resuscitation room in the ED.

33  
34 The patient simulator used was a Laerdal Resusci Anne SkillTrainer with an upgrade Vitale  
35  
36 Signs Sim Software Complete package. This simulator features heart and lung sounds, chest  
37  
38 excursions, pulse and can show all vital signs on a separate monitor. With a separate  
39  
40 computer, the sounds and vital signs can be changed during the scenario, to simulate several  
41  
42 acute medical conditions.  
43  
44  
45

46  
47 Each course group consisted of six participants and two instructors. During the simulation  
48  
49 rounds the group was split in half and two scenarios were run simultaneously in two  
50  
51 separate rooms.  
52  
53

54 The course encompassed a total of 24 simulations with a patient simulator in which  
55  
56 participants perform the primary assessment of acute ill patients. In each scenario, the role  
57  
58  
59  
60

1  
2  
3 of physician, “non-obstructive nurse” and observer were assigned to the three participants.

4  
5 One of the instructors operated the simulator and led the debriefing afterwards.

6  
7  
8 In eight scenarios, the participants fulfilled the role of physician; in the other scenarios, they  
9  
10 carried out the role of “non-obstructing nurse” or observer.

11  
12  
13 The participants received a certificate if they passed the theoretical test and if they were,  
14  
15 according to the instructors, capable of performing a structured primary assessment of an  
16  
17 acute ill patient, with recognition and resuscitation of life-threatening conditions and  
18  
19 adequate CRM-skills.

20  
21  
22 All course instructors have to follow a formalized educational program to become an  
23  
24 instructor: First they have to pass the course as participant and have to work in the field of  
25  
26 emergency medicine or acute care. Second they need to follow a two-day generic instructor  
27  
28 course specifically developed for simulation training. Then they have to act as assistant-  
29  
30 trainer for at least two courses and they need to write a report reflecting on their own role  
31  
32 as instructor. Finally they are observed by an experienced instructor to become certified. As  
33  
34 instructor, they have to teach the course least twice a year to stay competent and they need  
35  
36 to follow the course-specific instructors day each year.  
37  
38  
39  
40  
41  
42  
43  
44

### 45 **Study setting and population**

46  
47 This study was conducted in the same skills centre as were the course took place. During the  
48  
49 video recordings, the simulator, materials and environment were also the same as during  
50  
51 the course.

52  
53  
54 We approached all participants prior to this two-day course by e-mail and invited them to  
55  
56 participate voluntarily in the study between August 2012 and December 2013. We  
57  
58  
59  
60

1  
2  
3 endeavoured to achieve a safe response environment by a statement in the invitation e-mail  
4  
5 that declining to participate in the study would not influence their course results.  
6  
7

8 The three measurement moments were scheduled in consultation with the participants,  
9  
10 separate from the course. For each measurement moment, study participants were  
11  
12 instructed to act in a simulation scenario as physician and to perform a primary assessment  
13  
14 according to the ABCDE approach. One of the researchers participated as “non-obstructive”  
15  
16 nurse and one researcher operated the simulator and computer.  
17  
18  
19  
20  
21  
22

### 23 **Patient and public involvement**

24  
25 Participants of this study were not involved in the development of the research question,  
26  
27 design or outcome measures. All participants of the study participated voluntarily, they  
28  
29 knew all information about the investigation and they could withdraw from the study at any  
30  
31 moment, all provided verbal consent.  
32  
33  
34  
35  
36  
37

### 38 **Study Protocol**

39  
40 The first recording (T1) took place one to two weeks prior to the course. The second  
41  
42 recording (T2) took place within one week after the course. The third recording (T3) took  
43  
44 place between three to four months after the course.  
45  
46

47 The research team consisted of five physicians, who were also course instructors. They were  
48  
49 all instructed in detail to only facilitate the simulation and not help the participant in any  
50  
51 way.  
52  
53

54 The observers were two emergency physicians, who were also course instructors, but who  
55  
56 were not part of the research team and therefore not involved in the recordings. The  
57  
58 observers received specific instructions how to score each item on the assessment form.  
59  
60

1  
2  
3 They independently rated the recorded primary assessments in random order and were  
4  
5 blinded to the measurement moment.  
6  
7  
8  
9

## 10 **Measurements**

11  
12 Each skill or competence on the assessment form had a lowest score of 0 and a highest score  
13  
14 of 1, so the weight of each item was the same, independent of the two- (0 = not agree, 1 =  
15  
16 agree, not applicable = missing value) or four-point scale (agree=1, partially agree=0.67,  
17  
18 partially not agree=0.33, not agree=0, not applicable = missing value). This was the same for  
19  
20 the number of examined items during the physical examination. For example in the B there  
21  
22 was a maximum of 8 items to examine during physical examination. If one item was  
23  
24 examined the score was  $1/8 = 0.125$ , if two items were examined the score was  $2/8 = 0.25$ , if  
25  
26 three items were examined, the score was  $3/8 = 0.375$ , etc. So, the highest possible score on  
27  
28 complete examination in the B was  $8/8 = 1$ .  
29  
30  
31  
32  
33

34 Because some skills or competences were marked as not applicable, we calculated mean  
35  
36 scores in each category (A, B, C, D, E and remaining items) based on the skills and  
37  
38 competences which actually were applicable. In each category the maximal score to obtain  
39  
40 was 1. Therefore, the maximal total score to obtain on the primary assessment for each  
41  
42 scenario was 6 and the minimal score was 0.  
43  
44  
45  
46  
47  
48  
49

## 50 **Data analysis**

51  
52 To perform the statistical analysis, IBM SPSS version 23.0 was used. In all analyses, a p-  
53  
54 value of  $< 0.05$  was regarded as significant.  
55  
56

57 The inter-observer reliability between the scores given by the two observers for the three  
58  
59 different time measurements was calculated using the Spearman's rank correlation test (for  
60

1  
2  
3 T1, T2 and T3 (resp. R 0.81, 0.61, and 0.80). This inter-observer reliability was generally high  
4  
5 enough to average the scores of the two observers for use in further analyses, as a  
6  
7 correlation coefficient lower than 0.5 is considered as weak correlation, a correlation  
8  
9 coefficient between 0.5 and 0.7 is considered as moderate correlation, a correlation  
10  
11 coefficient between 0.7 and 0.9 is considered as high correlation and a correlation  
12  
13 coefficient between 0.9 and 1 is considered as very high correlation.  
14  
15

16  
17 We used the Friedman test for three related samples to analyse whether the total primary  
18  
19 assessment scores of the entire group of participants differed between the three  
20  
21 measurement moments. The Friedman test calculates and compares the mean ranks at T1,  
22  
23 T2 and T3. The mean rank is calculated by ranking the score of each participant on T1, T2  
24  
25 and T3 and then calculating the mean rank of the entire group on T1, T2 and T3.  
26  
27

28  
29 We used the Wilcoxon signed-rank test for two related samples to analyse whether the total  
30  
31 primary assessment scores of the entire group of participants differed between two  
32  
33 measurement moments and whether each skill or competence differed between two  
34  
35 measurement moments. The Wilcoxon signed-rank test also uses the mean ranks.  
36  
37

38  
39 Finally, we applied the Holm correction to reduce the possibility of getting a statistically  
40  
41 significant result (Type I error) when performing multiple tests.  
42  
43  
44  
45

## 46 47 **RESULTS**

### 48 49 **Characteristics of study subjects**

50  
51 Between August 2012 and December 2013, 27 courses were given to six participants each.

52  
53 From the total of 162 course participants 30 participants volunteered for this study. 21 were  
54  
55 female, nine were male. Their mean age was 27 years (range 24-35, SD 2.77), their mean  
56  
57 work experience was 11 months (range 0-48, SD14.4). Most participants did not have any  
58  
59  
60

1  
2  
3 experience with simulation training at all (18 out of 30), some participants had done some  
4  
5 training in their own department, like ALS or Basic Life Support (BLS) (7 out of 30), from five  
6  
7 participants we do not know whether they had any experience with simulation training.  
8  
9

10 The video recording of T3 of one participant was lost due to technical problems.  
11  
12  
13  
14

## 15 **Main results**

16  
17  
18 The mean ranks of the entire group on the total primary assessments at T1, T2 en T3 were  
19  
20 1.14, 2.62 and 2.24, respectively (Table 1), and they were significantly different, ( $p < 0.001$ ).  
21  
22

23 The mean rank on the total primary assessment at T2 (directly after the course) was  
24  
25 significantly higher than the mean rank at T1 (before the course, table 1). The mean rank on  
26  
27 the total primary assessment at T3 (3-4 months after the course) was significantly lower  
28  
29 than the mean rank at T2, but remained significantly higher than the mean rank at T1 (Table  
30  
31 1 and Figure 2 ).  
32  
33  
34  
35  
36

37 Table 1: Scores on the total primary assessment of the whole group at T1, T2 and T3  
38

Time	N	Median	Mean rank	Wilcoxon signed-rank test
1	30	2.79	1.14	T1 < T2, $p < 0.001$
2	30	5.22	2.62	T2 > T3, $p < 0.05$
3	29	4.70	2.24	T3 > T1, $p < 0.001$

39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49 The mean ranks of the separate skills or competences were almost all significantly higher at  
50  
51 T2 than at T1 (34 out of 40). With respect to the remaining skills, four could not be included  
52  
53 in our analyses as they were scored too often as “does not apply”, which rendered the  
54  
55 number of observations for those skills  $< N=10$ , which was too low to ascertain differences in  
56  
57 a reliable way. For only three skills – “examines the airway”, “orders additional diagnostics in  
58  
59  
60

the B” and “resuscitates adequately in the E”– we did not find a significant difference between T1 and T2.

Most of the separate skills did not show significant differences between mean rank at T2 and T3 (30 out of 40). Some skills (7 out of 40) had a significantly lower mean rank at T3 than at T2, but significantly higher than at T1 (Table 2).

Table 2: Outcomes for separate skills and competences that decreased between T2 and T3

Skill/Competence	Wilcoxon signed-rank test		
	N=		
mentions abnormal findings in the C	29	T2 > T3 T1 < T3	p<0.01 p<0.01
recognizes live-threatening conditions in the C	28	T2 > T3 T1 < T3	p<0.05 p<0.01
mentions conclusions in the C	28	T2 > T3 T1 < T3	p<0.05 p<0.01
examines the D completely	29	T2 > T3 T1 < T3	p<0.01 p<0.001
communicates clearly	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows confidence	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows good leadership	29	T2 > T3 T1 < T3	p<0.05 p<0.001



## DISCUSSION

Our study is the first to show the effectiveness of a course using simulation to teach physicians the ABCDE approach for the assessment of medically ill patients. We found that the positive effect on performing a primary assessment according the ABCDE approach persisted even 3-4 months after completing the course.

Our findings corroborate outcomes of other studies showing that simulation training in health professions education was consistently associated with large effects on knowledge, skills and behaviour [22, 23]. Our findings are also in line with previous research showing that simulation training establishes, corrects, and confirms knowledge and skills of the ABCDE approach and afterwards participants felt more competent in applying the ABCDE approach [3, 19-21].

In the follow-up we found decline in participant performance on some skills of the primary assessment. Strikingly, most skills that decrease over time are CRM-skills (Table 2). This is illustrated by a decrease in time of "recognition of life-threatening conditions in the C", while the scores on the resuscitation skills did not decline. It is possible that this lower score reflects 'not thinking out loud' rather than failing to recognize a life-threatening condition. This decrease in CRM-skills suggests that focusing on CRM-skills by refresher courses or team training, after completing a simulation course, may be an important topic for physicians to maintain their skills. The positive effect of team training for these non-technical skills has already been shown [16-18].

Another skill that does not yield scores as high as most other skills after three to four months, is a complete examination of the Disability. A possible explanation for this finding is that the participants decide on the level of consciousness of the patient, determined by the EMV, whether it is necessary to examine certain components of the Disability. The

1  
2  
3 performance of the EMV does not decrease over time. This finding is in line with previous  
4  
5 research from our group on primary assessment completeness showing that during the  
6  
7 primary assessment in the emergency department, residents and experienced staff have  
8  
9 equal, but not maximum ABCDE completeness scores (83 instead of 100) [7]. Fernandez et al.  
10  
11 also showed that professional lifeguards failed to fully perform the ABCDE sequence and  
12  
13 spend more time in the Circulation step, because they spent more time in steps considered  
14  
15 most important [5].  
16  
17 These outcomes may reflect that a score of 100 on the ABCDE approach is not necessary to  
18  
19 exclude potential life-threatening diseases or stabilize the patients.  
20  
21  
22  
23  
24  
25  
26  
27

### 28 **Limitations**

29  
30 It is not possible to define the impact of the book and the lectures that are also part of the  
31  
32 course, on the measured improvements in performance on the primary assessment.  
33

34  
35 Outcomes from the regular course evaluation – not part of this study – indicated that the  
36  
37 simulation training was the most powerful educational tool and accounted for most of the  
38  
39 improvements. This feedback is in line with previous research showing that adding  
40  
41 simulation training to a curriculum with lectures of medical students is associated with  
42  
43 higher oral exam scores and higher overall course grades [22].  
44  
45  
46

47  
48 This study evaluated a course with instructors who are experts in the field of acute medicine,  
49  
50 and experienced and certified course instructors. It is known that simulation-based  
51  
52 education is most effective if guided by a safe and efficient debriefing and that debriefing  
53  
54 can be challenging [23, 24]. We do not know if simulation training with debriefing by less  
55  
56 experienced instructors may have less effect.  
57  
58  
59  
60

1  
2  
3 During the study we have deliberately chosen for a researcher participating as “non-  
4 obstructive nurse” in the measurement to minimize potential bias caused by help from the  
5 “non-obstructive nurse”. The researcher knew the research questions and was instructed in  
6 detail to only follow instructions from the participant and not help in any way.  
7  
8  
9

10  
11  
12 We did not schedule the researchers and operators with an equal distribution over the  
13 measurement moments, but all five researchers rotated between roles of the nurse and  
14 operator on own initiative. We therefor think that the bias of the non-obstructive nurse  
15 influencing the participant is negligible.  
16  
17  
18  
19  
20  
21

22  
23 Another limitation of this study is that it was not possible to assess all specific skills in each  
24 simulation scenario, because they were often scored as “does not apply”. The amount of not  
25 applicable rated items was between 0-3 in ten items, between 3-10 in five items, between  
26 10-20 in two items and in four items the not applicable rated items was > 20. This limitation  
27 probably did not influence the results because items often scored as “does not apply” do not  
28 impact discriminating in quality of performance.  
29  
30  
31  
32  
33  
34  
35

36  
37 The sample size was chosen without power analysis, because we didn't know the expected  
38 effect. This relative small sample size of 30 participants already showed large significant  
39 differences. In our statistical analysis we accounted for a small sample size by using the  
40 Wilcoxon signed-rank test.  
41  
42  
43  
44  
45  
46

47 The observers may have been the instructor during the course of some study participants  
48 and we cannot exclude that this may have influenced their ratings for some of them. This  
49 potential bias was minimized by offering the videos in random order and blinding the  
50 observers to the measurement moment. Also, our study focused on the outcomes at group  
51 level and not individual outcomes and the inter-observer reliability was generally high.  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 The measurement moment of T3 varied between 3-4 months after T2. We do not know if  
4  
5 this range of one month between T2 and T3 have caused a variation in performance at T3.  
6  
7  
8 Some participants had experience with simulation training. These participants might have  
9  
10 had a higher score on T1 what might have caused an underestimation of the difference  
11  
12 between T1 and T2.  
13

14  
15 Finally, the participants knew they were a study subject and when the recordings were  
16  
17 scheduled. We do not know if they prepared for the study scenarios. Modifying behaviour in  
18  
19 response to the awareness of being observed is known as the Hawthorne effect. This may  
20  
21 have influenced the study scores at T1 and T3, whereas preparation for T3 might result in an  
22  
23 overestimation of the actual course effectiveness at follow-up, preparation at T1 might  
24  
25 result in an underestimation of the effectiveness of the course on both T2 and T3.  
26  
27  
28

### 29 30 **Conclusion**

31  
32 A course with simulation training is an effective educational tool to teach physicians to  
33  
34 perform a structured primary assessment using the ABCDE. This competence is largely  
35  
36 remained after three to four months. CRM-skills tend to decrease over time, so we  
37  
38 recommend organizing refresher courses, simulation team training or another kind of  
39  
40 simulation training with a focus on CRM-skills.  
41  
42  
43  
44  
45  
46

### 47 **Figure legend**

48  
49 Figure 1 Assessment form used by the observers.

50  
51  
52 Figure 2 Line chart for total score on primary assessment for each participant on T1, T2 and  
53  
54 T3.  
55  
56  
57  
58  
59  
60

### Contributors

AMDK and JCM have conceived the study and created the assessment form. AMDK, TJO, EKM and JCM collected the data. AMDK is guarantor and did the literature search, managed the data and performed data analysis and drafted the manuscript. JSA advised regarding to the data analysis. All authors contributed to the final manuscript, revision of the manuscript and final approval of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

### Competing interests

All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

### Funding

This study was only funded by the Emergency Department of the University Medical Center Groningen.

### Data sharing statement

Unpublished statistical data will be available on request to the corresponding author.

### Ethics approval

Ethical approval was waived by our medical ethics committee (METc UMC Groningen) as this research is educational research. We have received an independent review board

1  
2  
3 declaration from our medical ethics committee, which declares that this study fulfills all the  
4 requirements for patient anonymity and is in agreement with regulations of our University  
5  
6 Hospital.  
7  
8  
9

### 10 11 12 **Transparency**

13  
14 We declare that the manuscript is honest, accurate and transparent. No important aspects  
15 of the study have been omitted and discrepancies from the study as originally planned have  
16  
17 been explained.  
18  
19  
20  
21  
22

### 23 24 **Copyright/license for publication**

25  
26 The corresponding author has the right to grant on behalf of all authors and does grant on  
27 behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in  
28 all forms, formats and media (whether known now or created in the future), to i) publish,  
29 reproduce, distribute, display and store the Contribution, ii) translate the Contribution into  
30 other languages, create adaptations, reprints, include within collections and create  
31 summaries, extracts and/or, abstracts of the Contribution, iii) create any other derivative  
32 work(s) based on the Contribution, iv) to exploit all subsidiary rights in the Contribution, v)  
33 the inclusion of electronic links from the Contribution to third party material where-ever it  
34 may be located; and, vi) licence any third party to do any or all of the above."  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49

### 50 51 **Acknowledgements**

52  
53 We want to thank Kinge van der Heide for her help with the recordings. We want to thank  
54  
55 Mirjam Doff-Holman and Martine Oosterloo for the assessment of all recordings.  
56  
57  
58  
59  
60

**REFERENCES**

- 1 Soreide K. Three decades (1978-2008) of Advanced Trauma Life Support (ATLS) practice revised and evidence revisited. *Scand J Trauma Resusc Emerg Med* 2008;16:19,7241-16-19 doi:10.1186/1757-7241-16-19 [doi].
- 2 Jayaraman S, Sethi D, Chinnock P, et al. Advanced trauma life support training for hospital staff. *Cochrane Database Syst Rev* 2014;(8):CD004173. doi:CD004173 doi:10.1002/14651858.CD004173.pub4 [doi].
- 3 Abellsson A, Rystedt I, Suserud B, et al. Learning High-Energy Trauma Care Through Simulation. *CLIN SIMULATION NURS* 2018;17:1-6 doi:10.1016/j.ecns.2017.11.009.
- 4 Thim T, Krarup NHV, Grove EL, et al. Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. *Int J Gen Med* 2012;5:117-21 doi:10.2147/IJGM.S28478.
- 5 Fernández-Méndez F, Otero-Agra M, Abelairas-Gómez C, et al. ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross sectional simulation study. *PLoS ONE* 2019;14 doi:10.1371/journal.pone.0212080.
- 6 Ilgen JS, Sherbino J, Cook DA. Technology-enhanced simulation in emergency medicine: a systematic review and meta-analysis. *Acad Emerg Med* 2013;20:117-27 doi:10.1111/acem.12076 [doi].
- 7 Olgers TJ, Dijkstra RS, Drost-de Klerck AM, et al. The ABCDE primary assessment in the emergency department in medically ill patients: an observational pilot study. *Neth J Med* 2017;75:106-11.
- 8 Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. *Crit Care Med* 1994;22:244-7.
- 9 McQuillan P, Pilkington S, Allan A, et al. Confidential inquiry into quality of care before admission to intensive care. *BMJ* 1998;316:1853-8.
- 10 Kumar A, Roberts D, Wood KE, et al. Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care Med* 2006;34:1589-96 doi:10.1097/01.CCM.0000217961.75225.E9 [doi].

- 1  
2  
3 11 National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue  
4 plasminogen activator for acute ischemic stroke. *N Engl J Med* 1995;333:1581-7  
5  
6 doi:10.1056/NEJM199512143332401 [doi].  
7  
8  
9 12 Spoedeisende hulp: vanuit een stevige basis. Rapportage werkgroep levelindeling SEH.  
10 2009  
11  
12 [https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-](https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf)  
13 [Vanuit-een-stevig-basis.pdf](https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf).  
14  
15  
16 13 Ryu WHA, Dharampal N, Mostafa AE, et al. Systematic Review of Patient-Specific Surgical  
17 Simulation: Toward Advancing Medical Education. *J Surg Educ* 2017 doi:S1931-  
18 7204(16)30269-0 [pii].  
19  
20  
21 14 Price J, Naik V, Boodhwani M, et al. A randomized evaluation of simulation training on  
22 performance of vascular anastomosis on a high-fidelity in vivo model: the role of deliberate  
23 practice. *J Thorac Cardiovasc Surg* 2011;142:496-503 doi:10.1016/j.jtcvs.2011.05.015 [doi].  
24  
25  
26 15 Kory PD, Eisen LA, Adachi M, et al. Initial airway management skills of senior residents:  
27 simulation training compared with traditional training. *Chest* 2007;132:1927-31 doi:S0012-  
28 3692(15)52468-9 [pii].  
29  
30  
31 16 Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JD, et al. Interventions to  
32 improve team effectiveness: a systematic review. *Health Policy* 2010;94:183-95  
33 doi:10.1016/j.healthpol.2009.09.015 [doi].  
34  
35  
36 17 Hesselink G, Berben S, Beune T, et al. Improving the governance of patient safety in  
37 emergency care: a systematic review of interventions. *BMJ Open* 2016;6:e009837,2015-  
38 009837 doi:10.1136/bmjopen-2015-009837 [doi].  
39  
40  
41 18 Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency  
42 department staff: does it improve clinical team performance when added to an existing  
43 didactic teamwork curriculum?. *Qual Saf Health Care* 2004;13:417-21 doi:13/6/417 [pii].  
44  
45  
46 19 Willett TG, Kirlew M, Cardinal P, et al. An evaluation of the Acute Critical Events  
47 Simulation (ACES) course for family medicine residents. *Can J Rural Med* 2011;16:89-95.  
48  
49  
50 20 Carling J. Are graduate doctors adequately prepared to manage acutely unwell patients?.  
51 *Clin Teach* 2010;7:102-5 doi:10.1111/j.1743-498X.2010.00341.x [doi].  
52  
53  
54  
55  
56  
57  
58  
59  
60



1  
2  
3 21 Pantelidis P, Staikoglou N, Pappas G, et al. Medical students' satisfaction with the  
4 Applied Basic Clinical Seminar with Scenarios for Students, a novel simulation-based learning  
5 method in Greece. *J Educ Eval Health Prof* 2016;13:13 doi:10.3352/jeehp.2016.13.13 [doi].  
6  
7

8  
9 22 Frallicciardi A, Fried J, Regan T, et al. A comparison of traditional lecture to simulation  
10 based cases for emergency medicine education among fourth year medical students. *Acad*  
11 *Emerg Med* 2012;19:S386 doi:10.1111/j.1553-2712.2012.01332.x.  
12  
13

14  
15 23 Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health  
16 professions education: a systematic review and meta-analysis. *JAMA* 2011;306:978-88  
17 doi:10.1001/jama.2011.1234 [doi].  
18  
19

20  
21 24 Grant VJ, Robinson T, Catena H, et al. Difficult debriefing situations: A toolbox for  
22 simulation educators. *Med Teach* 2018;40:703-12 doi:10.1080/0142159X.2018.1468558.  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 1 Assessment form used by the observers.

Primary assessment		
A	<ul style="list-style-type: none"> <li>- examines the airway</li> <li>- mentions obstructed airway</li> <li>- applies airway maneuvers</li> <li>- applies oxygen</li> </ul>	agree / disagree agree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree/ d.n.a.
B	<ul style="list-style-type: none"> <li>- examines B completely (color, trachea, resp. rate, excursions, breathing effort, percussion, auscultation, saturation)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7 - 8  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
C	<ul style="list-style-type: none"> <li>- examines C completely (circulation of extremities, central pulse, heart rate, blood pressure, cap.refill, CVP, heart sounds)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
D	<ul style="list-style-type: none"> <li>- examines D completely (Glasgow Coma Scale, pupils, neck stiffness, glucose)</li> <li>- applies EMC correctly</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4  agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
E	<ul style="list-style-type: none"> <li>- examines E completely (temperature, head to toe)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 agree / partially agree / partially disagree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
R	- asks for help adequately	agree / partially agree / partially disagree / disagree
E	- communicates clearly	agree / partially agree / partially disagree / disagree
M	- summarizes adequately	agree / partially agree / partially disagree / disagree
A	- draws the right conclusions	agree / partially agree / partially disagree / disagree
I	- clinical reasoning is adequate	agree / partially agree / partially disagree / disagree
N	- works structured	agree / partially agree / partially disagree / disagree
I	- stays calm	agree / partially agree / partially disagree / disagree
N	- shows confidence	agree / partially agree / partially disagree / disagree
G	- shows good leadership	agree / partially agree / partially disagree / disagree

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

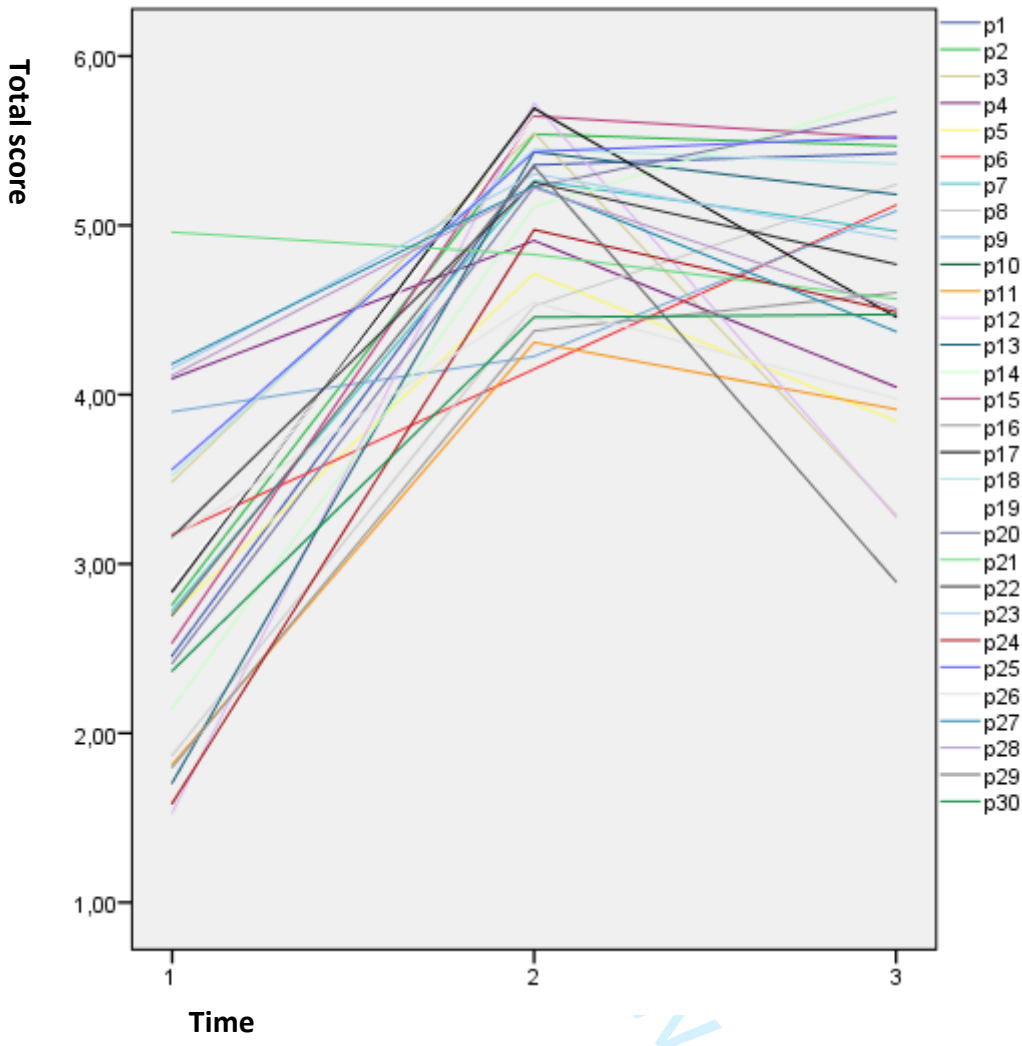


Figure 2: Line chart for total score on primary assessment for each participant on T1, T2 and T3. (p=participant)

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 4</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 6 and 7</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 7</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 7-9</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 9-10</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 7-11</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 7-12</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Page 7-12</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Page 7-12</b>
Study size	10	Explain how the study size was arrived at <b>(no effectsize known)</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 12-13</b> (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed <b>Page 12</b> (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy

---

(e) Describe any sensitivity analyses **Page 12 (interobserver reliability)**

For peer review only

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>Page 13</b> (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 13</b> (b) Indicate number of participants with missing data for each variable of interest <b>Page 13 and supplemental file Outcome</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <b>Page 13-15</b> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>Page 13-15, Table 1 and 2</b> (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 12 (interobserver reliability)</b>

**Discussion**

Key results	18	Summarise key results with reference to study objectives <b>Page 15-16</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>Page 17-18</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 15-18</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 15-18</b>

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>Page 3</b>
---------	----	---

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

For peer review only

# BMJ Open

## Use of simulation training to teach the ABCDE primary assessment: an observational study in a Dutch University Hospital with a 3-4 months follow up.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032023.R4
Article Type:	Original research
Date Submitted by the Author:	10-May-2020
Complete List of Authors:	Drost- de Klerck, Amanda; Universitair Medisch Centrum Groningen, emergency department Olgers, Tycho; University Medical Center Groningen, Internal medicine, Emergency dept. van de Meeberg, Evelien; Universitair Medisch Centrum Groningen, emergency department Schonrock-Adema, Johanna; Universitair Medisch Centrum Groningen, emergency department ter Maaten, Jan; University Medical Center Groningen, Emergency Department, Department of internal medicine
<b>Primary Subject Heading</b>:	Medical education and training
Secondary Subject Heading:	Emergency medicine
Keywords:	ACCIDENT & EMERGENCY MEDICINE, EDUCATION & TRAINING (see Medical Education & Training), GENERAL MEDICINE (see Internal Medicine), MEDICAL EDUCATION & TRAINING

SCHOLARONE™  
Manuscripts





I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1  
2  
3 **Use of simulation training to teach the ABCDE primary**  
4 **assessment: an observational study in a Dutch University**  
5 **Hospital with a 3-4 months follow up.**  
6  
7  
8  
9  
10  
11  
12  
13

14 *Amanda M Drost-de Klerck, Tycho J Olgers, Evelien K van de Meeberg, Johanna Schönrock-*  
15 *Adema, Jan C ter Maaten.*  
16  
17  
18  
19  
20  
21

22 *Emergency Department, University Medical Center Groningen, Hanzeplein 1, 9713 GZ*  
23 *Groningen, The Netherlands, Amanda M Drost-de Klerck, Consultant Emergency Medicine.*  
24 *Emergency Department, University Medical Center Groningen, Tycho J Olgers, Consultant*  
25 *Acute Internal Medicine. Emergency Department, University Medical Center Groningen,*  
26 *Evelien K van de Meeberg, Consultant Emergency Medicine. University of Groningen and*  
27 *University Medical Center Groningen, Institute for Medical Education, Johanna Schönrock-*  
28 *Adema, senior researcher. Emergency Department, University Medical Center Groningen, Jan*  
29 *C ter Maaten, Full Professor Acute Internal Medicine.*  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50

51 **Word count:** 3674  
52  
53  
54  
55

56 **Address for correspondence/request for reprints:**  
57  
58  
59  
60

A.M. Drost-de Klerck

Phone: +31503616161 / Fax: +31503611725

Email: [a.drost@umcg.nl](mailto:a.drost@umcg.nl)

## ABSTRACT

**Objectives** To investigate short- and long-term effectiveness of simulation training to acquire a structured Airway Breathing Circulation Disability Exposure (ABCDE) approach for medical emergencies; and to examine which skills were learned and maintained best.

**Design** an observational study with a three to four months follow-up.

**Setting** Skills centre of the University Medical Center Groningen.

**Participants** Thirty voluntary participants (21 females & 9 males;  $27 \pm 2.77$  years) of a simulation-based course.

**Intervention** A two-day ABCDE-teaching course for residents and non-residents. The course encompasses 24 simulations in which participants perform primary assessments of acute ill patients. Video recordings were taken of each participant performing a primary assessment, before (T1), directly after (T2) and three to four months after the intervention (T3).

**Main outcome measures** Physicians' performance in the ABCDE primary assessment at T1, T2 and T3. Two observers scored the primary assessments, blinded to measurement moment, using an assessment form to evaluate the performance with regard to skills essential for a structured ABCDE approach. The Friedman and Wilcoxon signed-rank test were used to compare physicians' performances on the subsequent measurement moments.

**Results** The mean ranks on the total primary assessment at T1, T2 and T3 were 1.14, 2.62 and 2.24, respectively, and were significantly different, ( $p < 0.001$ ).

The mean ranks on the total primary assessment directly after the course (T2 vs. T1  $p < 0.001$ ) and three to four months after the course (T3 vs. T1  $p < 0.001$ ) were significantly better than before the course. Certain skills deteriorated during the follow-up. Strikingly, most skills that decrease over time are Crew Resources Management (CRM)-skills.

## Conclusion

A course using simulation training is an effective educational tool to teach physicians the ABCDE primary assessment. Certain CRM-skills decrease over time, so we recommend organizing refresher courses, simulation team training or another kind of simulation training with a focus on CRM-skills.

### Strengths and limitations of this study

#### Strengths

- This is an observational study to investigate the short- and long-term effect of a simulation course.
- This study used the same environment for course and study.
- The observers were blinded to measurement moment during this study on participants' performance on the primary assessment using the ABCDE approach.

#### Limitations

- The fact that the observers might have been also the instructor of some study participants, may have influenced their ratings for a few participants, but potential bias was minimized by offering the videos in random order and blinded to measurement moment, analysis showed a moderate to high inter-observer reliability and our study focused on the outcomes at group level and not individual outcomes.
- There might be bias in the fact that we do not know if the participants have prepared for the study scenario at T1 and T3 (the Hawthorne effect), whereas preparation for T3 might result in an overestimation of the actual course effectiveness at follow-up, preparation at T1 might result in an underestimation of the effectiveness of the course on both T2 and T3.

## INTRODUCTION

### Background

In emergency medicine, assessing incoming patients in life-threatening conditions according to a structured approach is considered essential for successful resuscitation. The most widely used structured approach for early recognition and immediate treatment of life-threatening conditions is the “Airway-Breathing-Circulation-Disability-Exposure” (ABCDE) approach. The ABCDE approach is taught in the Advanced Trauma Life Support (ATLS) since 1978 and has been the standard approach in trauma since [1-3].

The use of the ABCDE primary assessment has also increased in other medical emergencies in recent years [4-7].

Using the ABCDE approach likely improves outcomes by helping health care professionals focus on the most life-threatening clinical problems and perform immediate resuscitation.

Although solid empirical evidence for the usefulness of the ABCDE approach and its clinical benefits to patients is limited[1, 2], the importance of early treatment has been recognized in several emergencies such as trauma, stroke, sepsis and shock [1-5, 8-11].

### Importance

The Dutch inspection for healthcare requires that physicians treating non-trauma patients in the emergency department are ABCDE qualified [12]. Therefore, completing an ABCDE course is mandatory for physicians who work at the Emergency Department (ED). These courses usually contain lectures and simulation scenario training. Despite the wide use of simulation training for teaching the systematic ABCDE approach, little research has been done to analyse the effectiveness of simulation training in acquiring this structural approach.

Simulation training has been proven to be effective for learning technical skills and

1  
2  
3 maintaining skills that are not frequently used in daily practice, like airway management and  
4  
5 surgical skills [13-15]. Simulation training can also improve communication, efficiency and  
6  
7 safety during teamwork [16-18]. A few studies based on self-perceptions showed that  
8  
9 simulation training improved participants' confidence levels; they felt more competent in  
10  
11 applying the ABCDE approach and several other skills [3, 19-21].  
12  
13

14  
15 To our knowledge, it has not been investigated before whether simulation training actually  
16  
17 improves physicians' skills in performing the structured ABCDE approach.  
18  
19

20  
21  
22 Our study focused on the effectiveness of simulation training to acquire a structured ABCDE  
23  
24 approach. Our main goal was to analyse the short- and long-term effectiveness of simulation  
25  
26 training to acquire a structured ABCDE approach. We analysed the improvement in  
27  
28 physicians' primary assessment scores as a result of the ABCDE simulation training.  
29  
30 We also investigated whether the skills acquired were maintained over a period of three to  
31  
32 four months and which skills and competences were learned and maintained best.  
33  
34  
35  
36  
37  
38  
39

## 40 **METHODS**

### 41 **Study design**

42  
43 We conducted an observational study to investigate short- and long-term effectiveness of a  
44  
45 two-day simulation-based ABCDE teaching course. The measurements through video  
46  
47 recordings were obtained before (T1), directly after (T2) and three to four months after the  
48  
49 intervention (T3).  
50  
51  
52

53  
54 Three simulation scenarios (A, B and C) with different medical emergencies were specifically  
55  
56 designed for this study. Scenario A was a case with pneumosepsis and hypoglycaemia, a  
57  
58 partially obstructed airway due to low consciousness and shock. Scenario B concerned a case  
59  
60

1  
2  
3 with obstructive shock caused by pulmonary embolism and an opioid overdose with altered  
4  
5 consciousness. Scenario C was a case with meningococcal sepsis with a partially obstructed  
6  
7 airway due to low consciousness, bronchospasm and shock. We have designed three  
8  
9 different and realistic scenarios with comparable difficulty by creating a life-threatening  
10  
11 condition which needs resuscitation in three of the five main items from the ABCDE.  
12  
13

14  
15 To prevent bias caused by the type or difficulty of the simulation, we varied the order in  
16  
17 which participants had to complete the three simulation scenarios in such a way that the  
18  
19 different scenario sequences were equally divided over T1, T2 and T3 (participant 1: T1  
20  
21 scenario A, T2 scenario B, T3 scenario C; participant 2: T1 scenario B, T2 scenario C, T3  
22  
23 scenario A; participant 3: T1 scenario C, T2 scenario A, T3 scenario B, etcetera). We made a  
24  
25 schedule in which the order of the scenarios was prescribed for each participant and  
26  
27 participants were divided over the schedule in order of inclusion.  
28  
29

30  
31 We developed an assessment form (Figure 1) to evaluate the participants' performance  
32  
33 regarding skills and competences essential to assess medical emergencies. The assessment  
34  
35 form was divided in six categories; five concerned the ABCDE structure and the sixth  
36  
37 contained remaining items. The remaining items focus on some Crew Resources  
38  
39 Management (CRM) skills, like collaboration, communication, acknowledge own boundaries,  
40  
41 and leadership. In each category, the skills or competences could be rated on a two- (agree,  
42  
43 not agree, does not apply) or four-point scale (agree, partially agree, partially not agree, not  
44  
45 agree or does not apply). We have added the option "does not apply", because some skills  
46  
47 were not required in some simulation scenarios. In the categories B, C, D and E also the  
48  
49 number of examined items during the physical examination was scored. The following items  
50  
51 could be scored; in the B: skin color, trachea position, respiratory rate, thorax excursions,  
52  
53 breathing effort, lung percussion, lung auscultation and saturation; in the C: circulation of  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 extremities, central pulse, heart rate, blood pressure, capillary refill, central venous  
4  
5 pressure, heart sounds; in the D: Glasgow Coma Scale (EMV), pupils, neck stiffness, glucose;  
6  
7 in the E: temperature, head to toe examination (Figure 1).  
8  
9

### 13 **Intervention**

14  
15 The ABCDE course is a two-day course for non-residents and first year residents which exists  
16  
17 for ten years now. For most participants, it was a mandatory course that they need to pass  
18  
19 before they were allowed to work in the ED. The course consisted mainly of simulation  
20  
21 training and two theoretical lectures about airway management and Advanced Life Support  
22  
23 (ALS). Previous to this course, the participants received a book with chapters describing the  
24  
25 ABCDE approach and various acute medical emergencies.  
26  
27

28  
29 The course focused on learning to recognize and treat life-threatening conditions, but also  
30  
31 paid attention to some CRM-skills necessary for an efficient ABCDE approach.  
32  
33

34  
35 This course was given in the skills centre in a room similar to a resuscitation room in the ED.  
36

37  
38 The patient simulator used was a Laerdal Resusci Anne SkillTrainer with an upgrade Vitale  
39  
40 Signs Sim Software Complete package. This simulator features heart and lung sounds, chest  
41  
42 excursions, pulse and can show all vital signs on a separate monitor. With a separate  
43  
44 computer, the sounds and vital signs can be changed during the scenario, to simulate several  
45  
46 acute medical conditions.  
47  
48

49  
50 Each course group consisted of six participants and two instructors. During the simulation  
51  
52 rounds the group was split in half and two scenarios were run simultaneously in two  
53  
54 separate rooms.  
55

56  
57 The course encompassed a total of 24 simulations with a patient simulator in which  
58  
59 participants perform the primary assessment of acute ill patients. In each scenario, the role  
60



1  
2  
3 of physician, “non-obstructive nurse” and observer were assigned to the three participants.

4  
5 One of the instructors operated the simulator and led the debriefing afterwards.

6  
7  
8 In eight scenarios, the participants fulfilled the role of physician; in the other scenarios, they  
9  
10 carried out the role of “non-obstructing nurse” or observer.

11  
12  
13 The participants received a certificate if they passed the theoretical test and if they were,  
14  
15 according to the instructors, capable of performing a structured primary assessment of an  
16  
17 acute ill patient, with recognition and resuscitation of life-threatening conditions and  
18  
19 adequate CRM-skills.

20  
21  
22 All course instructors have to follow a formalized educational program to become an  
23  
24 instructor: First they have to pass the course as participant and have to work in the field of  
25  
26 emergency medicine or acute care. Second they need to follow a two-day generic instructor  
27  
28 course specifically developed for simulation training. Then they have to act as assistant-  
29  
30 trainer for at least two courses and they need to write a report reflecting on their own role  
31  
32 as instructor. Finally they are observed by an experienced instructor to become certified. As  
33  
34 instructor, they have to teach the course least twice a year to stay competent and they need  
35  
36 to follow the course-specific instructors day each year.  
37  
38  
39  
40  
41  
42  
43  
44

### 45 **Study setting and population**

46  
47 This study was conducted in the same skills centre as were the course took place. During the  
48  
49 video recordings, the simulator, materials and environment were also the same as during  
50  
51 the course.

52  
53  
54 We approached all participants prior to this two-day course by e-mail and invited them to  
55  
56 participate in the study between August 2012 and December 2013  
57  
58  
59  
60

1  
2  
3 We endeavoured to achieve a safe response environment by a statement in the invitation e-  
4 mail that declining to participate in the study would not influence their course results. All  
5  
6 participants participated voluntarily, they knew all information about the investigation and  
7  
8 they could withdraw from the study at any moment, all provided verbal consent.  
9  
10

11  
12 The three measurement moments were scheduled in consultation with the participants,  
13  
14 separate from the course. For each measurement moment, study participants were  
15  
16 instructed to act in a simulation scenario as physician and to perform a primary assessment  
17  
18 according to the ABCDE approach. One of the researchers participated as “non-obstructive”  
19  
20 nurse and one researcher operated the simulator and computer.  
21  
22  
23  
24  
25  
26

### 27 **Ethics approval**

28  
29 Ethical approval was waived by our medical ethics committee (METc UMC Groningen) as this  
30  
31 research is educational research. We have received an independent review board  
32  
33 declaration from our medical ethics committee, which declares that this study fulfills all the  
34  
35 requirements for patient anonymity and is in agreement with regulations of our University  
36  
37 Hospital.  
38  
39  
40  
41  
42  
43  
44

### 45 **Patient and public involvement**

46  
47 Participants of this study were not involved in the development of the research question,  
48  
49 design or outcome measures. Some participants of the study encouraged others to  
50  
51 participate, but they were all voluntarily included. The results of the study will be available  
52  
53 for the participants on request.  
54  
55  
56  
57  
58

### 59 **Study Protocol**

1  
2  
3 The first recording (T1) took place one to two weeks prior to the course. The second  
4  
5 recording (T2) took place within one week after the course. The third recording (T3) took  
6  
7 place between three to four months after the course.  
8  
9

10 The research team consisted of five physicians, who were also course instructors. They were  
11  
12 all instructed in detail to only facilitate the simulation and not help the participant in any  
13  
14 way.  
15  
16

17 The observers were two emergency physicians, who were also course instructors, but who  
18  
19 were not part of the research team and therefore not involved in the recordings. The  
20  
21 observers received specific instructions how to score each item on the assessment form.  
22  
23 They independently rated the recorded primary assessments in random order and were  
24  
25 blinded to the measurement moment.  
26  
27  
28  
29  
30  
31

### 32 **Measurements**

33  
34 Each skill or competence on the assessment form had a lowest score of 0 and a highest score  
35  
36 of 1, so the weight of each item was the same, independent of the two- (0 = not agree, 1 =  
37  
38 agree, not applicable = missing value) or four-point scale (agree=1, partially agree=0.67,  
39  
40 partially not agree=0.33, not agree=0, not applicable = missing value). This was the same for  
41  
42 the number of examined items during the physical examination. For example in the B there  
43  
44 was a maximum of eight items to examine during physical examination. If one item was  
45  
46 examined the score was  $1/8 = 0.125$ , if two items were examined the score was  $2/8 = 0.25$ , if  
47  
48 three items were examined, the score was  $3/8 = 0.375$ , etc. So, the highest possible score on  
49  
50 complete examination in the B was  $8/8 = 1$ .  
51  
52  
53  
54

55 Because some skills or competences were marked as not applicable, we calculated mean  
56  
57 scores in each category (A, B, C, D, E and remaining items) based on the skills and  
58  
59  
60

1  
2  
3 competences which actually were applicable. In each category the maximal score to obtain  
4  
5 was 1. Therefore, the maximal total score to obtain on the primary assessment for each  
6  
7 scenario was 6 and the minimal score was 0.  
8  
9

### 10 11 12 **Data analysis**

13  
14  
15 To perform the statistical analysis, IBM SPSS version 23.0 was used. In all analyses, a p-  
16  
17 value of  $< 0.05$  was regarded as significant.  
18

19  
20 The inter-observer reliability between the scores given by the two observers for the three  
21  
22 different time measurements was calculated using the Spearman's rank correlation test (for  
23  
24 T1, T2 and T3 (resp. R 0.81, 0.61, and 0.80). This inter-observer reliability was generally high  
25  
26 enough to average the scores of the two observers for use in further analyses, as a  
27  
28 correlation coefficient lower than 0.5 is considered as weak correlation, a correlation  
29  
30 coefficient between 0.5 and 0.7 is considered as moderate correlation, a correlation  
31  
32 coefficient between 0.7 and 0.9 is considered as high correlation and a correlation  
33  
34 coefficient between 0.9 and 1 is considered as very high correlation.  
35  
36  
37  
38

39  
40 We used the Friedman test for three related samples to analyse whether the total primary  
41  
42 assessment scores of the entire group of participants differed between the three  
43  
44 measurement moments. The Friedman test calculates and compares the mean ranks at T1,  
45  
46 T2 and T3. The mean rank is calculated on a scale from 1-3, because three measurements  
47  
48 are ranked, 1 is the best rank and 3 the worst. The mean rank is calculated by ranking the  
49  
50 score of each participant on T1, T2 and T3 and then calculating the mean rank of the entire  
51  
52 group on T1, T2 and T3.  
53  
54

55  
56 We used the Wilcoxon signed-rank test for two related samples to analyse whether the total  
57  
58 primary assessment scores of the entire group of participants differed between two  
59  
60

1  
2  
3 measurement moments and whether each skill or competence differed between two  
4  
5 measurement moments. The Wilcoxon signed-rank test also uses the mean ranks.  
6  
7  
8 Finally, we applied the Holm correction to reduce the possibility of getting a statistically  
9  
10 significant result (Type I error) when performing multiple tests.  
11  
12  
13  
14

## 15 RESULTS

### 16 **Characteristics of study subjects**

17  
18 Between August 2012 and December 2013, 27 courses were given to six participants each.  
19  
20 From the total of 162 course participants 30 participants volunteered for this study. 21 were  
21  
22 female, nine were male. Their mean age was 27 years (range 24-35, SD 2.77), their mean  
23  
24 work experience was 11 months (range 0-48, SD14.4). Most participants did not have any  
25  
26 experience with simulation training at all (18 out of 30), some participants had done some  
27  
28 training in their own department, like ALS or Basic Life Support (BLS) (7 out of 30), from five  
29  
30 participants we do not know whether they had any experience with simulation training.  
31  
32  
33  
34  
35  
36  
37 The video recording of T3 of one participant was lost due to technical problems.  
38  
39  
40  
41

### 42 **Main results**

43  
44 The median total score on the primary assessment was 2,79 at T1, 5.22 at T2 and 4.70 at T3  
45  
46 (Table 1 and Figure 2).  
47

48  
49 The mean ranks of the entire group on the total primary assessments at T1, T2 en T3 were  
50  
51 1.14, 2.62 and 2.24, respectively (Table 1), and they were significantly different, ( $p < 0.001$ ).  
52  
53

54  
55 The mean rank on the total primary assessment at T2 (directly after the course) was  
56  
57 significantly higher than the mean rank at T1 (before the course, table 1). The mean rank on  
58  
59 the total primary assessment at T3 (three to four months after the course) was significantly  
60

1  
2  
3 lower than the mean rank at T2, but remained significantly higher than the mean rank at T1  
4  
5 (Table 1).  
6  
7  
8  
9

10 Table 1: Scores on the total primary assessment of the whole group at T1, T2 and T3  
11  
12

Time	N	Median	25 percentile	75 percentile	Mean rank	Wilcoxon signed-rank test
1	30	2.79	2.31	3.53	1.14	T1 < T2, p<0.001
2	30	5.22	4.57	5.43	2.62	T2 > T3, p<0.05
3	29	4.70	4.20	5.30	2.24	T3 > T1, p<0.001

13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27 The mean ranks of the separate skills or competences were almost all significantly higher at  
28  
29 T2 than at T1 (34 out of 40). With respect to the remaining skills, four could not be included  
30  
31 in our analyses as they were scored too often as “does not apply”, which rendered the  
32  
33 number of observations for those skills < N=10, which was too low to ascertain differences in  
34  
35 a reliable way. For only three skills – “examines the airway”, “orders additional diagnostics in  
36  
37 the B” and “resuscitates adequately in the E”– we did not find a significant difference  
38  
39 between T1 and T2.  
40  
41  
42  
43

44 Most of the separate skills did not show significant differences between mean rank at T2 and  
45  
46 T3 (30 out of 40). Some skills (7 out of 40) had a significantly lower mean rank at T3 than at  
47  
48 T2, but significantly higher than at T1 (Table 2).  
49  
50  
51  
52  
53

54 Table 2: Outcomes for separate skills and competences that decreased between T2 and T3  
55

Skill/Competence	Wilcoxon signed-rank test		
	N=		

mentions abnormal findings in the C	29	T2 > T3 T1 < T3	p<0.01 p<0.01
recognizes life-threatening conditions in the C	28	T2 > T3 T1 < T3	p<0.05 p<0.01
mentions conclusions in the C	28	T2 > T3 T1 < T3	p<0.05 p<0.01
examines the D completely	29	T2 > T3 T1 < T3	p<0.01 p<0.001
communicates clearly	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows confidence	29	T2 > T3 T1 < T3	p<0.05 p<0.001
shows good leadership	29	T2 > T3 T1 < T3	p<0.05 p<0.001

## DISCUSSION

Our study is the first to show the effectiveness of a course using simulation to teach physicians the ABCDE approach for the assessment of medically ill patients. We found that the positive effect on performing a primary assessment according the ABCDE approach persisted even three to four months after completing the course.

Our findings corroborate outcomes of other studies showing that simulation training in health professions education was consistently associated with large effects on knowledge, skills and behaviour [22, 23]. Our findings are also in line with previous research showing that simulation training establishes, corrects, and confirms knowledge and skills of the ABCDE approach and afterwards participants felt more competent in applying the ABCDE approach [3, 19-21].

In the follow-up we found decline in participant performance on some skills of the primary assessment. Strikingly, most skills that decrease over time are CRM-skills (Table 2). This is illustrated by a decrease in time of "recognition of life-threatening conditions in the C",

1  
2  
3 while the scores on the resuscitation skills did not decline. It is possible that this lower score  
4  
5 reflects 'not thinking out loud' rather than failing to recognize a life-threatening condition.  
6

7  
8 This decrease in CRM-skills suggests that focusing on CRM-skills by refresher courses or team  
9  
10 training, after completing a simulation course, may be an important topic for physicians to  
11  
12 maintain their skills. The positive effect of team training for these non-technical skills has  
13  
14 already been shown [16-18].  
15  
16

17  
18 Another skill that does not yield scores as high as most other skills after three to four  
19  
20 months, is a complete examination of the Disability. A possible explanation for this finding is  
21  
22 that the participants decide on the level of consciousness of the patient, determined by the  
23  
24 EMV, whether it is necessary to examine certain components of the Disability. The  
25  
26 performance of the EMV does not decrease over time. This finding is in line with previous  
27  
28 research from our group on primary assessment completeness showing that during the  
29  
30 primary assessment in the emergency department, residents and experienced staff have  
31  
32 equal, but not maximum ABCDE completeness scores (83 instead of 100) [7]. Fernandez et al.  
33  
34 also showed that professional lifeguards failed to fully perform the ABCDE sequence and  
35  
36 spend more time in the Circulation step, because they spent more time in steps considered  
37  
38 most important [5].  
39  
40  
41  
42  
43

44  
45 These outcomes may reflect that a score of 100 on the ABCDE approach is not necessary to  
46  
47 exclude potential life-threatening diseases or stabilize the patients.  
48  
49  
50

## 51 **Limitations**

52  
53 It is not possible to define the impact of the book and the lectures that are also part of the  
54  
55 course, on the measured improvements in performance on the primary assessment.  
56  
57

58  
59 Outcomes from the regular course evaluation – not part of this study – indicated that the  
60



1  
2  
3 simulation training was the most powerful educational tool and accounted for most of the  
4  
5 improvements. This feedback is in line with previous research showing that adding  
6  
7 simulation training to a curriculum with lectures of medical students is associated with  
8  
9 higher oral exam scores and higher overall course grades [22].  
10  
11

12 This study evaluated a course with instructors who are experts in the field of acute medicine,  
13  
14 and experienced and certified course instructors. It is known that simulation-based  
15  
16 education is most effective if guided by a safe and efficient debriefing and that debriefing  
17  
18 can be challenging [23, 24]. We do not know if simulation training with debriefing by less  
19  
20 experienced instructors may have less effect.  
21  
22

23  
24 During the study we have deliberately chosen for a researcher participating as “non-  
25  
26 obstructive nurse” in the measurement to minimize potential bias caused by help from the  
27  
28 “non-obstructive nurse”. The researcher knew the research questions and was instructed in  
29  
30 detail to only follow instructions from the participant and not help in any way.  
31  
32

33  
34 We did not schedule the researchers and operators with an equal distribution over the  
35  
36 measurement moments, but all five researchers rotated between roles of the nurse and  
37  
38 operator on own initiative. We therefore think that the bias of the non-obstructive nurse  
39  
40 influencing the participant is negligible.  
41  
42

43  
44 Another limitation of this study is that it was not possible to assess all specific skills in each  
45  
46 simulation scenario, because they were often scored as “does not apply”. The amount of not  
47  
48 applicable rated items was between 0-3 in ten items, between 3-10 in five items, between  
49  
50 10-20 in two items and in four items the not applicable rated items was > 20. This limitation  
51  
52 probably did not influence the results because items often scored as “does not apply” do not  
53  
54 impact discriminating in quality of performance.  
55  
56  
57  
58  
59  
60

1  
2  
3 The sample size was chosen without power analysis, because we didn't know the expected  
4  
5 effect. This relative small sample size of 30 participants already showed large significant  
6  
7 differences. In our statistical analysis we accounted for a small sample size by using the  
8  
9 Wilcoxon signed-rank test.  
10  
11

12  
13 The observers may have been the instructor during the course of some study participants  
14  
15 and we cannot exclude that this may have influenced their ratings for some of them. This  
16  
17 potential bias was minimized by offering the videos in random order and blinding the  
18  
19 observers to the measurement moment. Also, our study focused on the outcomes at group  
20  
21 level and not individual outcomes and the inter-observer analysis showed a moderate to  
22  
23 high inter-observer reliability.  
24  
25

26  
27 The measurement moment of T3 varied between three to four months after T2. We do not  
28  
29 know if this range of one month between T2 and T3 have caused a variation in performance  
30  
31 at T3.  
32  
33

34  
35 Some participants had experience with simulation training. These participants might have  
36  
37 had a higher score on T1 what might have caused an underestimation of the difference  
38  
39 between T1 and T2.  
40  
41

42  
43 Finally, the participants knew they were a study subject and when the recordings were  
44  
45 scheduled. We do not know if they prepared for the study scenarios. Modifying behaviour in  
46  
47 response to the awareness of being observed is known as the Hawthorne effect. This may  
48  
49 have influenced the study scores at T1 and T3, whereas preparation for T3 might result in an  
50  
51 overestimation of the actual course effectiveness at follow-up, preparation at T1 might  
52  
53 result in an underestimation of the effectiveness of the course on both T2 and T3.  
54  
55  
56  
57  
58

## 59 **Conclusion**

60

1  
2  
3 A course with simulation training is an effective educational tool to teach physicians to  
4 perform a structured primary assessment using the ABCDE. This competence is largely  
5 remained after three to four months. CRM-skills tend to decrease over time, so we  
6 recommend organizing refresher courses, simulation team training or another kind of  
7 simulation training with a focus on CRM-skills.  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17

### 18 **Figure legend**

19  
20 Figure 1 Assessment form used by the observers.  
21

22  
23 Figure 2 Boxplot showing median and interquartile range of total score on primary  
24 assessment at T1, T2 and T3.  
25  
26  
27  
28  
29

### 30 **Contributors**

31  
32 AMDK and JCM have conceived the study and created the assessment form. AMDK, TJO,  
33 EKM and JCM collected the data. AMDK is guarantor and did the literature search, managed  
34 the data and performed data analysis and drafted the manuscript. JSA advised regarding to  
35 the data analysis. All authors contributed to the final manuscript, revision of the manuscript  
36 and final approval of the manuscript. The corresponding author attests that all listed authors  
37 meet authorship criteria and that no others meeting the criteria have been omitted.  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48

### 49 **Competing interests**

50  
51 All authors have completed the ICMJE uniform disclosure form at  
52 [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: no support from any organisation for the  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 submitted work; no financial relationships with any organisations that might have an interest  
4  
5 in the submitted work in the previous three years; no other relationships or activities that  
6  
7 could appear to have influenced the submitted work.  
8  
9

### 10 11 12 **Funding**

13  
14 This study was only funded by the Emergency Department of the University Medical Center  
15  
16 Groningen.  
17  
18

### 19 20 21 22 **Data sharing statement**

23  
24 Unpublished statistical data will be available on request to the corresponding author.  
25  
26

### 27 28 29 **Transparency**

30  
31 We declare that the manuscript is honest, accurate and transparent. No important aspects  
32  
33 of the study have been omitted and discrepancies from the study as originally planned have  
34  
35 been explained.  
36  
37

### 38 39 40 41 **Copyright/license for publication**

42  
43 The corresponding author has the right to grant on behalf of all authors and does grant on  
44  
45 behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in  
46  
47 all forms, formats and media (whether known now or created in the future), to i) publish,  
48  
49 reproduce, distribute, display and store the Contribution, ii) translate the Contribution into  
50  
51 other languages, create adaptations, reprints, include within collections and create  
52  
53 summaries, extracts and/or, abstracts of the Contribution, iii) create any other derivative  
54  
55 work(s) based on the Contribution, iv) to exploit all subsidiary rights in the Contribution, v)  
56  
57  
58  
59  
60

1  
2  
3 the inclusion of electronic links from the Contribution to third party material where-ever it  
4  
5 may be located; and, vi) licence any third party to do any or all of the above."  
6  
7  
8  
9

## 10 **Acknowledgements**

11  
12 We want to thank Kinge van der Heide for her help with the recordings. We want to thank  
13  
14 Mirjam Doff-Holman and Martine Oosterloo for the assessment of all recordings.  
15  
16  
17  
18  
19

## 20 **REFERENCES**

- 21  
22 1 Soreide K. Three decades (1978-2008) of Advanced Trauma Life Support (ATLS) practice  
23 revised and evidence revisited. *Scand J Trauma Resusc Emerg Med* 2008;16:19,7241-16-19  
24 doi:10.1186/1757-7241-16-19 [doi].  
25  
26 2 Jayaraman S, Sethi D, Chinnock P, et al. Advanced trauma life support training for hospital  
27 staff. *Cochrane Database Syst Rev* 2014;(8):CD004173. doi:CD004173  
28 doi:10.1002/14651858.CD004173.pub4 [doi].  
29  
30 3 Abellsson A, Rystedt I, Suserud B, et al. Learning High-Energy Trauma Care Through  
31 Simulation. *CLIN SIMULATION NURS* 2018;17:1-6 doi:10.1016/j.ecns.2017.11.009.  
32  
33 4 Thim T, Krarup NHV, Grove EL, et al. Initial assessment and treatment with the Airway,  
34 Breathing, Circulation, Disability, Exposure (ABCDE) approach. *Int J Gen Med* 2012;5:117-21  
35 doi:10.2147/IJGM.S28478.  
36  
37 5 Fernández-Méndez F, Otero-Agra M, Abelairas-Gómez C, et al. ABCDE approach to victims  
38 by lifeguards: How do they manage a critical patient? A cross sectional simulation study.  
39 *PLoS ONE* 2019;14 doi:10.1371/journal.pone.0212080.  
40  
41 6 Ilgen JS, Sherbino J, Cook DA. Technology-enhanced simulation in emergency medicine: a  
42 systematic review and meta-analysis. *Acad Emerg Med* 2013;20:117-27  
43 doi:10.1111/acem.12076 [doi].  
44  
45 7 Olgers TJ, Dijkstra RS, Drost-de Klerck AM, et al. The ABCDE primary assessment in the  
46 emergency department in medically ill patients: an observational pilot study. *Neth J Med*  
47 2017;75:106-11.  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 8 Franklin C, Mathew J. Developing strategies to prevent in-hospital cardiac arrest: analyzing  
4 responses of physicians and nurses in the hours before the event. *Crit Care Med*  
5 1994;22:244-7.  
6  
7

8  
9 9 McQuillan P, Pilkington S, Allan A, et al. Confidential inquiry into quality of care before  
10 admission to intensive care. *BMJ* 1998;316:1853-8.  
11  
12

13 10 Kumar A, Roberts D, Wood KE, et al. Duration of hypotension before initiation of effective  
14 antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care*  
15 *Med* 2006;34:1589-96 doi:10.1097/01.CCM.0000217961.75225.E9 [doi].  
16  
17

18  
19 11 National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue  
20 plasminogen activator for acute ischemic stroke. *N Engl J Med* 1995;333:1581-7  
21 doi:10.1056/NEJM199512143332401 [doi].  
22  
23

24  
25 12 Spoedeisende hulp: vanuit een stevige basis. Rapportage werkgroep levelindeling SEH.  
26 2009  
27

28 [https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-](https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf)  
29 [Vanuit-een-stevig-basis.pdf](https://www.netwerkacuteczorgnoordwest.nl/app/uploads/2017/01/200910-Rapport-SEH-Vanuit-een-stevig-basis.pdf).  
30  
31

32  
33 13 Ryu WHA, Dharampal N, Mostafa AE, et al. Systematic Review of Patient-Specific Surgical  
34 Simulation: Toward Advancing Medical Education. *J Surg Educ* 2017 doi:S1931-  
35 7204(16)30269-0 [pii].  
36  
37

38  
39 14 Price J, Naik V, Boodhwani M, et al. A randomized evaluation of simulation training on  
40 performance of vascular anastomosis on a high-fidelity in vivo model: the role of deliberate  
41 practice. *J Thorac Cardiovasc Surg* 2011;142:496-503 doi:10.1016/j.jtcvs.2011.05.015 [doi].  
42  
43

44  
45 15 Kory PD, Eisen LA, Adachi M, et al. Initial airway management skills of senior residents:  
46 simulation training compared with traditional training. *Chest* 2007;132:1927-31 doi:S0012-  
47 3692(15)52468-9 [pii].  
48  
49

50  
51 16 Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JD, et al. Interventions to  
52 improve team effectiveness: a systematic review. *Health Policy* 2010;94:183-95  
53 doi:10.1016/j.healthpol.2009.09.015 [doi].  
54  
55

56  
57 17 Hesselink G, Berben S, Beune T, et al. Improving the governance of patient safety in  
58 emergency care: a systematic review of interventions. *BMJ Open* 2016;6:e009837,2015-  
59 009837 doi:10.1136/bmjopen-2015-009837 [doi].  
60

- 1  
2  
3 18 Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency  
4 department staff: does it improve clinical team performance when added to an existing  
5 didactic teamwork curriculum?. *Qual Saf Health Care* 2004;13:417-21 doi:13/6/417 [pii].  
6  
7  
8  
9 19 Willett TG, Kirlew M, Cardinal P, et al. An evaluation of the Acute Critical Events  
10 Simulation (ACES) course for family medicine residents. *Can J Rural Med* 2011;16:89-95.  
11  
12  
13 20 Carling J. Are graduate doctors adequately prepared to manage acutely unwell patients?.  
14 *Clin Teach* 2010;7:102-5 doi:10.1111/j.1743-498X.2010.00341.x [doi].  
15  
16  
17 21 Pantelidis P, Staikoglou N, Pappas G, et al. Medical students' satisfaction with the  
18 Applied Basic Clinical Seminar with Scenarios for Students, a novel simulation-based learning  
19 method in Greece. *J Educ Eval Health Prof* 2016;13:13 doi:10.3352/jeehp.2016.13.13 [doi].  
20  
21  
22 22 Frallicciardi A, Fried J, Regan T, et al. A comparison of traditional lecture to simulation  
23 based cases for emergency medicine education among fourth year medical students. *Acad*  
24 *Emerg Med* 2012;19:S386 doi:10.1111/j.1553-2712.2012.01332.x.  
25  
26  
27 23 Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health  
28 professions education: a systematic review and meta-analysis. *JAMA* 2011;306:978-88  
29 doi:10.1001/jama.2011.1234 [doi].  
30  
31  
32 24 Grant VJ, Robinson T, Catena H, et al. Difficult debriefing situations: A toolbox for  
33 simulation educators. *Med Teach* 2018;40:703-12 doi:10.1080/0142159X.2018.1468558.  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

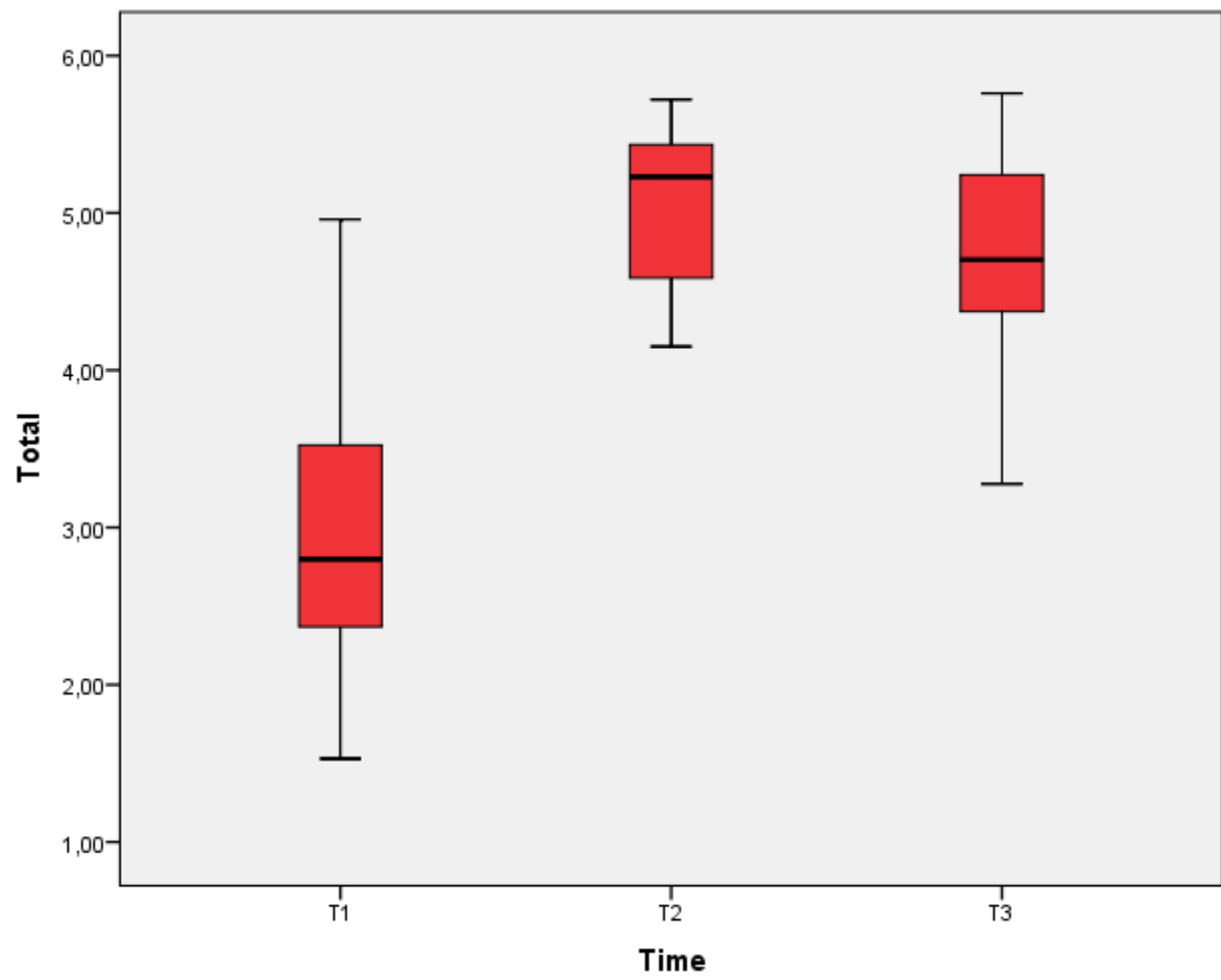
Figure 1 Assessment form used by the observers.

Primary assessment		
A	<ul style="list-style-type: none"> <li>- examines the airway</li> <li>- mentions obstructed airway</li> <li>- applies airway maneuvers</li> <li>- applies oxygen</li> </ul>	agree / disagree agree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree/ d.n.a.
B	<ul style="list-style-type: none"> <li>- examines B completely (color, trachea, resp. rate, excursions, breathing effort, percussion, auscultation, saturation)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7 - 8  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
C	<ul style="list-style-type: none"> <li>- examines C completely (circulation of extremities, central pulse, heart rate, blood pressure, cap.refill, CVP, heart sounds)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4 - 5 - 6 - 7  agree / partially agree / partially disagree / disagree / d.n.a. agree / partially agree / partially disagree / disagree / d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
D	<ul style="list-style-type: none"> <li>- examines D completely (Glasgow Coma Scale, pupils, neck stiffness, glucose)</li> <li>- applies EMC correctly</li> <li>- mentions abnormal findings</li> <li>- recognizes life-threatening conditions</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 - 3 - 4  agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
E	<ul style="list-style-type: none"> <li>- examines E completely (temperature, head to toe)</li> <li>- gives nurse the right orders</li> <li>- mentions abnormal findings</li> <li>- orders right additional diagnostic tests</li> <li>- mentions conclusions/interpretation</li> <li>- resuscitates adequately</li> </ul>	1 - 2 agree / partially agree / partially disagree / disagree/ d.n.a. agree / partially agree / partially disagree / disagree/ d.n.a. agree / disagree / d.n.a. agree / partially agree / partially disagree / disagree agree / partially agree / partially disagree / disagree / d.n.a.
R	- asks for help adequately	agree / partially agree / partially disagree / disagree
E	- communicates clearly	agree / partially agree / partially disagree / disagree
M	- summarizes adequately	agree / partially agree / partially disagree / disagree
A	- draws the right conclusions	agree / partially agree / partially disagree / disagree
I	- clinical reasoning is adequate	agree / partially agree / partially disagree / disagree
N	- works structured	agree / partially agree / partially disagree / disagree
I	- stays calm	agree / partially agree / partially disagree / disagree
N	- shows confidence	agree / partially agree / partially disagree / disagree
G	- shows good leadership	agree / partially agree / partially disagree / disagree



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 2: Boxplot showing median and interquartile range of total score on primary assessment at T1, T2 and T3.



## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>Page 1</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Page 4</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Page 6 and 7</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Page 7</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Page 7-9</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Page 9-10</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Page 7-11</b> <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Page 7-12</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>Page 7-12</b>
Bias	9	Describe any efforts to address potential sources of bias <b>Page 7-12</b>
Study size	10	Explain how the study size was arrived at <b>(no effectsize known)</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>Page 12-13</b> (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed <b>Page 12</b> (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy

---

(e) Describe any sensitivity analyses **Page 12 (interobserver reliability)**

For peer review only

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>Page 13</b> (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>Page 13</b> (b) Indicate number of participants with missing data for each variable of interest <b>Page 13 and supplemental file Outcome</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <b>Page 13-15</b> <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>Page 13-15, Table 1 and 2</b> (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>Page 12 (interobserver reliability)</b>

**Discussion**

Key results	18	Summarise key results with reference to study objectives <b>Page 15-16</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>Page 17-18</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>Page 15-18</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>Page 15-18</b>

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>Page 3</b>
---------	----	---

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

For peer review only