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Simulation and education

A nationwide investigation of CPR courses, books, and skill retention

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Abstract

Introduction: Survival from Out-of-Hospital Cardiac Arrest is highly associated with bystander cardiopulmonary resuscitation. The quality of bystander CPR is influenced by citizens attending Basic Life Support (BLS) courses and the quality of these courses. The purpose of the study was to investigate content, quality and compliance with the European Resuscitation Council (ERC) guidelines in national Danish BLS courses and the skill retention.

Methods: Books from 16 different course providers were analyzed for compliance with guidelines using the principle of mutually exclusive and collectively exhaustive questioning. Observation of 56 BLS courses were conducted using an evaluation sheet, with a five-point Likert scale including theoretical, technical, and non-technical skills. BLS skills of participants were assessed with a follow-up test 4–6 months after a course using a modified Cardiff Test.

Results: Analysis of the books, showed compliance with ERC guidelines of 69% on the examined items. Courses using ERC educational structure and having maximum six participants per instructor were associated with high quality in the course observations and a better follow-up test. Especially, the use of automated external defibrillator showed significant odds ratio (OR) of 21.8 (95% CI 4.1–114.7) to 31.3 (95% CI 3.7–265.1) of achieving high quality on courses with similar results in the follow-up test.

Conclusion: National BLS courses had significant variation in the content of books, and compliance to ERC guidelines during courses and in skills retention 4–6 months after the courses. This study can be used to further improve and standardize BLS courses.

Keywords: BLS, Education, CPR, Quality CPR, Retention, Survival

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Introduction

Out-of-Hospital Cardiac Arrest (OHCA) is one of the most common causes of sudden death. In Europe 350,000–700,000 individuals are affected by sudden cardiac arrest each year and[1–3] in Denmark, approximately 4000 OHCA's are registered annually.[4,5] Between 2001 and 2014 Denmark has tripled 30-day survival from 3.9% to 12.7%.[4,5] The trend is associated with a large increase in bystander cardiopulmonary resuscitation (CPR) from 19.4% in 2001 to 65.8% in 2014.[4,5] Similar trends have been observed in other European countries and the Global Resuscitation Alliance has emphasized the importance of high quality bystander CPR.[3,6,7]

Evidence show that education in basic life support (BLS) and the use of an automated external defibrillator (AED) can increase survival rates of OHCA.[6,8,9] It is important to ensure a certain standard of bystander CPR quality to increase survival.[10,11] Furthermore, BLS courses may facilitate better collaboration between medical dispatchers and bystanders, dispatcher assisted CPR (DA-CPR), which is emphasized in the recent guidelines for resuscitation.[11,12,13] The ERC has created standardized guidelines for BLS courses and the training of instructors.[14–18] Items important for the effect of bystanders' actions on survival include early recognition of cardiac arrest and agonal breathing, call for emergency medical services (EMS), quality of CPR, and AED use.[5,11] All these items are part of the chain of survival and should be part of both books and courses, enabling the participants to acquire these skills after course participation. Other recommended elements include the methodology and educational structure of the course, time for practical training, feedback and the number of participants per instructor.[14,15] In several studies the effect of having health care educated instructors opposed to non-health care educated instructors have been examined when teaching schoolchildren. The apparent reports indicate that health care educated instructors are not more effective.[19] However, it is still partly unanswered whether the same conclusion can be drawn on adult certified courses. The ERC course guidance serves as marker for quality in courses and books. A previous examination on content of Danish books have indicated that ERC BLS guidelines have only been partly implemented in books.[20] To illuminate implementation and compliance to BLS guidelines all uniform parts of courses and outcome should be examined in conjunction. A systematic examination of all relevant national books in conjunction with courses and skills of participant's does not exist.

Many studies have established the effect of a rise in the quantity of courses.[4,5,9] It has been demonstrated that courses can vary both in terms of quality and compliance to guidelines in limited settings.[21–23] However, there is a gap of knowledge regarding the level of implementation of the resuscitation guidelines in basic life support courses for laypeople as well as the quality of courses and participants' retention of skills. Further, the effect of using the ERC educational structure on courses, of health care educated instructor and the number of participants per instructor is not known.

This study had three overall objectives: 1) To examine whether the Danish books complied with international guidelines; 2) To investigate the content, quality and compliance with ERC guidelines in all certified Danish CPR courses; 3) To examine the BLS skills of participants after a retention period of 4–6 months.

Methods

This study was an observational study of CPR-AED courses, consisting of book analysis, course observations, and follow-up tests of course participants' skills after a retention period of 4–6 months. Allowing organizations, a maximum amount of time to implement the 2010 guidelines, this study was conducted just before the implementation of the 2015 guidelines. Inclusion criteria were certified CPR-AED courses with a minimum length of three hours and 30 min and a maximum of five hours announced length (excluding breaks).

Setting

In Denmark, approximately 250,000 citizens attend CPR-AED courses annually.[6] Most courses follow either the international ERC certified courses educational structure or the structure provided by the Danish First Aid Council.[18] Both recognized structures intend to follow the standards of the ERC guidelines.[14,16]

Books

We identified 16 books containing instructions and guidance for training laypersons in CPR and AED use just before the introduction of the 2015 ERC BLS guidelines.[14] All books were evaluated based on a checklist (supplementary material) developed using the MECE (mutually exclusive and collectively exhaustive questioning) principle.[24–27] Items with low interrater reliability (kappa score below 0,6) were excluded.

Course observations

We recruited 6 experienced CPR-AED instructors as observers. The selection of course observers focused on attaining broad experience, geographical distribution, and selection of observers from different organizations. The observers attended a course on non-technical skills followed by training in objective observation. This included plenary rating of test video sequences of each item with a panel discussion on challenging items and deliberate practice which is used in other settings with the specific goal of improving performance.[28] The course observers were informed not to interact with either instructors or participants during courses to minimize the disturbing element and avoid interruptions to normal course structure. This practice partially limited the ability to collect additional information about the instructors (e.g. years of experience as an educator) with the aim of collecting more accurate data on the courses. Instructors of courses were informed by their respective organizations that an observer from a national investigation of courses would attend the course as an observer. Two pilot tests were conducted to test interrater reliability between the observers on two different courses where all six observers were present. A Cronbach alpha of 0.6 was considered acceptable level of agreement.

Data collection of the course observations was performed using an observation sheet. The sheet was developed based on previous sheets by Wagner et al. and the ERC 2010 BLS guidelines.[14,21] The final sheet contained 31 items and was divided into five overall categories: logistic and materials, theoretical items, technical items, non-technical items, and feedback (supplementary materials). We were not able to collect data on age and gender of the

instructor in the current study due to the restrictions in the data collection and storage permission from the national data protection agency. Data collection at course observations was aimed at balancing factors with potential influence on courses in a Danish setting. Data collection was balanced to achieve an even regional (geographical), organizational (course providers) and course structural (ERC certificate or Danish first aid council certificate) distribution.

Follow-up test

Following a period of 4–6 months approximately 10% of course participants took part in a 6-minute follow-up test. All participants were invited and those who responded were included. Participants were rewarded with a minor financial compensation. The test started with a standard scenario with a sudden cardiac arrest (supplementary materials). After completion of the standard scenario test each test participant completed a video test of recognition of agonal breathing. The video started with an introductory text describing the case of an unconscious person. It then displayed a person simulating one minute of almost normal appearing (10 irregular occurring gasps) breathing, one minute of agonal breathing followed by one minute of respiratory arrest. The participant was instructed to stop the video when they thought it would be appropriate to start CPR. Data collection was aimed at balancing the same factors as mentioned at course observations. We aimed at an even distribution between participants from courses with health care educated instructors and number of participants below and above 6 per instructor.

Primary outcome measures

The primary outcome variables were recognition of agonal breathing, calling EMS, DA-CPR, compression depth, compression rate, compression recoil, correct ventilations, AED usage, and minimizing hands off time. These variables were measured differently for each level of analysis (books, course observations, and participant's retention of skills).

In the book analysis, the primary outcome measures were set up as binary variables being either addressed or not (supplementary materials). For the course observations, most items were presented as a five-point ordinal Likert scale ranging from wrong/no teaching to excellent marks/correcting mistakes, except for DA-CPR and minimizing hands off time that were binary outcomes (supplementary materials). Non-technical skills were addressed with open ended questions. The primary outcome measures for the follow-up tests were binary variables (being either achieved or not). Items measured by manikin were depth (marked as achieved if between 5–6 cm), rate (marked as achieved if average between 100–120 compressions per minute), recoil/lean (marked as achieved if correct recoil was measured in 50%), rescue breaths (marked as achieved if between 400–700 ml), and correct pad placement (marked as achieved if pads were placed within magnetic fields). Items not measured through the manikin were observed by the researcher using a modified Cardiff test assessment tool.[29] These items were "Call EMS" (call 1-1-2), "AED usage" and "AED safety". Hands off time was calculated as the "no flow time" (time without chest compressions) registered from the manikin subtracted relevant seconds (s) if the rescuer: checked safety (5 s), examined consciousness (5 s), called for help (5 s), checked breathing (10 s), informed helper to call EMS and retrieve AED (20 s), AED first shock (50 s) and AED shock (30 s). These subtracted times were estimations based on the recorded pilot tests. Data were collected using a Laerdal™ QCPR system and a modified Phillips FrX2 AED trainer. A variety of secondary outcome measures were collected from the three parts of the study (supplementary materials).

Statistical analysis

Descriptive analysis of the books analysis was presented by frequencies and percentages (N, %). Agreement between raters of books was analysed using Fleiss kappa analysis. The analyses of course observations were presented by frequency distributions of scores. Interrater reliability between course observers for the pilot test were conducted using a Cronbach alpha analysis. The association between the educational background of the instructors, number of participants and educational course structure and the primary outcome measures was tested using Fishers exact test. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for associations. The follow-up tests were analysed similarly. The association between background of the instructors, number of participants and course structure and time to recognition of agonal breathing was analysed using a *t*-test.

Data from all three parts of the study were collected and all analyses were completed in SAS JMP (2016).

Ethical approval

The regional ethical committee waived the need for approval (ref. no. 15,010,456). An agreement was made with the course organizers from the Danish First Aid Council that the data were presented in an anonymous form in order not to expose individual organizers.

Results

Books

The length of the books was median 97 pages (range 4–273). The Fleiss kappa analysis of agreement between raters revealed that questions regarding coverage of the chain of survival and AED instructions did not produce a value above 0.6 and hence was excluded from further analysis.

Overall, we found compliance with the 2010 guidelines in 69% of the answers (384 of 540 possible "yes" answers). More than half of the books were not compliant with guidelines in several items. In 11 of the examined items the books had poor or no compliance to guidelines. Notably, elements regarding AED usage had low compliance (supplementary materials).

Course observations

The two pilot tests resulted in Cronbach alpha scores of 0.97 and 0.76, respectively. A total of 56 courses was observed from September to December 2015. On average, the courses had 8 participants per instructor and the average course length (excluding breaks) was 3 h and 58 min. The educational background of the instructor was mainly categorized as either health care (defined as doctors, nurses, medical students and EMS-personal, i.e. paramedics, emergency medical technicians) or other. The three non-health categories for educational background was combined to a single group of non-heath care educated instructors. Three courses were excluded because the

Table 1 – Distribution of course observations primary measures. Markings from course evaluation sheet stratified by educational background of the instructor, number of participants per instructor and the educational structure of the course. Presented by number of observations and percentage.

	Educational background of instructor		N° participants/N° instructors		Educational structure of the course		
	Health care, N = 27 Count (%)	Other, N = 26 Count (%)	≤ 6, N = 30 Count (%)	> 6, N = 23 Count (%)	Other, N = 27 Count (%)	ERC, N = 26 Count (%)	All
Agonal breathing							
Not mentioned	4 (15)	8 (31)	5 (17)	7 (30)	9 (33)	3 (12)	12
Not normal breathing	5 (19)	3 (12)	4 (13)	4 (17)	3 (11)	5 (19)	8
Occur before arrest	1 (4)	2 (8)	1 (3)	2 (9)	2 (7)	1 (4)	3
Irregular breathing	3 (11)	2 (8)	3 (10)	2 (9)	2 (7)	3 (12)	5
Demonstrates examples	14 (52)	11 (42)	17 (57)	8 (35)	11 (41)	14 (54)	25
P-Value		0.66		0.51		0.35	
Call EMS							
Not addressed correct	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
1-1-2 mentioned	1 (4)	5 (19)	1 (3)	5 (22)	6 (22)	0 (0)	6
Inform: cardiac arrest	0 (0)	1 (4)	0 (0)	1 (4)	1 (4)	0 (0)	1
Inform: location	10 (37)	12 (46)	13 (43)	9 (39)	8 (30)	14 (54)	22
Instructed to call before cardiac arrest	16 (59)	8 (31)	16 (53)	8 (35)	12 (44)	12 (46)	24
P-Value		0.069		0.092		0.021*	
DA-CPR							
Not addressed	17 (63)	16 (62)	22 (73)	11 (48)	12 (44)	21 (81)	33
Addressed	10 (37)	10 (38)	8 (27)	12 (52)	15 (56)	5 (19)	20
P-Value		1.0		0.087		0.010*	
Depth							
Not addressed correct	0 (0)	5 (19)	1 (3)	4 (17)	5 (19)	0 (0)	5
Instructor explains	1 (4)	0 (0)	1 (3)	0 (0)	0 (0)	1 (4)	1
Instructor demonstrates	2 (7)	2 (8)	0 (0)	4 (17)	4 (15)	0 (0)	4
All participants practice	1 (4)	2 (8)	1 (3)	2 (9)	3 (11)	0 (0)	3
Instructor gives feedback	23 (85)	17 (65)	27 (90)	13 (57)	15 (56)	25 (96)	40
P-Value		0.077		0.005*		<0.001*	
Rate							
Not addressed correct	2 (7)	3 (12)	0 (0)	5 (22)	5 (19)	0 (0)	5
Instructor explains	1 (4)	2 (8)	1 (3)	2 (9)	2 (7)	1 (4)	3
Instructor demonstrates	0 (0)	1 (4)	0 (0)	1 (4)	1 (4)	0 (0)	1
All participants practice	1 (4)	3 (12)	2 (7)	2 (9)	3 (11)	1 (4)	4
Instructor gives feedback	23 (85)	17 (65)	27 (90)	13 (57)	16 (59)	24 (92)	40
P-Value		0.52		0.008		0.028*	
Recoil							
Not addressed correct	7 (26)	13 (50)	9 (30)	11 (48)	14 (52)	6 (23)	20
Instructor explains	1 (4)	0 (0)	1 (3)	0 (0)	0 (0)	1 (4)	1
Instructor demonstrates	2 (7)	1 (4)	1 (3)	2 (9)	2 (7)	1 (4)	3
All participants practice	2 (7)	3 (12)	4 (13)	1 (4)	2 (7)	3 (12)	5
Instructor gives feedback	15 (56)	9 (35)	15 (50)	9 (39)	9 (33)	15 (58)	24
P-Value		0.27		0.44		0.14	
Ventilations							
Not addressed correct	1 (4)	6 (23)	3 (10)	4 (17)	5 (19)	2 (8)	7
Instructor explains	0 (0)	1 (4)	0 (0)	1 (4)	1 (4)	0 (0)	1
Instructor demonstrates	3 (11)	0 (0)	1 (3)	2 (9)	3 (11)	0 (0)	3
All participants practice	1 (4)	3 (12)	1 (3)	3 (13)	4 (15)	0 (0)	4
Instructor gives feedback	22 (81)	16 (62)	25 (83)	13 (57)	14 (52)	24 (92)	38
P-Value		0.027*		0.20		0.008*	
AED usage							
Not addressed correct	1 (4)	4 (15)	0 (0)	5 (22)	5 (19)	0 (0)	5
Instructor explains	1 (4)	3 (12)	0 (0)	4 (17)	4 (15)	0 (0)	4
Instructor demonstrates	1 (4)	6 (23)	2 (7)	5 (22)	6 (22)	1 (4)	7
All participants practice	2 (7)	1 (4)	2 (7)	1 (4)	3 (11)	0 (0)	3
Instructor gives feedback	22 (81)	12 (46)	26 (87)	8 (35)	9 (33)	25 (96)	34
P-Value		0.031*		< 0.001*		< 0.001*	

(continued on next page)

Table 1 *(continued)*

	Educational background of instructor		N° participants/N° instructors		Educational structure of the course		
	Health care, N = 27 Count (%)	Other, N = 26 Count (%)	≤ 6, N = 30 Count (%)	> 6, N = 23 Count (%)	Other, N = 27 Count (%)	ERC, N = 26 Count (%)	All
Hands off							
Not addressed	10 (37)	12 (46)	9 (30)	13 (57)	14 (52)	8 (31)	22
Addressed	17 (63)	14 (54)	21 (70)	10 (43)	13 (48)	18 (69)	31
P-Value		0.58		0.091		0.17	

Distribution of course observations of the primary measure. Each number indicate the number of courses observations rated within the category. Fishers exact test was conducted to test the association between the educational background of the instructor, the number of participant and the educational structure of the course and the course observations primary measures. A P-value below 0.05 indicate a significant association.
* Significant within a 95% confidence interval.

Table 2 – Distribution of course observations primary measures, compliance to guidelines. Markings from course evaluation bundled into observations with no compliance (rated 1) and observations with correct explanation (rated 2 or more). Stratified by educational background of the instructor, number of participants per instructor and the educational structure of the course. Presented by number of observations and percentage.

	Educational background of instructor		N° participants/N° instructors		Educational structure of the course		
	Health care, N = 27 Count (%)	Other, N = 26 Count (%)	≤ 6, N = 30 Count (%)	> 6, N = 23 Count (%)	Other, N = 27 Count (%)	ERC, N = 26 Count (%)	All
Agonal breathing							
No compliance	4 (15)	8 (31)	5 (17)	7 (30)	9 (33)	3 (12)	12
Compliant	23 (85)	18 (69)	25 (83)	16 (70)	18 (67)	23 (88)	41
P-Value		0.20		0.32		0.099	
Call EMS							
No compliance	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
Compliant	27 (100)	26 (100)	30 (100)	23 (100)	27 (44)	26 (46)	53
P-Value		–		–		–	
DA-CPR							
Not addressed	17 (63)	16 (62)	22 (73)	11 (48)	12 (44)	21 (81)	33
Addressed	10 (37)	10 (38)	8 (27)	12 (52)	15 (56)	5 (19)	20
P-Value		1.00		0.087		0.010*	
Depth							
Not addressed correct	0 (0)	5 (19)	1 (3)	4 (17)	5 (19)	0 (0)	5
Instructor explains	27 (100)	21 (81)	29 (97)	19 (83)	22 (81)	26 (100)	48
P-Value		0.023*		0.15		0.051	
Rate							
Not addressed correct	2 (7)	3 (12)	0 (0)	5 (22)	5 (19)	0 (0)	5
Instructor explains	25 (93)	23 (88)	30 (100)	18 (78)	22 (81)	26 (100)	48
P-Value		0.67		0.012*		0.051	
Recoil							
Not addressed correct	7 (26)	13 (50)	9 (30)	11 (48)	14 (52)	6 (23)	20
Instructor explains	20 (74)	13 (50)	21 (70)	12 (52)	13 (48)	20 (77)	33
P-Value		0.093		0.25		0.047*	
Ventilations							
Not addressed correct	1 (4)	6 (23)	3 (10)	4 (17)	5 (19)	2 (8)	7
Instructor explains	26 (96)	20 (77)	27 (90)	19 (83)	22 (81)	24 (92)	46
P-Value		0.050		0.45		0.42	
AED usage							
Not addressed correct	1 (4)	4 (15)	0 (0)	5 (22)	5 (19)	0 (0)	5
Instructor explains	26 (96)	22 (85)	30 (100)	18 (78)	22 (81)	26 (100)	48
P-Value		0.192		0.012*		0.051	
Hands off							
Not addressed	10 (37)	12 (46)	9 (30)	13 (57)	14 (52)	8 (31)	22

Table 2 *(continued)*

	Educational background of instructor		N° participants/N° instructors		Educational structure of the course		
	Health care, N = 27 Count (%)	Other, N = 26 Count (%)	≤ 6, N = 30 Count (%)	> 6, N = 23 Count (%)	Other, N = 27 Count (%)	ERC, N = 26 Count (%)	All
Addressed	17 (63)	14 (54)	21 (70)	10 (43)	13 (48)	18 (69)	31
P-Value		0.58		0.091		0.17	

Distribution of course observations of the primary measure divided into compliance or no compliance with guidelines. Compliance with guidelines was defined as observations mark with at least 2, meaning that the instructor explained the item correctly. Hence, all course observations rated 1 (not addressed correct) were label "no compliance". Each number indicate the number of courses observations rated within the category. The Fishers exact test was conducted to test the association between the educational background of the instructor, the number of participant and the educational structure of the course and compliance to guidelines. A P-value below 0.05 indicate that factor significantly influence whether courses were in compliance with guidelines.

* Significant within a 95% confidence interval.

Table 3 – Odds ratio of course observations primary measures rated high quality. Odds ratio of achieving high quality course observations defined as course observations marked.4-5.

Educational background of the instructor				
Item	**Health care, N = 27 Count (%)**	**Other, N = 26 Count (%)**	**Odds Ratio [CI, 95%]**	**P-value**
*Agonal breathing**	14 (52)	11 (42)	1.47 [0.50, 5.09]	0.59
Call EMS	26 (96)	21 (81)	6.19 [0.67, 57.15]	0.10
DA-CPR	10 (37)	10 (39)	0.94 [0.31, 2.86]	1.0
Depth	24 (89)	19 (73)	2.95 [0.67, 12.95]	0.18
Rate	24 (89)	20 (77)	2.40 [0.53, 10.84]	0.29
Recoil	12 (46)	17 (63)	1.98 [0.66, 5.94]	0.27
Rescue breaths	23 (85)	19 (73)	2.12 [0.54, 8.34]	0.33
AED usage	24 (89)	13 (50)	8.00 [1.92, 33.27]	0.003**
Hands off	17 (63)	14 (54)	1.46 [0.49, 4.37]	0.58
Number of participants per instructor				
Item	**≤ 6, N = 30 Count (%)**	**> 6, N = 23 Count (%)**	**Odds Ratio [CI, 95%]**	**P-value**
*Agonal breathing**	17 (57)	8 (35)	2.50 [0.80, 7.53]	0.17
Call EMS	29 (97)	18 (78)	8.06 [0.87, 74.63]	0.074
DA-CPR	8 (27)	12 (52)	0.33 [0.11, 1.05]	0.087
Depth	28 (93)	15 (65)	7.47 [1.40, 39.73]	0.014**
Rate	29 (97)	15 (65)	15.47 [1.77, 135.51]	0.007**
Recoil	10 (33)	19 (83)	2.25 [0.74, 6.81]	0.17
Rescue breaths	26 (87)	16 (70)	2.84 [0.72, 11.27]	0.18
AED usage	28 (93)	9 (39)	21.78 [4.14, 114.66]	<0.001**
Hands off	21 (70)	10 (44)	3.03 [0.97, 9.44]	0.091
Educational course structure				
Item	**Other, N = 27 Count (%)**	**ERC, N = 26 Count (%)**	**Odds Ratio [CI, 95%]**	**P-value**
*Agonal breathing**	11 (41)	14 (54)	1.70 [0.57, 5.04]	0.41
Call EMS	21 (78)	26 (100)	- [-]	0.023**
DA-CPR	15 (56)	5 (19)	0.19 [0.06, 0.66]	0.010**
Depth	18 (67)	25 (96)	12.50 [1.45, 107.64]	0.011**
Rate	19 (70)	25 (96)	10.53 [1.21, 91.53]	0.024**
Recoil	11 (41)	18 (69)	3.27 [1.05, 10.16]	0.054
Rescue breaths	18 (67)	24 (92)	6.00 [1.15, 31.23]	0.039**
AED usage	12 (44)	25 (96)	31.25 [3.68, 265.11]	<0.001**
Hands off	13 (48)	18 (69)	2.42 [0.79, 7.46]	0.17

Signifying that the instructors gives a correct explanation and demonstration and that each participant trained correctly with the equipment themselves whilst receiving feedback.

* Agonal breathing was analysed as only the rating five indicating high quality.

** Significant within a 95% confidence interval.

Table 4 – Distribution of follow-up test primary measures. Markings from follow-up test stratified by educational background of the instructor, number of participants per instructor and the educational structure of the course. Presented by number of observations and percentage.

	Educational background of instructor		N° participants/N° instructors		Educational structure of the course		
	Health care, N = 14	Other, N = 41	≤ 6, N = 28	> 6, N = 28	Other, N = 33	ERC, N = 23	
	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	All
Call EMS							
Not called	4 (27)	16 (39)	7 (25)	13 (46)	15 (45)	5 (22)	20
1-1-2 called	11 (73)	25 (61)	21 (75)	15 (54)	18 (55)	18 (78)	36
P-Value		0.53		0.16		0.092	
Depth							
Not correct depth	4 (27)	24 (59)	9 (32)	19 (68)	21 (64)	7 (30)	28
Between 5-6 cm	11 (73)	17 (41)	19 (68)	9 (32)	12 (36)	16 (70)	28
P-Value		0.068		0.015*		0.029*	
Rate							
Not correct rate	11 (73)	28 (68)	16 (57)	23 (82)	26 (79)	13 (57)	29
Between 100-120	4 (27)	13 (32)	12 (43)	5 (18)	7 (21)	10 (43)	17
P-Value		1.00		0.080		0.087	
Recoil							
Less than 50% full release	4 (27)	18 (44)	8 (29)	14 (50)	11 (33)	11 (48)	22
More than 50% full release	11 (73)	23 (56)	20 (71)	14 (50)	22 (67)	12 (52)	34
P-Value		0.36		0.17		0.41	
Ventilations							
Not correct volume	12 (80)	35 (85)	24 (86)	23 (82)	27 (82)	20 (87)	45
400-700mL	3 (20)	6 (15)	4 (14)	5 (18)	6 (18)	3 (13)	9
P-Value		0.69		1.0		0.72	
AED usage							
Not addressed correct	2 (13)	7 (17)	2 (7)	7 (25)	8 (24)	1 (4)	9
Instructor explains	13 (87)	34 (83)	26 (93)	21 (75)	25 (76)	22 (96)	47
P-Value		1.0		0.14		0.067	
AED pad placement							
Incorrect placement	3 (20)	17 (41)	5 (18)	15 (54)	17 (52)	3 (13)	20
Correct placement	12 (80)	24 (59)	23 (82)	13 (46)	16 (48)	20 (87)	36
P-Value		0.21		0.011*		0.004*	
AED safety							
Safety demonstrated	8 (53)	22 (54)	6 (21)	24 (86)	29 (88)	1 (4)	30
Safety not demonstrated	7 (47)	19 (46)	22 (79)	4 (14)	4 (12)	22 (96)	26
P-Value		1.0		< 0.001*		< 0.001*	

Table 4 *(continued)*

	Educational background of instructor		N° participants/N° instructors		Educational structure of the course		
	Health care, N = 14	Other, N = 41	≤ 6, N = 28	> 6, N = 28	Other, N = 33	ERC, N = 23	
	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	All
Hands off							
More than 25% inactivity	6 (40)	16 (39)	7 (25)	15 (54)	19 (58)	3 (13)	26
Less than 25% inactivity	9 (60)	25 (61)	21 (75)	13 (46)	14 (42)	20 (87)	32
P-Value		1.0		0.054		< 0.001*	

Distribution of follow-up test results of the primary measure. Each number indicate the number of course participants rated within the category. Fishers exact test was conducted to test the association between the educational background of the instructor, the number of participant and the educational structure of the course and the follow-up test primary measures. A P-value below 0.05 indicate a significant association.
* Significant within a 95% confidence interval.

course length was above 5 h. These courses were not compatible to the general standard due to advanced level training.

Overall, the national results showed high standards. Several of the primary measures had a median score of five (maximum) including: compression depth; compression rate; ratio between compression and ventilations; ventilations and the use of AED. Other items had a median of four including recognition of agonal breathing; call EMS; compression recoil. However, there was substantial variation among courses in most items (Table 1).

The secondary measures showed similar tendencies (supplementary materials).

Factors influencing compliance to guidelines and quality in courses

Three factors were significantly associated with the primary outcome measures: the educational background of the instructor, number of participants per instructor, and whether the course followed the ERC educational course structure or not (Table 1–3). Notably AED usage were marked as significantly higher in courses where the instructor had an educational background within health care (OR:8.0, 95%CI: 1.92–33.27 P = 0.003), where there were six or less participants per instructor (OR:21.78, 95%CI: 4.14–114.66, P: <0.001) and where the course followed the ERC educational course structure (OR:31.25, 95%CI: 3.68–265.11, P = 0.001). Also, measures of depth and rate are examples of notably higher marks of courses where there were six or less participants per instructor (depth, OR: 7.47, 95%CI: 1.4, 39.73, P = 0.014 and rate OR:15.47, 95%CI: 1.77–135.51, P = 0.007) and where the course followed the ERC educational course structure (depth, OR:12.5, 95%CI: 1.45–107.64 P = 0.011 and rate, OR:10.53, 95%CI: 1.21–91.53, P = 0.024).

Measurement of non-technical skills

There was no systematic teaching of non-technical skills in the courses. The only examples of observed teaching in non-technical skills were instructions for the person giving compressions to count out loud and the mentioning of teamwork between the medical dispatcher and the bystander.

Follow-up test

From February to April 2016, 56 follow-up tests were conducted. Table 4 show the distribution of scores in the follow-up tests divided into the three factors influencing course observations. Fig. 1, portrays odds ratios on the three influencing factors from both the course observations and the follow-up tests.

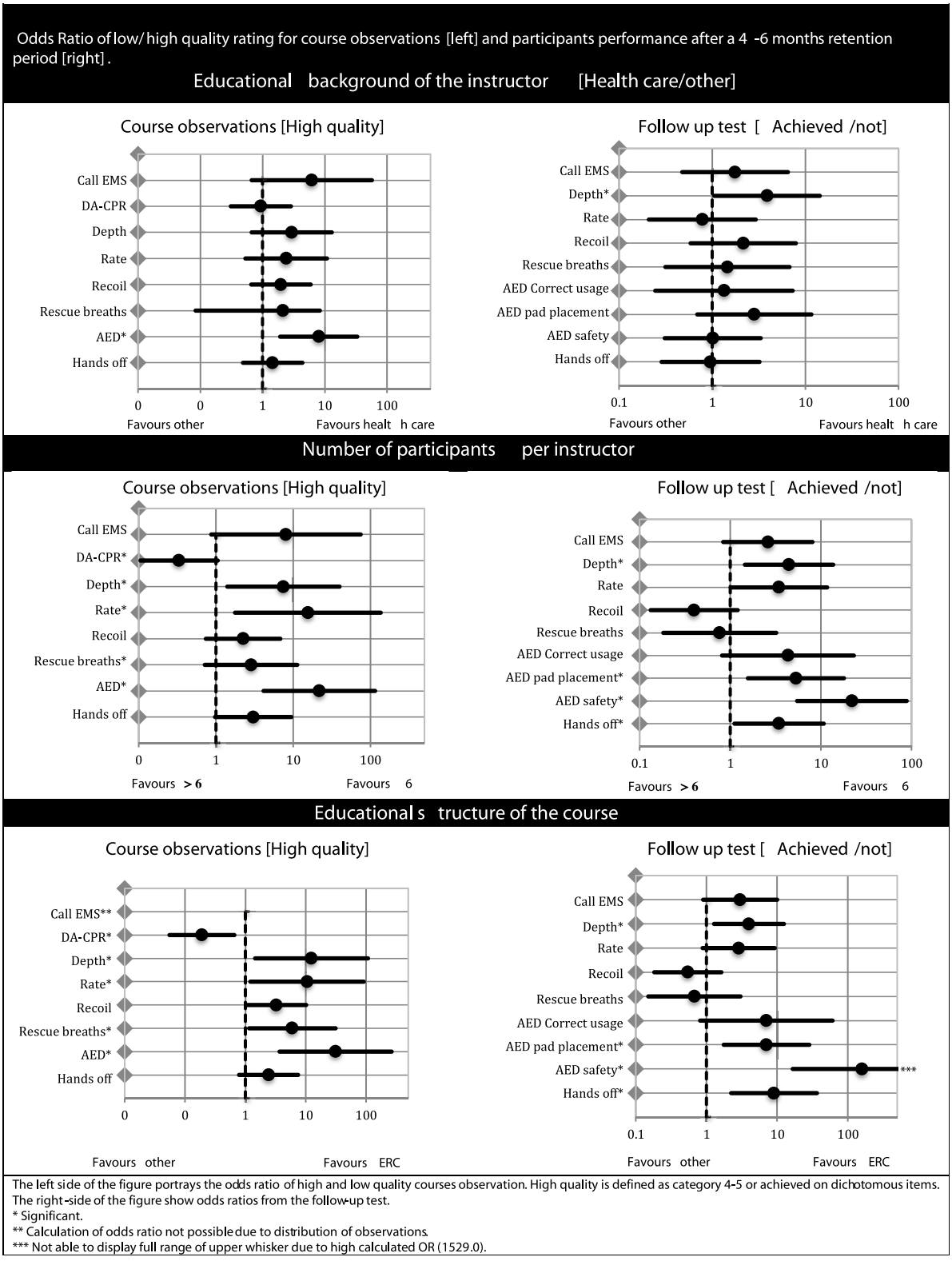
The educational background of the instructor showed only to be a significant weak factor concerning depth (3.88, 95%CI 1.06–14.28, P = 0.07). The participants attending courses with less than six participants had a significantly higher OR of giving correct depth (OR 4.46, 95%CI 1.45–13.68 P = 0.015), correct AED pad placement (OR:5.31, 95%CI 1.57–17.97, P = 0.01) and ensuring AED safety (OR:22.0, 95%CI 5.47–88.43, P < 0.01). Participant on ERC courses had significantly better OR than those attending other courses on depth (OR:4,0 95%CI 1.28–12.47, P = 0.03), rate (OR:2.86, 95%CI 0.88–9.24, P = 0.09), AED pad placement (OR: 7.08, 95%CI 1.76–28.51, P < 0.01), ensuring AED safety (OR: 159.5, 95%CI 16.64–1529.0, P < 0.01) and hands off time (9.05, 95%CI 2.24–36.55, P < 0.01). The supplementary materials contain a full list of results of OR calculations.

Agonal breathing in follow-up test

A significant difference in mean recognition time for agonal breathing was seen between participants who followed an ERC courses (M = 70.7 S, SD = 37.4S) and other courses (M = 92.1S, SD = 34.1). The other two factors examined did not show significant results (Table 5).

Discussion

The examination of books used for BLS-training showed large variation in compliance to guidelines notably, elements of DA-CPR



The left side of the figure portrays the odds ratio of high and low quality courses observation. High quality is defined as category 4-5 or achieved on dichotomous items. The right-side of the figure show odds ratios from the follow-up test.
* Significant.
** Calculation of odds ratio not possible due to distribution of observations.
*** Not able to display full range of upper whisker due to high calculated OR (1529.0).

Fig. 1 – Odds ratios from course observations and follow-up tests.

Table 5 – Recognition of agonal breathing. *t*-test of agonal breathing video recognition follow-up test. Stratified by educational background of the instructor, number of participant per instructor and the educational structure of the course.

Educational background of the instructor	N	Mean	St. Dev.	SE	95% CI	P
Other	41	84.46	36.84	5.75	72.84; 96.09	0.70
Health care	15	80.20	37.77	9.75	59.28; 101.12	
Number of participants per instructor	**N**	**Mean**	**St. Dev.**	**SE**	**95% CI**	**P**
More than six	28	91.36	35.43	6.70	77.62; 105.10	0.10
Six or below	28	75.29	36.99	6.99	60.94; 89.63	
Educational Course structure	**N**	**Mean**	**St. Dev.**	**SE**	**95% CI**	**P**
Other	33	92.09	34.46	6.00	79.87; 104.31	0.031*
ERC	23	70.74	37.10	7.74	54.70; 86.78	

* Significant within a 95% confidence interval.

and AED usage. Course observations revealed a huge variation within training of AED. In addition, we found substantial variation in some other key items defining quality CPR as compression depth, recoil and rate as well as rescue breaths in the course observations. Three factors influencing the results of the courses observations were identified. These were the educational background of the instructor, the number of participants per instructor and whether the course followed the ERC educational course structure.

The follow-up test of the course participants after a retention period showed the same tendencies with two of the three factors showing significant variation (number of participants per instructor and educational structure of the course).

We found that the overall quality of the courses in Denmark is high. However, few important items did reveal significant difference.

It is an established fact that high quality CPR and the early use of AED is associated with increased survival and hence it is important to focus on these issues in training. To increase this impact further it is important to increase the quality of the bystander intervention and hence the training. Only few studies have analyzed the quality of bystander CPR and relation to quality and compliance to guidelines of CPR courses.[21–23]

We observed huge variation in quality of some items and compliance to guidelines in training of AED during courses. The data show that AED usage was ranked low compared to most other factors indicating that on approximately one fourth of the courses not all participants trained with an AED and even more did not train correct usage of an AED. This fact is interesting in the national context due to the large and systematically placement of publicly accessible AED's in Denmark and the relatively rare use of AEDs by laypersons.[30,31]

Further, we see how teaching recognition of agonal gasps is challenging for instructors during courses and is an item that shows significant variation among courses. Similar results have been shown by Wagner et al.[21]

Our data clearly show the variation in the same skills was insufficient in the courses, notably AED usage and compression parameters. In line with the conclusions of Wagner et al.[21] we argue that mandatory quality management programs on key issues related to survival could prove beneficial.

Of the three factors examined to impact the quality and compliance of courses and participant's skills after a retention period, the number of participants and the educational structure of the course were most associated with favourable outcomes. Specifically, we find that having 6 or fewer participants per instructor significantly impacts both the quality of the course and the skills of the participants on several key issues related to survival. That is not to state that non-ERC courses with more 6 participants per instructor do not have merit in mass training. Rather we try to show what constitute high quality courses and serve as a base to improve those course formats that has a documented potential. In going from guidelines to best practice the relevant organizations can prove an essential and hence studies like this can serve as a tool for the organizations as well as scientific documentation. The effect of having health care educated instructors are not apparent in this study. Our data is in agreement with the results of a systematic review by Plant et al. Only one parameter of the follow-up test showed to weakly influenced by this factor. Like Plant et al. we note that there might be several benefits to using non-health care educated in terms of resources and availability of instructors.[19]

Strengths and limitation

The strength of this study is that is a nationwide study using three different sources of data to evaluate the same object. Our approach with calculating interrater reliability scores before rating books and courses add internal validity to our results. The large quantity of the material strengthens this study as there is substantially more observations than in previous studies.

Course instructors knew in advance that their courses would be observed, due to ethical and logistical considerations. However, the instructors did not know the specific data points observed and registered. Nevertheless, there is a possibility of social desirability bias and Hawthorne effect due to the logistical nature of the course observations. In addition, these biases are likely to occur in the follow-up tests in which logistical challenges were similar. Although relevant, age and gender was not collected in the current study due to limited data collection and storage permission. Similarly, potentially relevant information about years of experience as an educator of the instructor was not collected. The term health care educator instructor might encompass instructors with different length of education and different professional background, all of which might influence the training. Further, items not included in this examination, but inherently important to bystander action like barriers and willingness to act, are not included.

Future perspectives

The perspectives of gaining insight to the quality of BLS courses and compliance with guidelines are essential to improve survival. Thereby implementing lifesaving research faster and more efficiently and ensure high quality of bystander CPR ultimately changing survival rates.

The results of this study can guide future course improvements by all major course formats and serve as a baseline for future studies on compliance with guidelines and quality. Further studies on the implementation of non-technical skills to facilitate improved collaboration between dispatchers and bystanders are needed as well as a validated tool for testing course participants to compare course formats and the effect of years of experience educating are needed.

Conclusion

In this nationwide study, we found that books for BLS courses did not cover all steps needed for effective BLS. Three factors correlating with the quality of courses and the compliance to guidelines mostly in favour were identified: six or less participant per instructor, a health care educated instructor, and structuring the course according to ERC guidelines. After a period of 4–6 month the course participants exhibited variation in skills equal to those subjects not fully covered at the course.

Conflict of interest

TEP is chair of the Danish first aid council and head of the Danish People's Aid. JRH is member of the board in the BLS group in the Danish Resuscitation Council and has a position in the Danish Emergency Management Agency as head of education. FL is CEO of the EMS Copenhagen. AKE, FL, FF and TWJ have no competing interests. The EMS Copenhagen reports unrestricted research grants from the Danish foundation TrygFonden and from Laerdal Foundation.

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Declarations

No human participation or patient data were included in this study no ethics approval was deemed necessary or consents of publication. All data generated or analysed during this study are included in this published article and its supplementary information files.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2018.10.029.

REFERENCES

1. Berdowski J, Berg RA, Tijssen JG, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation 2010;81(11):1479–87.
2. Grasner JT, Bossaert L. Epidemiology and management of cardiac arrest: what registries are revealing. Best practice & research. Clin Anaesthesiol 2013;27(3):293–306.
3. Grasner JT, Herlitz J, Koster RW, Rosell-Ortiz F, Stamatakis L, Bossaert L. Quality management in resuscitation–towards a European cardiac arrest registry (EuReCa). Resuscitation 2011;82:989–94.
4. Hansen SM, Wissenberg M, Rajan S, et al. Danish cardiac arrest registry. Out-of-Hospital cardiac arrest in Denmark. Scientific report 2001- [in danish]. 2018 Available at: http://genoplivning.dk/wp-content/uploads/2016/05/Rapport-fra-Dansk-Hjertestopregister-2001-2014.pdf [Accessed 20 July 2018].
5. Wissenberg M, Lippert FK, Folke F, Weeke P, Hansen CM, Christensen EF, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. Jama 2013;310(13):1377–84.
6. Eisenberg M, et al. A call to establish a global resuscitation alliance. 2018 [ONLINE] Available at: https://foundation915.files.wordpress.com/2016/07/a-call-to-establish-a-global-resuscitation-alliance-2016.pdf [Accessed 20 July 2018].
7. Song J, et al. The effect of bystander cardiopulmonary resuscitation on the survival of out-of-hospital cardiac arrests: a systematic review and meta-analysis. Scand J Trauma Resusc Emerg Med 2018;26(1):86.
8. Stiell I, Nichol G, Wells G, De Maio V, Nesbitt L, Blackburn J, et al. Health-related quality of life is better for cardiac arrest survivors who received citizen cardiopulmonary resuscitation. Circulation 2003;108(16):1939–44.
9. Lockey A, Lin Y, Cheng A. Impact of adult advanced cardiac life support course participation on patient outcomes-A systematic review and meta-analysis. Resuscitation 2018;129:48–54.
10. Wik L, Steen PA, Bircher NG. Quality of bystander cardiopulmonary resuscitation influences outcome after prehospital cardiac arrest. Resuscitation 1994;28(3):195–203.
11. Holmberg M, Holmberg S, Herlitz J. Factors modifying the effect of bystander cardiopulmonary resuscitation on survival in out-of-hospital cardiac arrest patients in Sweden. Eur Heart J 2001;22(6):511–9.
12. Kashani S, Sanko S, Eckstein M. The critical role of dispatch. Cardiol Clin 2018;36(3):343–50.
13. Monsieurs KG, et al. European resuscitation council guidelines for resuscitation 2015: section 1. Executive summary. Resuscitation 2015;95:1–80.
14. Koster RW, Baubin MA, Bossaert LL, Caballero A, Cassan P, Castren M, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 2. Adult basic life support and use of automated external defibrillators. Resuscitation 2010;81(10):1277–92.
15. Mancini ME, Soar J, Bhanji F, Billi JE, Dennett J, Finn J, et al. Part 12: education, implementation, and teams: 2010 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation 2010;122(16 Suppl 2):S539–81.
16. Perkins GD, Handley AJ, Koster RW, Castren M, Smyth MA, Olasveengen T, et al. European Resuscitation Council Guidelines for

Resuscitation 2015: section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81–99.
17. Greif R, Lockey AS, Conaghan P, Lippert A, De Vries W, Monsieurs KG. European Resuscitation Council Guidelines for resuscitation 2015: section 10. Education and implementation of resuscitation. Resuscitation 2015;95:288–301.
18. Schroder H, et al. Influence of learning styles on the practical performance after the four-step basic life support training approach - an observational cohort study. PLoS One 2017;12(5):e0178210.
19. Plant N, Taylor K. How best to teach CPR to schoolchildren: a systematic review. Resuscitation 2013;84(4):415–21.
20. Hoyer CC, Christensen EF. [Recommendations for basic life support in Denmark. Comparison with international guidelines]. Ugeskr Laeger 2003;165(45):4301–5.
21. Wagner P, Lingemann C, Arntz HR, Breckwoldt J. Official lay basic life support courses in Germany: is delivered content up to date with the guidelines? An observational study. Emerg Med J 2015;32(7):547–52.
22. Parnell MM, Larsen PD. Poor quality teaching in lay person CPR courses. Resuscitation 2007;73:271–8.
23. Kaye W, Rallis SF, Mancini ME, Linhares KC, Angell ML, Donovan DS, et al. The problem of poor retention of cardiopulmonary resuscitation skills may lie with the instructor, not the learner or the curriculum. Resuscitation 1991;21(1):67–87.
24. Rasiel E. The McKinsey way. New York: Mcgraw-Hill; 1999.
25. Friga PN. The McKinsey engagement: a powerful toolkit for more efficient and effective team problem solving. New York: McGraw-Hill; 2008.
26. Minto B. The pyramid principle: logic in writing and thinking. Harlow: Financial Times Prentice Hall; 2009.
27. Jensen TW, et al. Danish first aid books compliance with the new evidence-based non-resuscitative first aid guidelines. Scand J Trauma Resusc Emerg Med 2018;26(1):7.
28. Hunt EA, et al. Pediatric resident resuscitation skills improve after "rapid cycle deliberate practice" training. Resuscitation 2014;85 (7):945–51.
29. Whitfield RH, Newcombe RG, Woollard M. Reliability of the Cardiff Test of basic life support and automated external defibrillation version 3.1. Resuscitation 2003;59(3):291–314.
30. Ringh M, et al. The challenges and possibilities of public access defibrillation. J Intern Med 2018.
31. Agerskov M, et al. Public Access Defibrillation: great benefit and potential but infrequently used. Resuscitation 2015;96:53–8.