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## Simulation and education

# Basic life support training using shared mental models improves team performance of first responders on normal wards: A randomised controlled simulation trial



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### Abstract

**Introduction:** Survival of in-hospital cardiac arrest (IHCA) depends on fast and effective action of the first responding team. Not only technical skills, but professional teamwork is required. Observational studies and theoretical models suggest that shared mental models of members improve teamwork. This study investigated if a training on shared mental models, improves team performance in simulated in-hospital cardiac arrest.

**Methods:** On the background of an introduction of mandatory Basic Life Support (BLS) training for clinical staff a randomized controlled trial was performed to compare two training methods. Staff from clinical departments was randomised to receive either a conventional instructor led training (control group) or an interventional training (intervention group). The interventional training was based on self-directed learning of the group in order to develop shared mental models. Primary outcome were mean scores of the team assessment scale (TAS) and the hands-off time. Secondary outcome were mean scores for quality of BLS.

**Results:** Performance of 75 teams of the interventional and 66 of the control group was analysed. The hands-off time was significantly lower in the interventional group (5.42% vs. 8.85%,  $p=0.029$ ). Scores of the TAS and the overall BLS score were high and not significantly different between the groups. Hands-off time correlated significantly negative with all TAS items.

**Conclusion:** BLS training for clinical staff which creates shared mental models reduces hands-off time in a simulated cardiac arrest scenario. Training methods establishing shared mental models of team members can be considered for effective team trainings without adding additional training time.

**Keywords:** Shared mental models, Self-directed learning, BLS, Basic life support, Training, Simulation, Teamwork

## Introduction

First responders starting basic life support (BLS) without delay and in an efficient way is essential for successful resuscitation in both in-hospital (IHCA) and out-of-hospital cardiac arrest. For early delivery of the three key elements of BLS – chest compression, automatic

external defibrillation and mask ventilation – a well co-working team is required.<sup>1</sup> To perform these technical skills in accordance with the European Resuscitation Council (ERC) algorithm, team members are supposed to have high non-technical skills, such as good communication and team adjustment, too. They have to work as a team.<sup>2–5</sup> So far, the ERC-guidelines of 2015 recommend imbedding team and leadership training in trainings of Advanced Life Support (ALS).<sup>1</sup> This

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recommendation is supported by randomised controlled trials which showed an improvement of team performance and quality of CPR if there was a focus on training non-technical skills and on a structured debriefing of the CPR-scenarios.<sup>6–10</sup>

But how to improve team performance? Salas and colleagues suggested that there are five components which are essential for successful teamwork: 1) team leadership, 2) mutual performance monitoring, 3) backup behaviour, 4) adaptability and 5) team orientation. For realisation of those five components at the bedside, team members have to trust each other, have to communicate and need shared mental models.<sup>11</sup>

The term shared mental model (SMM) means organised knowledge which is shared by every team member. Effective teams do not only have a common understanding of the task including goals and procedures, but also on the team itself. This includes not only roles, communication channels, information flow and resources but also knowledge, skills, strengths and weaknesses of the team members. Such shared mental models have a great impact on team performance especially in stressful situations.<sup>12–14</sup> This has been demonstrated repeatedly for acute patient care.<sup>15–20</sup> Training methods should foster co-construction of goals and priorities by the team.<sup>21</sup> For team-interaction training and cross-training (shadowing other team members) the effectiveness on SMM and team performance has been demonstrated.<sup>22,23</sup>

Therefore building shared mental models should be part of every team training.<sup>24–26</sup> Nevertheless the best way to establish SMM for first responding teams is still unknown.

In this study a training concept for establishing shared mental models in a simulated IHCA was assessed. The team performance of an interventional group, having a BLS training with focus on developing shared mental models of the team members, was compared with a conventional BLS training. It was hypothesized that the interventional training was superior to the conventional training in respect of hands-off time and team performance (primary outcomes). Secondary outcome was quality of BLS performance.

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## Methods

This investigation was a prospective, randomized, simulation study with blinded participants and assessors. It was performed between February and December 2017 at the University Medical Center Hamburg-Eppendorf (UKE), Germany.

In 2017, a mandatory BLS training for all clinical staff was introduced at the University Medical Center Hamburg. The clinical staff was randomised group wise to the interventional or control group. Therefore, the departments were assigned to either the intervention or the control group using computer-generated random numbers. The members of a department were trained in mixed groups including physicians and nurses. The randomisation was performed by a statistician of the department of medical biometry and epidemiology. Departments scheduled for ALS training like the department of anaesthesia, the department of emergency medicine and the department of intensive care medicine were excluded from the study.

The instructors were recruited from the departments of anaesthesia and intensive care. They were experienced nurses or physicians, regularly trained in cardiac life support and had a profound experience in it. All instructors participated in a three-hour preparatory seminar where they received an update on actual recommendations for BLS including scientific background and principals of effective teaching.

Then, following randomisation, the instructors of both groups were familiarized with the specific concept and course of the respective BLS-training, separately. The instructors were informed about the study goals but were asked to keep discreet about the details of their own training method and did not have access to the training material of the other training group.

### BLS-training

This training has been obligatory for clinical staff at the University Medical Center Hamburg. Participation in the study was voluntary and all participants gave their written informed consent. The participants were blinded for the study goal and group allocation. Before starting the training demographic data and clinical experience were recorded using a questionnaire. A maximum of 12 participants per course were trained.

The BLS training lasted 90 min in both groups. Both groups had the same learning goals but different methods and materials were used for skill acquisition and training (Fig. 1). The training of the control group included a 10-min BLS lecture explaining the BLS-algorithm and a brief introduction in essential non-technical skills (effective communication and teamwork, leadership and situational awareness) as recommended in the ERC guidelines.<sup>27</sup> The 15-min demonstration of BLS with use of an automated external defibrillator (Heartstart AED Trainer 3, Philips Medical Systems, Böblingen, Germany) was followed by deconstruction (4-step-approach) of single BLS steps. Afterwards every participant was trained hands-on in a two-rescuer BLS scenario on a high-fidelity manikin (Resusci Anne QCPR manikin, Laerdal Medical AS, Stavanger, Norway). Feedback was provided by the trainer following the structure and atmosphere of a Learning Conversation and including the feedback data from the manikin.<sup>27</sup>

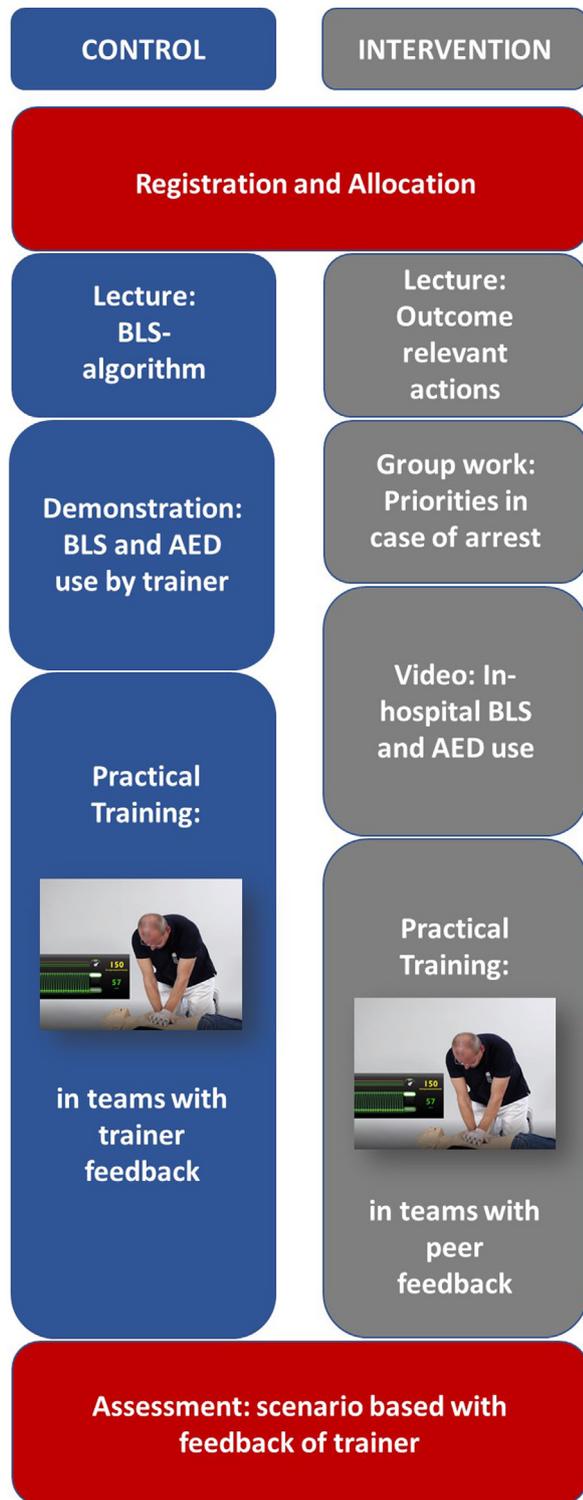
The intervention group received a 10-min BLS lecture outlining the outcome relevant actions during CPR (chain of survival). Afterwards the participants had to arrange the BLS steps according to priority in a 10-min small group work using a magnet board. The results were discussed by the whole group. Afterwards a 4-min teaching-video of how to treat an IHCA was shown,<sup>28</sup> followed by a demonstration of AED use. Afterwards every participant was trained hands-on in a two-rescuer BLS scenario on a high-fidelity manikin (Resusci Anne QCPR manikin). Feedback was provided by the other participants using performance checklists and feedback of the manikin. The participants were told, that maintaining high quality chest compression is a group task in CPR and therefore every participant should learn to detect the quality of CPR and give feedback accordingly. The interventional training was designed by the trial leaders based on their understanding on how shared mental models are created.

In the control group the instructor's role was one of a classic teacher, in the interventional group his or her role was one of a facilitator stimulating self-directed learning.

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## Assessment

At course conclusion three predefined in-hospital cardiac arrest scenarios were simulated. The first scenario was part of the training in both groups. Scenario two and three were used for assessment of the study outcomes. Three to four participants were assigned by randomization to each assessment scenario at the beginning of the training. The randomization followed a predefined system.



**Fig. 1 – Elements and sequence of the BLS training for the intervention and control group.**

#### **Primary outcome: team assessment scale and hands-off time**

The German version of the team assessment scale (TAS) was used to rate the team performance. This scale assesses three categories: Team Coordination (TC), Cooperation and Information Exchange (CIE), and Team Adjustment Behaviour (TAB). Each category has

four to five items and every item was rated on a five-point Likert scale. There was one rater for all groups and scenarios who was well trained to use this rating tool. The rater was blinded to the group allocation.

Based on the assumption that early, effective and minimal interrupted chest compression saves lives and the acceptance of the compression fraction as one proxy of high quality of resuscitation efforts, the total hands-off time was assessed. The delay at the beginning and all pauses were measured using a stopwatch and the skill reporter (Resusci Anne QCPR manikin). To calculate the real hands-off time (time in which no BLS action was performed) 30 s for the initial check, five seconds for two ventilations and 22 s for every rhythm analysis and defibrillation were removed from the total hands-off time. For further analysis the compression fraction was calculated using the equation:  $1 - (\text{real hands-off time} / \text{total scenario time})$ .

#### **Secondary outcome: quality of BLS**

Quality of chest compression and bag-mask ventilation were recorded by the skill reporter manikin. To represent the relevance of the three key stones of BLS on patient outcome and to avoid “construct underrepresentation” and “construct irrelevant variance”, the two most common flaws in examinations, quality of chest compression, bag-mask ventilation and AED-use were weighted 2:2:1 to calculate overall BLS-performance.

An overall chest-compression score of a maximum of 40 points could be achieved if hand position, chest recoil, compression depth (5–6 cm) and compression rate (100–120/min) were perfect over 90% of the time chest compression was attempted. The four quality parameters of chest compression were weighted equally. From the maximum of 10 points within every chest-compression parameter, one point was removed for every 10% of time the parameter was attempted but not performed correctly. This chest compression score was multiplied with the chest compression fraction to capture the quality and the time chest compression was performed.

A maximum of 40 points could be achieved for ventilation if the ventilation-frequency was 4–6 per minute and the mean ventilation volume was 500–600 ml. From this score four points were removed if mean ventilation frequency raised by one above or below the optimum frequency and so on. For every increase or reduction of mean ventilation volume per 25 ml two points were removed from the optimal ventilation score. A maximum of 20 points for AED-use could be achieved if rhythm analyses was performed within the first 30 s. For every delay of 30 s two points were removed from the AED-score.

#### **Statistical analysis**

Statistical analysis was performed with SPSS (version 24, IBM Corp., Armonk, New York, USA). The sample size calculation was based on the assumption of a mean difference of two points in the TAS, a standard deviation of three points, an average cluster size of three scenarios per cluster and an intra-cluster correlation of 0.05. With an  $\alpha$ -error of 0.05 (two-sided) and a power of 80% a minimum sample size of at least 45 test scenarios per group, totalling 90 scenarios were calculated.

Hands-off time, TAS scores and overall BLS-scores had a unimodal symmetrical distribution. For the primary and secondary outcomes, a two-sided t-test was calculated. For post-hoc analyses of the TAS scores, a chi-squared test was used to

compare the both groups. The Spearman correlation coefficient with hands-off time was calculated for TAS scores of the three dimensions and for every item. Categorical variables were reported as absolute and relative frequencies and continuous variables as means with standard deviations. Significance was considered for  $p \leq 0.05$ .

## Results

A total of 183 teams were randomised, 90 teams to the intervention group and 93 teams to the control group. Eight instructors trained the intervention group and eight the control group. Finally, 75 teams of the interventional and 66 teams of the control group were included in the analysis (Fig. 2). A high number of teams had to be excluded from the analyses because the skill reporter did not capture ventilation or denied saving. One trainer finished the scenario regularly before the intended assessment could be finished. Demographic data were comparable between the groups (Table 1).

### Primary outcome: team performance and hands-off time

Team performance assessed with the TAS was high in all dimensions and not significantly different between the groups (Table 2). For the dimension Team Coordination (TC) the intervention group achieved a mean of 4.08 (SD 1.05) points and the control 4.05 (SD 0.98). In the dimension Cooperation and Information Exchange (CIE) the

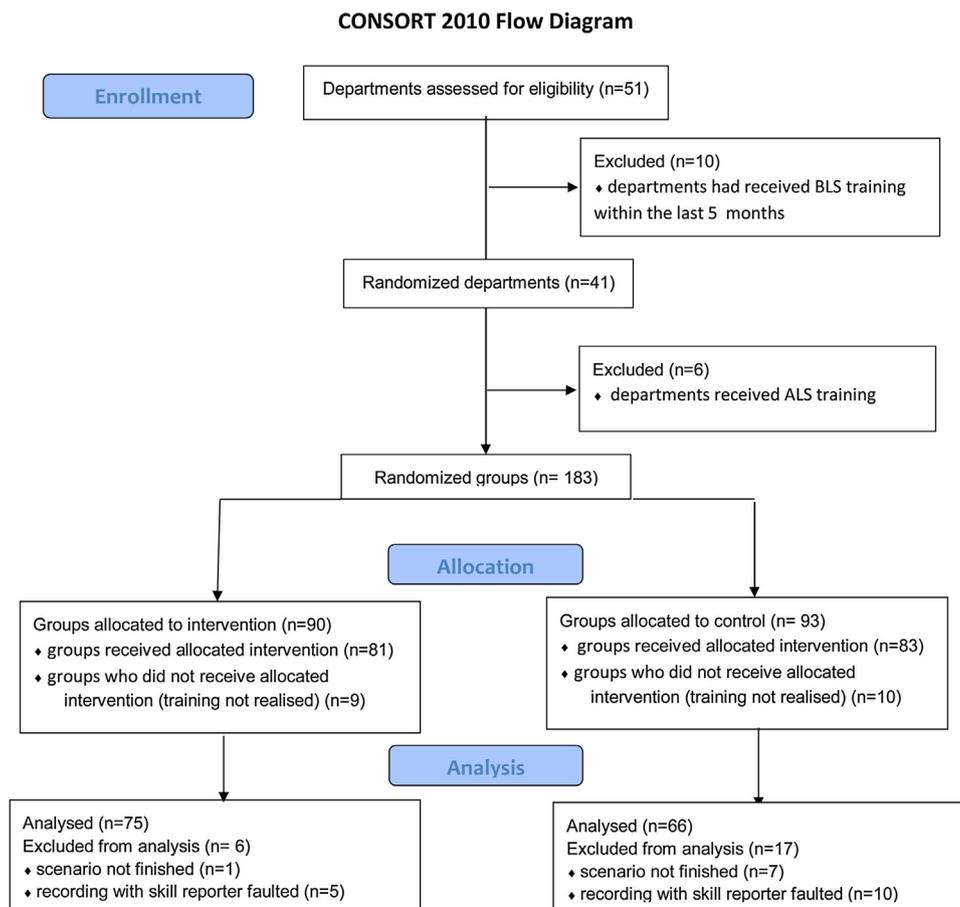
intervention group scored with a mean of 3.88 (SD 1.06) slightly higher than the control group with 3.74 (SD 1.02). Means of Team Adjustment Behaviour (TAB) were 4.28 (SD 0.90) for the intervention group and 4.31 (SD 0.75) in the control group.

The real hands-off time was significantly different between the groups ( $p = 0.029$ ). In the control group, the mean hands-off time was 8.85% (SD 10.6) and in the intervention group it was 5.42% (SD 7.75). The interventional groups started after 25.92 s (SD 11.63) with the chest compression and the control after 29.39 s (SD 17.42) at the beginning (mean difference 3.47, 95% CI:  $-1.09$  to  $8.03$ ;  $p = 0.14$ ) and made less pauses (Fig. 3). During the scenario the groups of the intervention training did not perform any BLS treatment action for 3.83 s (SD: 19.94) and the control training for 10.18 s (SD 24.31; mean difference 6.35, 95% CI:  $-1.02$  to  $13.72$ ;  $p = 0.091$ ).

All dimensions of the TAS correlated significantly negative with the hands-off time (TC:  $CC = -0.23$ ;  $p = 0.010$ , CIE:  $CC = -0.28$ ,  $p = 0.001$ , TAB:  $CC = -0.28$ ;  $p = 0.001$ ). For all items of the TAS a significant negative correlation with CC between  $-0.18$  and  $-0.31$  could be observed.

### Secondary outcome: quality of BLS

The overall score for BLS performance was not significantly different between the groups ( $p = 0.49$ ). The control group achieved a mean score of 71.41 (SD 10.57) and the intervention group of 70.19 (SD 9.71). For the quality of chest compression, the control group achieved slightly higher scores (mean 26.09, SD 5.09) than the intervention group (mean



**Fig. 2 – CONSORT flow diagram of the participants.**

**Table 1 – Demographic data of the participants.**

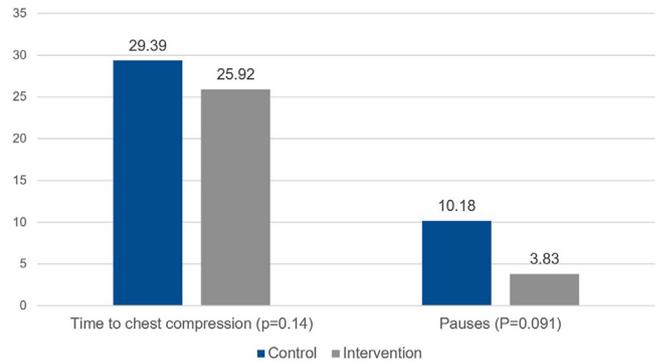
	Control	Intervention
Age % (n)		
16–29 years	16.9 (30/178)	23.7 (57/241)
30–39 years	33.1 (59/178)	34.4 (83/241)
40–49 years	21.3 (38/178)	18.3 (44/241)
50–59 years	23.6 (42/178)	20.3 (49/241)
60+ years	5.1 (9/178)	3.3 (8/241)
Gender % (n)		
Female (%)	66.7 (116/174)	68.1 (160/235)
Profession % (n)		
Nursing (%)	67.5 (114/169)	66.8 (155/232)
Physician (%)	30.2 (51/169)	31.9 (59/232)
Scientist (%)	0.6 (1/169)	3.9 (9/232)
Administration (%)	1.8 (3/169)	3.9 (9/232)
Work experience % (n)		
<5 years	22.2 (39/176)	28.8 (68/236)
5–10 years	19.3 (34/176)	22.5 (53/236)
10–15 years	12.5 (22/176)	15.7 (37/236)
15–20 years	10.2 (18/176)	7.6 (18/236)
>20 years	35.8 (63/176)	25.4 (60/236)
Last CPR-training % (n)		
<6 months	6.1 (10/164)	7.0 (16/228)
6–12 months	16.5 (27/164)	18.9 (43/228)
1–3 years	44.5 (73/164)	43.0 (98/228)
>3 years	25.0 (41/164)	21.5 (49/228)
Not recallable	7.9 (13/164)	9.6 (22/228)

24.63, SD 4.61). The difference of 1.46 points was not significant ( $p = 0.074$ ). Performance scores for quality of bag mask ventilation and AED use were not different between the groups (Table 3).

## Discussion

In this study teams with shared mental models for BLS had a shorter hands-off time during simulated cardiac arrest scenarios compared to the control group. This positive effect on hands-off time may be attributed to improved Cooperation and Information Exchange behaviours of the team. There was a significant correlation of team skills with hands-off time. Therefore, this study suggests three aspects for improving team performance in BLS.

First, shared mental models can be established successfully without the need of any additional training time. So comprehensive concepts for establishing shared mental models during BLS training should be recommended, as it has been for non-technical skills and structured debriefing of the CPR-scenarios.<sup>6–10</sup> For establishing shared mental models, no additional equipment for video debriefing is required. Instructors need to be instructed first, and they need moderation skills, but no formal training on crew-resource management and professional feedback skills is necessary. The teamwork processes during the training allow to acquire shared mental models, theoretical knowledge and skills at the same time. The presented concept improved team performance without adding training time.

**Fig. 3 – Time to first chest compression and pauses during the scenario in seconds.**

So far, there is little evidence of a correlation between team work and clinical team performance.<sup>29</sup> A negative correlation between hands-off time and effective team work has been demonstrated by Fernandez Castelao and colleagues.<sup>9</sup> The negative correlation of all dimensions and items of the team assessment scale with the hands-off time suggests that several aspects of teamwork are essential for effective team performance. In this study the reduced hands-off time can be attributed to improved Cooperation and Information Exchange behaviours. In return it can only be assumed, that an improvement in any other dimension of the team behaviours could lead to lower hands-off time.

Third, establishing shared mental models has been described to improve communication and back-up behaviour for example in fire-fighting simulations.<sup>13,24,30</sup> In the presented study mutual communication and coordination was better, when shared mental models were present. The teams with shared mental models showed more open, directed and closed-loop communication than the teams after the instructor-led course. However, there was no difference in back-up behaviour.

## Strengths and limitations

The study has a low risk of bias according to the Cochrane List of bias for randomised trials. For randomisation and allocation methods with low risk of bias were used. All outcomes are analysed and reported as pre-specified in the ethics application. Blinding of the participants and the assessor was not broken. The trainers were not blinded but highly motivated to train the clinical staff. Missing data due to technical malfunction of the skill reporter is considered as not leading to bias. Even though this randomised controlled trial has a low risk of bias the study has some important limitations.

The team performance in both groups was very high. Therefore, the difference was lower than expected in advance. For some aspects of teamwork, the TAS may not been sensitive enough as both groups were in the upper range of the five-point Likert scale. For better discrimination in the future two methods may be suggested. First,

**Table 2 – Mean points in the three dimensions of the team assessment scale.**

Team performance	Control	Intervention	p-Value
Team adjustment behaviour– mean (SD)	4.31 (0.75)	4.28 (0.90)	0.82
Cooperation and information exchange– mean (SD)	3.74 (1.02)	3.88 (1.06)	0.43
Team coordination– mean (SD)	4.05 (0.98)	4.08 (1.05)	0.88

**Table 3 – Basic life support performance.**

Parameter of BLS	Measured mean values		Calculated mean scores	
	Control	Intervention	Control	Intervention
Quality of chest compression			26.1 (5.1)	24.6 (4.6)
Hand position– time % correct (SD)	85.8 (20.1)	90.1 (17.2)	8.9 (1.9)	9.3 (1.6)
Compression depth– time % correct (SD)	56.5 (19.5)	52.2 (21.6)	6.1 (2.0)	5.7 (2.2)
Compression frequency– time % correct (SD)	34.7 (32.3)	29.2 (27.6)	3.9 (3.2)	3.4 (2.7)
Chest recoil– time % correct (SD)	67.8 (24.4)	58.3 (24.7)	7.2 (2.5)	6.3 (2.4)
Quality of chest compression × cc fraction			23.6 (4.6)	23.3 (4.7)
Hands-off time– % (SD)	8.9 (10.6)	5.4 (7.75)		
Chest compression fraction (SD)	0.91	0.95		
Quality of bag mask ventilation			31.4	30.6
Time to first ventilation– sec (SD)	54.9 (25.1)	54.5 (26.6)		
Mean ventilation rate– per min (SD)	4.1 (1.4)	4.1 (1.5)		
Mean ventilation volume– ml (SD)	588.8 (161.4)	600.5 (174.0)		
Time to first rhythm diagnostic– sec (SD)	73.6 (31.6)	73.3 (24.8)	16.3	16.2
Time to AED use– sec (SD)	45.4 (28.2)	46.1 (19.9)		
Overall-score BLS score			71.4 (10.6)	70.2 (9.7)

counting the frequency of certain behaviours seems to enhance the discrimination, however, this method is not validated for the TAS so far. Second, behaviours indicating shared mental models could be used as an endpoint of team interventions. Westli et al. reported that team performance of trauma teams is better predicted by behaviours indicating shared mental models than by teamwork skills.<sup>31</sup> To investigate if shared mental models are good predictors of team performance in resuscitation, validated instruments with high discriminatory power like the ATOM<sup>32</sup> could be used.

This study shows that this local training concept on shared mental models is effective to reduce hands-off time. However, it does not provide information about which component of the concept is the most effective. Therefore, the presented data only allows the conclusion, that this multifactorial concept of shared mental models is effective. Previous studies investigated single components of a training and outlined that co-construction is important for the development of task related shared mental models in teams.<sup>21</sup> Giving and receiving feedback from other team members provides the opportunity to learn more about the individual members of the team (skills, strengths, needs . . .). It supports open and directed communication and activates all team members to take responsibility for the performance of all team members. It can be assumed that this part had a strong impact on Cooperation and Information Exchange behaviours.

The effects of the intervention measured in a simulated cardiac arrest situation seems low and the clinical effect of the intervention cant be estimated. For assessing the effects of the training on patient outcome, performance markers as response times, time until chest compression and AED use and quality of chest compression and ventilation must be assessed in real cardiac arrest situations.

## Conclusion

BLS training for clinical staff which supports development of shared mental models reduces hands-off time in a simulated cardiac arrest scenario. The reduction of the hands-off time is associated with a better team coordination in this group. Training methods establishing shared mental models of team members should be considered for

effective team training, and they can be achieved without adding additional training time.

## Ethics approval

The study was rated by the head of the local Ethic Committee of the Medical Association of Hamburg as a study with humans but not on humans. Therefore, this educational study does not refer to the statutes of the ethic committee (§ 9 des Hamburgischen Kammergesetzes für Heilberufe) and the study was not appropriate for ethic consultation.

## Conflicts of interest

None.

## Acknowledgements

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## REFERENCES

1. Finn JC, Bhanji F, Lockey A, et al. Part 8: education, implementation, and teams. 2015 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Resuscitation* 2015;95:e203-24.
2. Greif R, Lockey AS, Conaghan P, et al. European resuscitation council guidelines for resuscitation 2015. Section 10. Education and implementation of resuscitation. *Resuscitation* 2015;95:288-301.
3. Hunziker S, Johansson AC, Tschan F, et al. Teamwork and leadership in cardiopulmonary resuscitation. *J Am Coll Cardiol* 2011;57:2381-8.
4. Hunziker S, Tschan F, Semmer NK, et al. Hands-on time during cardiopulmonary resuscitation is affected by the process of teambuilding: a prospective randomised simulator-based trial. *BMC Emerg Med* 2009;9:1-10.

5. Yeung JHY, Ong GJ, Davies RP, Gao F, Perkins GD. Factors affecting team leadership skills and their relationship with quality of cardiopulmonary resuscitation. *Crit Care Med* 2012;40:2617–21.
6. Thomas EJ, Taggart B, Crandell S, et al. Teaching teamwork during the neonatal resuscitation program: a randomized trial. *J Perinatal* 2007;27:409–14.
7. Hunziker S, Bühlmann C, Tschan F, et al. Brief leadership instructions improve cardiopulmonary resuscitation in a high-fidelity simulation: a randomized controlled trial. *Crit Care Med* 2010;38:1086–91.
8. Fernandez R, Pearce M, Grand JA, et al. Evaluation of a computer-based educational intervention to improve medical teamwork and performance during simulated patient resuscitations. *Crit Care Med* 2013;41:2551–62.
9. Fernandez Castela E, Russo SG, Cremer S, et al. Positive impact of crisis resource management training on no-flow time and team member verbalisations during simulated cardiopulmonary resuscitation: a randomised controlled trial. *Resuscitation* 2011;82:1338–43.
10. Blackwood J, Duff JP, Nettel-Aguirre A, Djogovic D, Joynt C. Does teaching crisis resource management skills improve resuscitation performance in pediatric residents? *Pediatr Crit Care Med* 2014;15:e168–74.
11. Salas E, Sims DE, Shawn Burke C. Is there a “big five” in teamwork? *Small Group Res* 2005;36:555–99.
12. Mathieu JE, Heffner TS, Goodwin GF, Salas E, Cannon-Bowers JA. The influence of shared mental models on team process and performance. *J Appl Psychol* 2000;85:273–83.
13. Zhou Z. Planning and team shared mental models as predictors of team collaborative processes. Old Dominion University; 2017.
14. Scheutz M, DeLoach SA, Adams JA. A framework for developing and using shared mental models in human-agent teams. *J Cogn Eng Decis Mak* 2017;11:203–24.
15. Burtscher MJ, Kolbe M, Wacker J, Manser T. Interactions of team mental models and monitoring behaviors predict team performance in simulated anesthesia inductions. *J Exp Psychol Appl* 2011;17:257–69.
16. Markert ML, Devlin BH, Chinn I, Elizabeth A. Impact of an electronic handoff documentation tool on team shared mental models in pediatric critical care. *J Biomed Inform* 2016;44:61–70.
17. Custer JW, White E, Fackler JC, et al. A qualitative study of expert and team cognition on complex patients in the pediatric intensive care unit. *Pediatr Crit Care Med* 2012;13:278–84.
18. Martinez AR. The role of shared mental models in team coordination crew resource management skills of mutual performance monitoring and backup behaviors. University of Southern Mississippi; 2015.
19. Nakarada-Kordic I, Weller JM, Webster CS, et al. Assessing the similarity of mental models of operating room team members and implications for patient safety: a prospective, replicated study. *BMC Med Educ* 2016;16:1–11.
20. Borrill CS, Carletta J, Carter AJ, et al. The effectiveness of health care teams in the National Health Service report. Birmingham: University of Aston; 2001.
21. van den Bossche P, Gijssels W, Segers M, Woltjer G, Kirschner P. Team learning: building shared mental models. *Instr Sci* 2011;39:283–301.
22. Nelson S, White CF, Hodges BD, Tassone M. Interprofessional team training at the prelicensure level: a review of the literature. *Acad Med* 2017;92:709–16.
23. Marks MA, Sabella MJ, Burke CS, Zaccaro SJ. The impact of cross-training on team effectiveness. *J Appl Psychol* 2002;87:3–13.
24. Reynolds Rosemarie, Blickensderfer E. Crew resource management and shared mental models: a proposal. *J Aviat Educ Res* 2009;19:15–24.
25. Stout RJ, Salas E, Fowlkes JE. Enhancing teamwork in complex environments through team training. *Group Dyn Theory Res Pract* 1997;1:169–82.
26. Sundar E, Sundar S, Pawlowski J, Blum R, Feinstein D, Pratt S. Crew resource management and team training. *Anesthesiol Clin* 2007;25:283–300.
27. Perkins GD, Travers [101\_TD\$DIFF][98\_TD\$DIFF]3ew AH, Berg RA, et al. Part 3: adult basic life support and automated external defibrillation. 2015 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Resuscitation* 2015;95:e43–69.
28. Thieme I care-. *Sofortmaßnahmen Reanimation*. (Accessed 15 January 2017, at [https://www.youtube.com/watch?v=D\\_C3hFhXXyY](https://www.youtube.com/watch?v=D_C3hFhXXyY). Published 2015).
29. Schmutz J, Manser T. Do team processes really have an effect on clinical performance? A systematic literature review. *Br J Anaesth* 2013;110:529–44.
30. Stout RJ, Cannon-Bowers JA, Salas E, Milanovich DM. Planning, shared mental models, and coordinated performance: an empirical link is established. *Hum Factors J Hum Factors Ergon Soc* 1999;41:61–71.
31. Westli KH, Johnsen BH, Eid H, Rasten I, Brattebo G. Teamwork skills, shared mental models, and performance in simulated trauma teams: an independent group design. *Scand J Trauma Resusc Emerg Med* 2010;1–8.
32. Dickinson TL, McIntyre RM. A conceptual framework for teamwork measurement. *Team performance assessment and measurement: theory, methods, and applications. series in applied psychology*. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers; 1997. p. 19–43.