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Review

Stepwise approach to skills teaching in resuscitation: A systematic review

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Abstract

Aim: To compare the effectiveness of Peyton's four-step approach for teaching resuscitation skills with alternative approaches.

Methods: For this systematic review, we followed the PICOST format (population, intervention, comparison, outcome, study design, timeframe) using Peyton's four-step approach as the standard. We included all studies analyzing skills training related to resuscitation and First Aid in any educational setting. Eligible were randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies, published conference abstracts, and case series where $n \geq 5$). We excluded unpublished results (e.g. trial protocols), commentaries, editorials, reviews. Medline, Embase, PsycINFO, ERIC, CINAHL, and Cochrane were searched from inception until November 10, 2020 (updated November 25, 2022) for publications in all languages as long as there was an English abstract. Titles and abstracts of the papers retrieved were screened, and eligible publications were analysed in full text. From the final set of papers, data were extracted into a spreadsheet, subsequently risk of bias assessment was performed (using RoB2 and ROBINS-I), and the certainty of evidence (using GRADE) for each paper was assessed. Screening of studies, data extraction, risk-of-bias assessment, and assessment of certainty of evidence were all performed by two independent researchers. This review was conducted in adherence with PRISMA standards and was registered with PROSPERO (CRD42023377398).

Results: Overall, the search identified 2,574 studies from which 17 were included in the final analysis (14 RCTs, and 3 non-RCTs). The studies involved a total of 2,906 participants from various populations (from lay persons to health care professionals) and analysed nine different resuscitation skills being taught (ranging from chest compressions to needle cricotomy). The alternative teaching approaches ranged from two-steps to five-steps with various modifications of single steps. High methodological and clinical heterogeneity precluded a meta-analysis from being conducted. The risk of bias assessment showed considerable variation between the studies ranging from 'low' to 'serious'. Across all studies, certainty of evidence was rated as very low due to imprecision and inconsistency. Overall, 14 out of 17 studies showed no difference in skill acquisition or retention when comparing Peyton's four steps to other stepwise approaches.

Conclusions: Very low certainty evidence suggest that Peyton's four-step approach was not more effective in resuscitation skills training compared to alternative approaches.

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Keywords: Resuscitation skills, Skills teaching, Four-step-approach, Peyton, Stepwise skills teaching, Medical education

Introduction

Skills teaching is an integral component of resuscitation training with the aim of cardiac arrest patients receiving high quality cardiopulmonary resuscitation (CPR).[1,2] The instructional approach for skills teaching is likely to impact later performance, and various methods have been described.[3–7] Walker and Peyton proposed that a stepwise approach for skills teaching would be more effective than other approaches.[8] Peyton's 'four-steps' have a firm foundation in educational theory[7,9] and consist of the steps 'demonstration' (skill is demonstrated), 'deconstruction' (skill is shown and explained step

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by step), 'comprehension' (learner gives instructions to instructor to perform the skill), and 'practice' (learners practice individually and receive feedback). Peyton's four-step approach to teach skills is applied in the standard course formats of the European Resuscitation Council (ERC),[10] the Australian Resuscitation Council, and various National Resuscitation Councils in Europe while the American Heart Association does not use the approach. However, it is not clear in the literature whether a four-step approach to teach skills is superior to such modifications as using less than four steps, or substituting single steps by e.g., video[11] or lecture[12] or to no sequencing at all.[13]

To date, no systematic review has specifically focussed on the Peyton's four-step approach for resuscitation training. While one recent systematic review analyzed the value of Peyton's four-step approach in the education of health professionals,[14] the results of this review were less useful for the field of resuscitation since the review included a broad variety of skills with heterogeous complexities (e.g. laparoscopic procedures). The present systematic review sought to compare the educational and clinical outcomes of using the Peyton's four-step approach in resuscitation training with alternative approaches, including modifications of the four-step approach.

Methods

The review was undertaken as part of the continuous evidence evaluation process of the International Liaison Committee on Resuscitation (ILCOR) Task Force on Education, Implementation, and Teams (EIT). The review was registered at the Prospective Registry for Systematic Reviews (PROSPERO CRD42023377398). We report this review in accordance with the PRISMA Preferred Reporting Items for a Systematic Review and Meta-Analysis.[15]

The research question was structured as a 'PICOST' (Population, Intervention, Comparison, Outcome, Study design, Timeframe) question:

- 'For adults and children undertaking skills training related to resuscitation and First Aid in any educational setting (**P**opulation),
- do approaches to skills teaching that are not the 'Peyton four-steps' (**I**ntervention),
- if compared to the 'Peyton four-step' approach for skills teaching (**C**omparison),
- improve 'skills performed appropriately on real patient after the course', 'skill retention measured ≥3 months after training', 'skill performance at end of course', 'participants' confidence to perform the skill on patients', 'participants' preference of teaching method', and 'instructors' preference of training method' (**O**utcomes)
- Eligibilty for inclusion: randomized controlled trials (RCTs) and non-randomized studies (non-RCTs, interrupted time series, controlled pre-/post studies, cohort studies, published conference abstracts, and case series with $n \geq 5$). Studies were excluded if they reported unpublished results (e.g. trial protocols, conference abstracts), or were commentaries, editorials, or reviews (**S**tudy design).
- Publications from all years and all languages were included as long as an English abstract was available (**T**imeframe).

In contrast to the prior Prospero registration, we adapted the threshold of the educational outcome of 'mid- to long-term retention' from >6 months to ≥3 months after training. We found this important since after the first screening of papers no study had analyzed skill retention at >6 months, and no study would have been included for this outcome. As there is no rigid threshold for 'mid- to long-term retention' in the literature, this change appeared reasonable. We also added the outcome 'instructors' preference of training method' as we found this aspect to be important from an instructor's perspective.

We searched Medline, Embase, PsycINFO, ERIC, CINAHL, and Cochrane from inception until 20 Nov, 2020, and updated on 25 Nov, 2022. The Medline search was undertaken in addition to what was indicated in the prior Propspero registration. An information specialist of ILCOR developed the search strategy. The updated search was undertaken by the University of Zurich using the same search strategy. The detailed search strategy is shown in Supplemental File 1.

Definitions

We defined Peyton's four-step approach to skills teaching as a sequence of (a) 'demonstration' (of the skill, at normal pace, without commenting), (b) 'deconstruction' (of the skill, i.e., demonstration in slow motion, with detailed explanations for the learner with a special focus on critical steps), (c) 'comprehension' (by the learner, e.g., by explaining each step while talking the teacher through the skill), (d) 'performing and practicing' (of the skill by the learner, ideally until performance is sufficient).[8] We defined the intervention as any approach to skills teaching with distinct stages or using modified 'Peyton four-step' approaches with more or less than four steps, or with delivering one or more steps by alternative methods, e.g. video. The specific skills of interest included all skills related to resuscitation, such as chest compressions, bag-mask-ventilation, defibrillation, or tracheal intubation. Critical clinical outcome was defined as 'Skills performed appropriately on real patient after the course' and the critical educational outcome as 'Skill retention measured ≥3 months after training'. Important educational outcomes were 'Skill performance at end of course measured as less than three months after the course', 'Participants' confidence to perform the skill on patients', 'Participants' preference of teaching method', and 'Instructors' preference of training method'.

Potential subgroup analyses were considered for: teaching simple vs. more complex skills; teaching adults vs. children; laypersons vs. health care professionals.

Eligibility criteria

The inclusion criteria were studies with: i) adults and children undertaking skills training related to resuscitation and First Aid in any educational setting, ii) reporting a skill teaching strategy of Peyton four-step' approach compared to alternative skills teaching approaches, and iii) studies that reported educational outcomes, outcomes on the patient level and/or on the participant level.

Data extraction

Each article title and abstract was assessed by the first author and one of the co-authors independently to exclude all papers which were clearly not relevant to the research question by using Rayyan.[16] Disagreements were sorted out in consensus or with the advice of another member of the author group. Each of the remaining papers was analyzed in full text by two authors independently, and the study characteristics and outcome data were extracted into a spreadsheet file (years of publication and of data acquisition, countries of studies, skills and populations taught, alternative approaches to Peyton's four-steps, trainee-to-instructor ratio, time points of outcomes).

Table 1 – Systematic review 'Stepwise Skills teaching for resuscitation training': Overview of studies included.

	Author, year, country, study type	skill	Population/ sample size	design	Student to teacher ratio	Teaching times comparable	primary outcome	scondary outcomes	mainresults	additional results
1	Archer, 2015 [21] (South Africa) RCT	manual defibrillation	1st year med stud *n* = 294	3 groups: – 2 steps – 4 steps- 5 steps (with peer feedback)	20 to 1	40 min for all groups	composite score for defib skills end-of-course	retention at 2 months; questionnaire for stud perception of knowledge & skill acquisition and retention	**all 3 approaches equivalent for acquisition and retention**; differences in 'total score': mean 76.6% (80%, 77%, 73%) $p = 0.37$	including peer-teaching (5-step) is feasible
2	Bjornshave, 2018 [26] (Denmark) RCT	single rescuer BLS/AED	laypersons (mean age 40.5 y) *n* = 142	2 groups: – 2 steps- 4 steps	6 to 1	2 steps: 3 h 15′ 4 steps: 4 h 00′	passing a scenario test (17 of 17 skills) end-of-course	CC rates and depths, ventilations	**2 steps non-inferior to 4 steps**; pass rate 2 steps: 57% vs. 4 steps: 59%)	CC rate 114 vs. 115; CC depth 47 vs. 48 mm, rescue breaths 1.7 vs. 1.6
3	Bomholt, 2019 [27] (Denmark) RCT	single rescuer BLS/AED	laypersons (mean age 40.5 y) *n* = 129	2 groups: – 2 steps- 4 steps	6 to 1	2 steps: 3 h 15′ 4 steps: 4 h00′	passing a scenario test (17 of 17 skills) at 3 months	CC rates and depths, ventilations	**2 steps non-inferior to 4 steps**; pass rate (for 17 of 17 skills): 2 steps 11% vs. 4 steps 11%)	CC rate 108 vs. 107; CC depth 43 vs. 46 mm, rescue breaths 1.6 vs. 1.6
4	Frangez, 2017 [28] (Slovenia) RCT	BLS	1st year med stud *n* = 266	2 groups: – 2 steps (steps 2 & 4)- 4 steps	not known	4 h 00′ for both groups	correct steps of BLS scenario steps end-of-course	differences between teaching according to guidelines 2000 and 2005	**4 steps superior** for the elements: 'call for help', 'open airway', 'CC hand position', 'CCs correct' (all $p < 0.01$)	more pronounced effects for 2000 guidelines (compared to 2005 which were perceived as 'simpler')
5	Greif, 2010 [25] (Switzerland) RCT	(needle) crico-thyroido-tomy	4th year med stud *n* = 128	4 groups: - tradit. - no step 2 - no step 3—4 steps	not known	not known	time until ventilation (percentage of par-ticipants reaching < 60 sec) end-of-course	learning curves (50% of cohort reaching < 60 sec; point of no further improvement)	**all approaches equivalent** (percentage of participants achieving ventilation in less than 60 sec; and 'learning curves')	
6	Hansen, 2020 [12] (Denmark) RCT	BLS/AED	1st year med stud *n* = 253	2 groups: - steps 1 & 2 as a lecture – 4 steps	8–12 to 1 (lecture); 4–6 to 1 (4 steps group)	3 h 30′ for both groups	pass rate for skills test end-of-course	participants: self-perceived skills, preference of teaching method	**equivalence** of both approaches (pass rate 63% in both groups, $p = 1.00$)	'lecture' group: tidal volumes better, CC rates worse, confidence lower. Preferred method: 'demonstration'
7	Herrmann-Werner, 2011 [23] (Germany)	naso-gastral intubation;	1st year med stud	4 groups: - BP-SL* at	3 to 1	length of teaching identical	binary and global assessment	assessment in skills lab scenario at 6 months; 'clinical	**BP-SL* more effective than traditional approach** (checklist ratings & global assessment) at ***all***	BP-SL* group showed higher 'clinical competence'

(*continued on next page*)

Table 1 (continued)

	Author, year, country, study type	skill	Population/ sample size	design	Student to teacher ratio	Teaching times comparable	primary outcome	scondary outcomes	mainresults	additional results
	RCT	i.v. canulation	*n* = 94	3 months - BP-SL* at 6 months - Tradit. at 3 months - Tradit. at 6 months			scales in skills lab scenario at 3 months	compe-tence' – (global impression in video recording)	***timepoints*** for ***both skills***	
8	Jenko, 2012 [29] (Slovenia) RCT	CCs	1st year med stud *n* = 126	2 groups: – 2 steps- 4 steps	12–13 to 1	length of teaching identical	scenario testing end-of-course	questionnaires for self-rating of competence	**no difference overall**; percentage of students with all variables correct: 13% for 2 steps vs. 15% for 4 steps ($p = 0.741$). No difference for CC rate, CC depth, correct hand position. 4 steps with better CC rate/min ($p = 0.02$)	no correlation between actual (assessed) and self-evaluated knowledge
9	Krautter, 2011 [24] (Germany) RCT	naso-gastral intubation	2nd/3rd year med stud *n* = 34	2 groups: - standard (steps 2 & 4)- 4 steps	1 to 1	equal instruc-tion time	scenario testing (video recording) end-of-course	time to complete task; assessment of 'professiona-lism' and communication	**no difference** in 'correct stepwise performance of the procedure', assessed by checklist ($p < 0.802$)	4 steps superior for time to complete task; 'professionalism'; communication.
10	Lapucci, 2018 [30] (Italy) RCT	BLS	nursing students *n* = 60	2 groups: – 2 steps- 4 steps	10 to 1	equal instruc-tion time	BLS (CCs, ventilations) end-of-course		**no difference** (effective CCs for 2-steps: 75.2 vs. 73.3 for 4 steps; $p = 0.885$)	
11	Münster, 2016 [31] (Germany) RCT	CCs	1st/2nd year med stud *n* = 134	3 groups: – 4 steps- 4 steps omitting step 3 - standard (steps 2 & 4)	13 (9–16) to 1	not stated	CC rate, CC depth at 1 week end-of-course	CC fraction; retention at 5–6 months	**no difference** at **1 week** (no significant difference for 'correct checklist items' between the groups; $p = 0.487$) **no difference** at **6 months** (no significant difference for 'correct checklist items' between the groups; $p = 0.824$)	at end-of-course: significantly lower CC rate in standard group: 90 ± 16 bpm vs. 99 ± 17 bpm, and 101 ± 16 bpm in the 4 steps groups ($p = 0.007$)

Table 1 (continued)

	Author, year, country, study type	skill	Population/ sample size	design	Student to teacher ratio	Teaching times comparable	primary outcome	scondary outcomes	mainresults	additional results
12	Nourkami-Tutdibi, 2020 [32] (Germany) RCT	Newborn life support	4th/5th year med stud *n* = 123	2 groups: – 4 steps-step 3 with 'functional verbalisation'	3–4 to 1	similar' teaching time in both groups	megacode score on day 4 end-of-course	megacode score at 6 months follow-up	**equal levels of knowledge acquisition** (megacode score control group: 27.3 ± 2.6 vs. trial group: 27.6 ± 2.3; $p < 0.527$)	total scores at 6 months: 4 steps: 25.6 ± 4.3 vs. trial group (modif. 4 steps): 25.1 ± 4.3, $p < 0.748$)
13	Orde, 2010 [33] (Australia) RCT	Laryngeal mask insertion	final year med stud, crit care and ICU nursing stud *n* = 120	2 groups: – 2 steps (steps 2 & 4)- 4 steps	1 to 1	Overall teaching times not stated	proportion of participants with successful 'ventil. I*n* < 30 sec' testing at end-of-training	follow-up at 'a number of weeks later' (mean: 71 days): same outcomes as at end-of-training	**no statistical difference** at end-of-training (mean time to LMA insertion 44.3 s for 2 steps vs. 42.5 s for 4-steps teaching; $p > 0.05$)	No statisitically significant differences at 2 months after training. slight advantages in secondary outcomes for 4 steps
14	Schauwinhold, 2022 [34] (Germany) non-RCT	CCs	1st year med stud *n* = 346	2 groups: – 4 steps - tele-instruction (online course elements)	unclear (online): approx. 4–8 to 1	not stated	BLS skills (CC depth and rate) end-of-course	performance of BLS algorithm; self-reported confidence for BLS skills	tele-instructor method **non-inferior** (demonstrated for CC rate, CC depth)	Non-inferiority for secondary outcomes (BLS algorithm, confidence to perform BLS)
15	Schwerdtfeger, 2014 [22] (Germany) RCT	ATLS (steps ABC), trauma management	med stud (advanced) *n* = 313	2 groups: – 4 steps-video for steps 1 & 2	not stated, presumed 6 to 1	'similar' times	OSCE score (5 min ATLS: ABC, 9 items + global rating) end-of-course	subjective evaluation by participants (global score)	**no difference** of median OSCE score (control group: median 9, IQR 8–9; study group: median 9, IQR 8–9; $p = 0.29$)	global score: modif. 4 steps better (median 1/6 vs. 2/6; 1 is best); subjective evaluation by students: modif. 4 steps better
16	Sopka, 2012 [35] (Germany) non-RCT	CCs (only)	1st year med stud *n* = 220	2 groups: – 4 steps-podcast for steps 1 & 2	not stated	'same course duration'	CC quality end-of-course	CC quality at 6 months;self-rated selfconfidence	**no difference for all outcomes** (except from modif. 4 steps with deeper CCs at end-of-course)	self confidence: 'no difference' between groups (only 120 questionnaires)
17	Zamani, 2020 [36] (Iran) non-RCT	Endotracheal intubation (ETI)	advanced med stud (interns) *n* = 124	2 groups: – 2 steps (control)-modif. 4 steps	10 to 1	not stated	ETI score (range 0 – 32); assessment at end-of-semester	satisfaction score (from 18-90)	**modified 4 steps better** for ETI score (0–32): modif. 4 steps: 30.1 pts. vs. 2 steps: 26.6 pts. ($p < 0.001$)	modif. 4 steps with higher satisfaction score (range 18–90): modif. 4 steps: 74.5 pts vs. 2 steps: 57.7 pts ($p < 0.001$)

Abbreviations: AED: automated external defibrillator; ATLS: Advanced Trauma Life Support; BLS: basic life support; *BP-SL: *Best-Practice Skills Lab*; CC: Chest compressions; ETI: Endotracheal intubation; modif.: modified; OSCE: objective structured clinical examination.

Table 2 – Overview of study characteristics.

Years of publication	2010–2022
Years of data acquisition	2004–2020
Countries of studies	14 Europe (7 Germany,[22–24,31,32,34,35] 6 centres); 3 Denmark[12,26,27] (1 centre); 2 Slovenia[28,29] (1 centre); 1 Switzerland[25]; 1 Italy[30];
	1 South Africa[21]; 1 Australia[33]; 1 Iran[36]
Alternatives to Peyton's four-steps	○ 2 steps ('see one – do one')[21,24,26–31,33,36];
	○ omission of Peyton step 2, or Peyton step 3[25];
	○ podcast for Peyton step 1 and 2[35];
	○ lecture for Peyton step 1 and 2[12];
	○ tele-instruction omitting Peyton step 3[34];
	○ functional verbalisatzion added to Peyton step 3[32];
	○ video for Peyton step 1 and 2[22];
	○ Peyton step four (step 5: with or without peer feedback)[21]
Trainee-to-instructor ratio	From 1 : 1 to 1 : 20; unknown in 5 studies[22,25,28,34,35]
Time points of outcomes	○ End-of-course only (n = 9)[12,22,24–26,28–30,34];
	○ End-of-course, all (n = 14)[12,21,22,24–26,28–35];
	○ 'End of semester' (n = 1)[36];
	○ 2 months (n = 2)[21,33];
	○ 3 months (n = 2)[23,27];
	○ 5-6 months (n = 1)[31];
	○ 6 months (n = 3)[12,32,35];
Skills taught	○ Manual defibrillation (n = 1)[21];
	○ BLS+AED (n = 3)[12,26,27];
	○ BLS (n = 2)[28,30];
	○ chest compressions only (n = 4)[29,31,34,35];
	○ naso-gastric tube (n = 2)[23,24];
	○ Neonatal Life Support (n = 1)[32];
	○ Advanced Trauma Life Support algorithm (n = 1)[22];
	○ Needle cricotomy (n = 1)[25];
	○ Laryngeal mask (n = 1)[33];
	○ Tracheal intubation (n = 1)[36]
Populations taught	○ Novice medical students (n = 8)[12,21,23,28,29,31,34,35];
	○ Advanced medical students (n = 5)[22,24,25,32,36];
	○ Nursing students (n = 1)[30];
	○ Mixed Health Care Professionals (n = 1)[33];
	○ Lay persons (n = 2)[26,27]

Table 3 – Overview of the types of outcomes, the overall findings, risk of bias (RoB) assessments for the alternative intervention compared to the classical Peyton four-steps approach (primary outcomes).

	No of studies	Neutral	In favour of		RoB of single studies
			Alternative approach	Four-step approach	
Skill performance after ≥3 months	5	4 [a]	-	1[b]	'low' to 'serious'
Skill performance at end-of-course	14	12[c]	-	2 [d]	'low' to 'serious'
Participants' confidence to perform skill on patients	6	5 [e]	-	1[f]	'some concerns' to 'serious'
Participants' preference of teaching method	4	2 [g]	1 [h]	1 [i]	'some concerns' to 'serious'
Skills performed appropriately on real patient	0	-	-	-	-

a – references (Table 4) [27,31,32,35].
b – four-steps approach as one element of a 'Best practice skills lab teaching' including 'feedback', 'manikin practice'.[23].
c – references (Table 5) [12,21,22,24–26,29,30,32–35].
d – references (Table 5) [28,36].
e – references (Table 6) [21,27,29,34,35].
f – as compared to 'lecture' for Peyton steps 1 and 2.[12].
g – references (Table 6) [12,26].
h – reference (Table 6) [21].
i – reference (Table 6) [36].

Table 4 – Educational outcome: skill performance after 3 or more months.

Study	Study type	Skill taught / primary outcome	Population taught	Type of alternative	Overall results	RoB
Bomholt (2019) [27]	RCT	BLS-AED / BLS-AED scenario test at 3 months	Laypersons	2 steps skills teaching	Neutral	Some concerns[a]
Herrmann-Werner (2013) [23]	RCT	Intravenous cannulation; insertion of naso-gastric tube / performance scores at 6 months	1st year medical students	'traditional teaching' (2 steps)	four-step approach [b] superior	Low
Münster (2016) [31]	RCT	BLS / chest compression quality[c] at 5–6 months	1st and 2nd year medical students	3 steps (step 3 omitted), and 2 steps (Peyton steps 2 and 4)	Neutral	Some concerns[d]
Nourkami-Tutdibi (2020) [32]	RCT	Neonatal Life Support / megacode scenario score at 6 months	4th and 5th year medical students	Modified four-steps approach [e]	Neutral	Serious [f]
Sopka (2012) [35]	Non-RCT	BLS (CC only) / chest compression quality at 6 months	1st year medical students	Modified four-steps approach[g]	Neutral	Serious [h]

a – due to randomization and missing outcome data.
b – 'Best practice skills lab teaching' including 'feedback', 'manikin practice', and the four-step approach.
c – chest compression rate, depth, chest compression fraction.
d – due to randomization.
e – step 3 including additional functional verbalization by the student.
f – due to high drop-out rate.
g – podcast for steps 1 and 2.
h – due to 'confounding' and 'deviations from the intended intervention'.

Risk of bias assessment

The first author and one of the co-authors independently analyzed the included papers using the 'Risk of Bias 2 (RoB 2) tool' for RCTs[17] and 'risk of bias in non-randomised studies of interventions (ROBINS-I) tool' for non-RCTs[18]. If the reviewers disagreed on any domain, consensus was reached by discussion and the involvement of a third reviewer. Three authors (AL, RG, KGL) were excluded from bias assessment of the studies they had published.

Synthesis method

The overall certainty of evidence was assessed according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology.[19] Meta-analysis was not undertaken due to significant methodological and clinical heterogeneity. We followed the Synthesis Without Meta-Analysis (SWiM) reporting guidelines[20] and we stratified into the predefined outcomes.

Results

In the primary search, we identified 2,199 records. After removal of duplicates and screening of titles and abstracts, 36 studies remained for full text analysis. Twenty-two of these did not meet the predefined inclusion criteria. Studies excluded at this stage had analysed skills not related to resuscitation (such as surgery, intramuscular injection, physiotherapy; $n = 3$), had compared instructor-led training to other learning formats (such as web-based learning, blended learning, Virtual Reality, or self-instruction; $n = 10$), had analysed new course content or structure ($n = 4$), other stepwise teaching methods than Peyton ($n = 2$), influences of learning styles, or gender ($n = 2$), or had been a survey ($n = 1$). While hand search based on article bibliographies yielded another ten potentially eligible studies, one of these could be included into the final analysis with 15 articles. From the updated search on November 22nd 2022 we retrieved 375 more records. Out of this update, two more articles were identified to be included leaving us with 17 studies for the final analysis (for the flow diagram, see Supplemental File 2). Study characteristics, designs, and main outcomes are described in Table 1. Fourteen studies were RCTs,[12,21–33] and 3 non-RCTs[34–36] with a total number of 2,906 participants. Publication dates ranged from 2010 to 2022 (with data acquisition between 2004 and 2020). Fourteen studies (82%) were undertaken in Europe, and the studies analyzed nine different skills related to resuscitation. Fourteen studies [12,21,22,24–26,28–30,32–36] reported short term outcomes (up to less than 3 months), while five studies [23,27,31,32,35] reported mid- to long-term retention (from 3 months up to 6 months post training). We found a wide range of target populations with 15 studies investigating various groups of healthcare professionals, [12,21–25,28–36] and two studies investigating lay persons [26,27] (Tables 1 and 2). All studies had been undertaken in adult learner populations. All studies reported educational outcomes only, and no patient related outcomes were included. For a summary table of study characteristics including the alternative interventions,[12,21–36] see Table 2.

Risk of bias assessment and certainty of evidence

Risk of bias for single studies varied from 'low' to 'serious' (for details, see Supplemental File 3). Overall, the studies showed high heterogeneity regarding the skills and populations taught, student-to-instructor ratios, and interventions being compared to Peyton's four-step approach (Table 2). Overall certainty of evidence was rated as very low being downgraded due to indirectness, imprecision, risk of bias, and inconsistency.

Overview of study outcomes

Table 3 gives a summary of the overall findings for each outcome. For the critical educational outcome of skill retention $\geq$3 months after training, we identified very low certainty evidence from five stud-

Table 5 – Important educational outcome: skill performance at end of course.

Study	Study type	Skill taught / primary outcome	Population taught	Type of alternative	Overall results	RoB
Archer (2015) [21]	RCT	Manual defibrillation / composite score for defibrillation skills end-of-course and at 2 months	1st year medical students	Traditional 2-steps and 5-steps approaches	overall study outcome: neutral [a]	Serious [b]
Bjornshave (2018) [26]	RCT	Single rescuer BLS plus AED/ pass rate at end-of-course	Laypersons	'Traditional' 2-steps approach	Neutral	Low
Frangez (2017) [28]	RCT	BLS (without AED) / BLS scenario test[c] at end-of-course	1st year medical students	'Conventional' 2-steps approach	4-step approach superior [d]	Low
Greif (2010) [25]	RCT	Needle crico-thyroidotomy / time needed to successful ventilation at end-of-course	4th year medical students	3 alternatives: traditional 2 steps; step 2 omitted; step 3 omitted	Neutral (for all 4 approaches)	Some concerns [e]
Hansen (2020) [12]	RCT	BLS and AED / scenario test at end-of-course	1st year medical students	Lecture as a subsitute for steps 1 and 2	Neutral	Some concerns [f]
Jenko (2012) [29]	RCT	Chest compressions / BLS scenario test[c] at end-of-course	1st year medical students	2-step approach	Neutral	Concerns [g]
Krautter (2011) [24]	RCT	Inserting a naso-gastric tube / performing steps of the procedure at end-of-course	2nd and 3rd year medical students	2-steps approach	Neutral [h]	Low
Lapucci (2018) [30]	RCT	Chest compressions and ventilations /	Nursing students	2-steps approach	Neutral	Some concerns [i]
Nourkami-Tutdibi (2020) [32]	RCT	Neonatal Life Support / megacode scenario at 4 days after intervention	Advanced medical students	Modified 4 steps (step 3) [j]	Neutral	Concerns [k]
Orde (2010) [33]	RCT	Laryngeal mask insertion / proportion of participants achieving ventilation < 30 seconds	Critical care nurses, ICU nursing stud., final year med. Students	2 steps approach	Neutral	Concerns [l]
Schauwinhold (2022) [34]	Non-RCT	BLS / chest compression rate and depth at end-of-course	1st year medical, dentristry and physiotherapy students	3 steps with 'tele-instructor supported peer feedback'	Neutral (non-inferiority of the TSP group)	Serious [m]
Schwerdtfeger (2014) [22]	RCT	Advanced Trauma Life Support / Median OSCE score at end-of-course	Advanced medical students	Modified 4-steps approach (steps 1 and 2 by video)	Neutral [n]	Concerns [o]
Sopka (2012) [35]	Non-RCT	BLS (CC only) / chest compression quality at end-of-course	1st year medical students	Modified 4-steps approach [p]	Neutral	Some concerns [q]
Zamani (2020) [36]	Non-RCT	Endotracheal intubation (ETI) / 'ETI score' at 'end-of-semester'	Advanced medical students	2 steps	4-step approach superior	Serious [r]

a – for direct statistical comparison between 2 steps and 4 steps, the 2-step approach was superior.
b – due to high drop-out rate.
c – scenario steps 'call for help', 'open airway', 'hand position', 'chest compressions correct'.
d – the study analyzed students trained with the guidelines 2000 and with the guidelines 2005. The authors found more pronounced effects of the 4-step approach for 2000 guidelines (compared to 2005, perceived as 'simpler').
E – due to deviations from the intended intervention, measurement of the outcome (intervention included elements of mastery learning).
f – due to deviations of the measurement of the outcome.
g – due to randomization.
h – for primary outcome; for three secondary outcomes advantages for the 4-step approach ('time to complete insertion', 'professionalism', 'communication').
l–- due to selection of reported results.
j–- step 3 including additional functional verbalization by the student.
k–- due to measurement of the outcome.
l–- due to drop-out rate, and different teaching times between groups.
m–- due to selection bias with differing learning conditions between groups (Covid-19), and measurement of outcomes.
n–- neutral for performance score (OSCE); global score (secondary outcome) superior for intervention.
o–- due to missing baseline data, drop-out rate and measurement of outcomes.
p–- podcast for steps 1 and 2.
q–- due to confounding, deviations from intended intervention.
r–- due to confunding, selection bias, measurement of the outcomes.

Table 6 – Important educational outcomes: evaluation by participants: 'Confidence to perform the skill on patients, and participants' preference of teaching method.

Participants' confidence to perform the skill on patients						
Study	Study type	Skill taught / outcome	Population taught	Type of alternative	Overall results	RoB
Archer (2015) [21]	RCT	Manual defibrilla-tion / confidence to perform manual defibrillation on a manikin / on a patient	1st year medical students	Traditional 2-steps and 5-steps approaches	Neutral	Serious [a]
Bomholt (2019) [27]	RCT	BLS-AED / self-confidence to per-form BLS/AED on patient	Laypersons	2 steps skills teaching	Neutral	Some concerns [b]
Hansen (2020) [12]	RCT	BLS and AED / scenario test at end-of-course	1st year medical students	Lecture as a subsitute for steps 1 and 2	Higher confidence in the 4-steps group	Some concerns [c]
Jenko (2012) [29]	RCT	Chest compressions / self-evaluated BLS competence	1st year medical students	2-steps approach	Neutral [d]	Concerns [e]
Schauwin-hold (2022) [34]	Non-RCT	BLS / confidence in CPR perfor-mance, handling emergency situation, and real-life situation	1st year medical, dentistry and physio-therapy students	3 steps with 'tele-instructor supported peer feed-back' (TSP)	Neutral (non-inferiority of the TSP group)	Serious [f]
Sopka (2012) [35]	Non-RCT	BLS (CC only) / self-confidence for knowledge of the algorithm and chest compression performance	1st year medical students	Modified 4-steps approach [g]	Neutral	Some concerns [h]
Participants' preference of teaching method						
Study	Study type	Skill taught	Population taught	Type of alternative	results	RoB
Archer (2015) [21]	RCT	Manual defibrillation	1st year medical students	Traditional, 2-steps, and 5-steps approaches	Alternative approach with advantages: 4-step group wanted more practice. 'Demons-tration with explanation' and 'Practice session with feedback' were rated the most useful part	Serious [i]
Bjornshave (2018) [26]	RCT	Single rescuer BLS plus AED	Laypersons	Traditional 2-steps approach	No difference of students' satisfaction	Serious
Hansen (2020) [12]	RCT	BLS and AED / scenario test at end-of-course	1st year medical students	Lecture as a subsitute for steps 1 and 2	Neutral	Some concerns [j]
Zamani (2020) [36]	Non-RCT	Endotracheal intubation (ETI) / 'ETI score' at 'end-of-semester'	Advanced medical students	2 steps	Higher satisfaction score in 4-steps group (19% difference, $p < 0.001$)	Serious [k]

a - due to high drop-out rate.
b - due to randomization and missing outcome data.
c - due to deviations of the measurement of the outcome.
d - both groups over-rated their performance about 50% in relation to objective performance.
e - due to randomization.
f - due to confounding, selection, measurement of outcomes.
g - podcast for steps 1 and 2.
h - due to confounding, deviations from intended intervention.
i - due to high drop-out rate.
j - due to deviations of the measurement of the outcome.
k - due to confounding, selection, measurement of outcomes.

ies[23,27,32,35,37] (downgraded for risk of bias, inconsistency, indirectness and imprecision) including a total of 671 students (Table 4). Four studies showed no difference,[27,32,35,37] but one found superior results using Peyton's four-step approach as compared to the alternative.[23] However, in this study, the four-step approach was only one element of a bundle of 'best practice skills lab' strategies and the alterantive was a traditional two-step approach.[23]

For the important educational outcome skill performance from end-of-course up to 3 months, we found 14 studies with overall very low certainty of evidence (downgraded for risk of bias, inconsistency, indirectness and imprecision) including a total of 2,683 students (Table 5).[12,21,22,24–26,28–30,32–36] Twelve studies did not show differences for this outcome,[12,21,22,24–26,29,30,32–35] whereas two studies found an advantage of Peyton's four-step approach.[28,36] Both stud-

ies compared four-steps to a traditional two-steps approach. One study of 266 Slovenian 1st year medical students learning BLS found that four of the BLS elements were executed better using Peyton's four-step approach,[28] whereas the other study of 67 Iranian advanced medical students found that a modified four-step approach led to significantly better scores for tracheal intubation skills (30.1 ± 1.2 points of an observational score with a maximum of 32 points, compared to 26.6 ± 2.14 points in the control group ($p < 0.001$)).[36]

For the important educational outcome of participants' confidence to perform the skill on patients', we found very low certainty evidence from six studies (downgraded for risk of bias, inconsistency, indirectness and imprecision) including a total of 1,368 students (Table 6). Five of these studies showed no differences between the groups.[21,27,29,34,35] The sixth study found higher confidence to perform the skill after Peyton's four-step approach as compared to a lecture substituting steps one and two of Peyton's four-steps (the highest level of self-confidence was reported in 72% as compared to 54% in the alternative group, $p = 0.009$).[12]

Regarding the important educational outcome of participants' preference of teaching method, we found very low certainty evidence from four studies (downgraded for risk of bias, inconsistency, indirectness and imprecision) including a total of 813 students (Table 6).[12,21,26,36] One study examining tracheal intubation skills in advanced medical students reported higher satisfaction with Peyton's four-step approach compared to two steps and found additional advantages such as more student interactions and cooperative learning.[36] Another study analysing manual defibrillation skills found that all study groups wanted more practice, but the Peyton 4-step group wanted it most.[21] In this study students rated 'Demonstration with explanation' and 'Practice session with feedback' as the most useful parts.[21] In the two remaining studies, there were no differences in participants' preference.[12,26]

With regard to the outcome 'instructors' preference of training method' we did not find any evidence.

Discussion

Several Resuscitation Councils rely on Peyton's four-step approach for skills training.[10] However, the efficiency of Peyton's four-steps has not been fully proven and it is suspected that some instructors do not adhere to the four-step approach in their teaching. We identified seventeen studies investigating nine different skills related to resuscitation and the overall results showed no differences between the effectiveness of Peyton's four-step approach and varying approaches of stepwise training. While the overall certainty was very low, our findings suggest that Peyton's four-step approach is not superior to other stepwise approaches.

Despite no identified superiority of Peyton's four-step approach, educational theory provides a solid foundation that stepwise training approaches to teach psychomotor skills are of value.[4,5,9] Of note, the only three studies in this review showing advantages of Peyton's four-step approach compared it to 'two-step' approaches.[23,28,33] Herrmann-Werner et al. compared 'traditional skills teaching with two steps' to a bundle of 'skills-lab best practice' (including the four-step approach, structured feedback, and practice on manikins)[23] which makes it very difficult to credit the positive findings to Peyton's four-step approach alone. The second paper compared BLS training for 1st year medical students with Peyton's four-step approach or a two-step approach after the students had 'listened to a one-hour introductory lesson about the BLS algorithm'.[28] The lecture may have primed the two approaches differently and could have favoured the more structured four-step approach. This point might further be supported by the fact that the paper explicitly states instructors had 'experience in teaching skills using the 4-stage teaching technique'.[28] The third paper had a critical risk of bias and compared a modified version of Peyton's four-steps to a traditional two-step approach using an educational movie with explanations by a trainer followed by a demonstration of the skill and a subsequent practice phase with students explaining their actions to the group.[36] Taken together, applying only '*traditional* two-steps' (show it, then let the trainees do it), to teach skills, with no expert feedback, appears to have little educational structure or value. It is therefore reasonable to conclude that stepwise structured approaches remain the method of choice for skills training in resuscitation but there is insufficient evidence to recommend specific number or order of steps. The optimal number and the order of steps may depend on contextual factors such as the time available for teaching (with special regard to adaequate practice time), the distribution of teaching content over time,[38] the type of skills taught,[4] the participants' group composition,[39] group size,[40] and the expertise level of providers (beginners or more experienced learners). Educational theory supports that skills learning is enhanced by more longitudinal and integrative approaches such as the 'Learn, see, practice, prove, do, maintain' framework proposed by Sawyer et al.[7] In any case, weak evidence indicates that stepwise skills training should be limited to skills of low to moderate complexity with less than seven steps.[4]

Limitations of the SR

This systematic review was limited to papers analyzing Peyton's four-step approach. Studies comparing other stepwise approaches to each other could have come to different results.

Limitations of the results, knowledge gaps and future research

This systematic review has highlighted several limitations. Firstly, heterogeneity of the studies was high therefore it was not possible to conduct a meta-analysis. For the same reason, we were unable to perform any of the pre-planned subgroup analyses. Secondly, almost all studies investigated health care professionals at various stages of training. Findings may only relate to training of healthcare professionals and training approaches for other populations, such as lay persons, children,[41] or elderly citizens,[42,43] might differ from those included in this review. An additional observational note is that most studies were conducted in Europe, with limited evidence from non-Europen countries. A crucial and severe limitation pertaining to all studies was that no study reported on the teaching quality of individual instructors. Teacher performance is known to have substantial influence on learning success,[44,45] and could have differed between study and control groups. This potential effect modifier should be controlled for in future studies. As a further knowledge gap, no studies considered how stepwise approaches to skills teaching could alter the future performance of course participants when treating patients in real cardiac arrest. Finally, reporting of educational outcomes in resuscitation science was not at all uniform. It would be of great value if an Utstein-like uniform reporting of educational outcomes in resuscitation science guidelines could be developed to allow comparative summaries of such studies, as is done for a number of other contexts.[46,47]

Conclusions

This systematic review identified very low certainty evidence finding no difference on learning outcomes between Peyton's four-step approach and the alternative stepwise skill teaching strategies. We recommend that a stepwise approach to skills teaching is used for resuscitation training but that Peyton's four-step approach may not always be the preferred one depending on context.

Availability of data sources

All data retrieved is included in the article and the supplemental files. A review protocol can be accessed from the first author upon reasonable request.

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Declaration of Competing Interest

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Appendix A

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Appendix B. Supplementary data

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