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Review

Impact of accredited advanced life support course participation on in-hospital cardiac arrest patient outcomes: A systematic review

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Abstract

Aim: Advanced life support courses have a clear educational impact; however, it is important to determine whether participation of one or more members of the resuscitation team in an accredited advanced life support course improves in-hospital cardiac arrest patient survival outcomes.

Methods: We searched EMBASE.com, Medline, Cochrane and CINAHL from inception to 1 November 2022. Included studies were randomised or non-randomised interventional studies assessing the impact of attendance at accredited life support courses on patient outcomes. Accredited life support courses were classified into 3 contexts: Advanced Life Support (ALS), Neonatal Resuscitation Training (NRT), and Helping Babies Breathe (HBB). Existing systematic reviews were identified for each of the contexts and an adolopment process was pursued. Appropriate risk of bias assessment tools were used across all outcomes. When meta-analysis was appropriate a random-effects model was used to produce a summary of effect sizes for each outcome.

Results: Of 2714 citations screened, 19 studies (1 ALS; 7 NRT; 11 HBB) were eligible for inclusion. Three systematic reviews which satisfied AMSTAR-2 criteria for methodological quality, included 16 of the studies we identified in our search. Among adult patients all outcomes including return of spontaneous circulation, survival to discharge and survival to 30 days were consistently better with accredited ALS training. Among neonatal patients there were reductions in stillbirths and early neonatal mortality.

Conclusion: These results support the recommendation that accredited advanced life support courses, specifically Advanced Life Support, Neonatal Resuscitation Training, and Helping Babies Breathe improve patient outcomes.

Keywords: Advanced life support, Course, Neonatal, Adult, Patient outcome

Introduction

Accredited advanced resuscitation training has existed since the 1970s when the Advanced Cardiac Life Support (ACLS) course (for adults) was developed by the American Heart Association (AHA).[1,2] This course paved the way for advanced life support (ALS) courses offered by other resuscitation councils. Resuscitation courses focusing on other patient populations, such as neonates and pediatrics, were subsequently developed in the 1980s. More recently, programs like Helping Babies Breathe (HBB), a simulation-based curriculum to facilitate resuscitation training for facility birth attendants from resource limited settings, were established to make high-priority resuscitation training concepts accessible to a global audience.[3] Evaluations have confirmed the educational impact of these courses;[4] however, a key question is whether attendance of healthcare personnel on such courses has an impact on survival of patients with cardiac arrest.

A 2018 systematic review identified very low certainty evidence that resuscitation team member completion of an adult ALS course improves patient outcomes after cardiac arrest.[5] The primary limitation of this review was that it focused exclusively on courses intended to treat adult patients. Understanding whether completion of accredited advanced life support courses improves patient outcomes in populations other than adults or within other contexts was identified as a priority topic by the Education, Implementation and Teams (EIT) Task Force of the International Liaison Committee on Resuscitation (ILCOR).[6]

The objective of this systematic review was to determine if participation of one or more members of the resuscitation team in an

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accredited advanced life support course, including courses focused on the care of adult, paediatric, and neonatal patients improve patient outcomes.

Methods

This systematic review was commissioned by the ILCOR Education, Implementation and Teams (EIT) Task Force as part of a continuous evidence evaluation process. The study and protocol were registered with Prospero (registration number CRD42021253673).

Research question

To guide the systematic review, a research question using the PICOST (Population, Intervention, Control, Outcomes, Study design, and Timeframe)[7] format was formulated, as follows: "In patients requiring in-hospital cardiac arrest resuscitation of any age (Population), does prior participation of one or more members of the resuscitation team in an accredited advanced life support course (Intervention), as opposed to no such participation (Control), affect return of spontaneous circulation (ROSC), survival to hospital discharge or to 30 days, survival to one year, survival with favorable neurological outcome, or specifically in neonatal studies: stillbirth rate, neonatal and perinatal mortality (Outcomes)?"

We defined 'accredited life support course' as structured advanced life support courses that have been approved by a professional organization (e.g., a resuscitation council) this includes Advanced Life Support (ALS), Advanced Cardiac Life Support (ACLS), Neonatal Resuscitation Program (NRP), Neonatal Life Support (NLS), Advanced Resuscitation of the Newborn Infant (ARNI), Pediatric Advanced Life Support (PALS), European Paediatric Advanced Life Support Course (EPALS), Helping Babies Breathe (HBB) and the European Paediatric Immediate Life Support (EPILS). Basic life support, trauma and First Aid courses were excluded.

Study eligibility

We included randomised and non-randomised interventional studies that specifically described the impact upon patient outcomes of attendance at an accredited life support course, including ALS, ACLS, PALS, EPALS, EPILS, NRT, NRP, HBB, NLS or ARNI by one or more of the healthcare personnel attending a patient requiring resuscitation. We excluded studies in trauma life support (as not primarily cardiac aetiology for cardiac arrest), and studies that only looked at the impact of individual components of a course (e.g., defibrillation, airway management, drug therapy). Studies written in any language were included if there was an English-language abstract.

Data sources

We searched EMBASE.com, Medline, Cochrane and CINAHL with the search date of 18 October 2021, but updated the search on 1 November 2022. The search strategy is described in Appendix 1.

Appraisal and update of existing systematic reviews

When existing systematic reviews addressing our PICOST question were identified, we pursued an adolopment process to update previous evidence. The adolopment process is based on the GRADE-ADOLOPMENT approach proposed by the GRADE working group[8] and adopted by ILCOR.[9] The steps of this process included (1) Determination of appropriate methodological rigour of the existing systematic review via the AMSTAR-2 criteria;[10] (2) Review of the existing review's literature search to determine if it was sufficiently recent (within the last 3 months) or needed to be repeated/revised; (3) Re-analysis of the data in light of any new literature identified. Components of the AMSTAR 2 checklist that were considered essential to pursue adolopment included published evidence of all the following: search strategy, inclusion/exclusion criteria, data extraction tables, bias assessment tables (including criteria used), GRADE Evidence Profile tables and meta-analysis.

Study selection

The titles and abstracts of all potentially eligible studies were screened for inclusion by four reviewers split into pairs. The included studies were independently screened in more detail for eligibility in these pairs based upon set inclusion and exclusion criteria. Any disagreements between the reviewers at either stage were resolved by discussion.

Data collection and quality assessment

Data from each study were independently extracted by each reviewer. Data were collated separately for each outcome, namely ROSC, survival to hospital discharge, survival to 30 days, survival to 1 year, and survival with favourable neurological outcome. We decided to combine survival to hospital discharge and survival to 30 days in the analysis.[11] For neonatal studies we also recorded: stillbirth rate (deaths prior to complete expulsion or extraction of products of conception from its mother), fresh stillbirth rate (deaths with no signs of life at any time after birth and without any signs of maceration), 1-day neonatal mortality, 7-day neonatal mortality, 28-day neonatal mortality, and perinatal mortality (all deaths in the first week after birth, including intrapartum-related stillbirths).[12]

Two reviewers independently assessed the overall quality of evidence of individual studies using the GRADE approach (Grades of Recommendation, Assessment, Development and Evaluation).[13] Where the adolopment process was used to update previously published systematic reviews, the same risk of bias tool was used as per the initial publication, for consistency. When available, we examined study protocols of included studies to assess for any reporting bias; and checked that our search of the literature did not identify studies that were missed or unreported by included systematic reviews. In case of disagreement, consensus was reached by discussion. An assessment of certainty of evidence was made using GRADE methodology.[13]

Analysis

We used both quantitative and narrative syntheses of evidence.

Considering the clinical and methodological heterogeneity of included studies, we used a random effects model for meta-analysis where indicated. Data were entered into Review Manager (RevMan5, The Cochrane Collaboration, Oxford, UK) to calculate the Odds ratio (OR) and risk difference (RD), 95% confidence intervals (CI) and statistical heterogeneity. Heterogeneity between studies was statistically assessed using the chi-squared test. The extent of heterogeneity among studies was expressed with I^2, with I^2 values > 50% indicating large inconsistency or heterogeneity.

In situations where it was deemed inappropriate to perform a meta-analysis (due to clinical or methodological heterogeneity), a narrative summary was provided.

Results

The search identified 2714 articles after duplicates were removed. Of these, 2677 articles were excluded during the title and abstract screen, leaving 37 full text articles to be screened for eligibility (see Fig. 1). Eighteen papers were excluded as shown in Fig. 1. Identified studies mapped to three separate contexts, namely adult Advanced Life Support (ALS), Neonatal Resuscitation Training (NRT), and Helping Babies Breathe (HBB). Three systematic reviews were identified which individually covered ALS,[5] NRT,[12] and HBB.[14] These systematic reviews included sixteen of the identified studies. An additional three studies not included in the published systematic reviews were identified for inclusion from the search, comprising ALS (n = 1);[15] and HBB (n = 2).[16,17] No studies were identified for other types of accredited advanced life support courses. Table 1 contains the characteristics of included studies.

Risk of bias within studies

The risk of bias assessment is summarised in Tables 2-4. The Risk of Bias In Non-randomised Studies of Interventions (ROBINS-I)[18] tool was used for ALS studies, the criteria suggested by Cochrane Effective Practice and Organization of Care[19] and criteria outlined in Chapter 8 of Cochrane Handbook for Systematic Reviews and interventions[20] for NRT studies, and the McMaster critical review form for quantitative studies[21] for HBB studies.

Advanced life support (ALS)

One systematic review including eight studies satisfied the AMSTAR-2 criteria for appropriate methodological quality.[5] Our literature search identified one additional study for inclusion.[15]

The additional study within the ALS context for adults was a 2018 pre-post intervention study from India evaluating the impact of an AHA ACLS course on patient outcomes after in-hospital cardiac arrest.[15] This additional study supported the association between

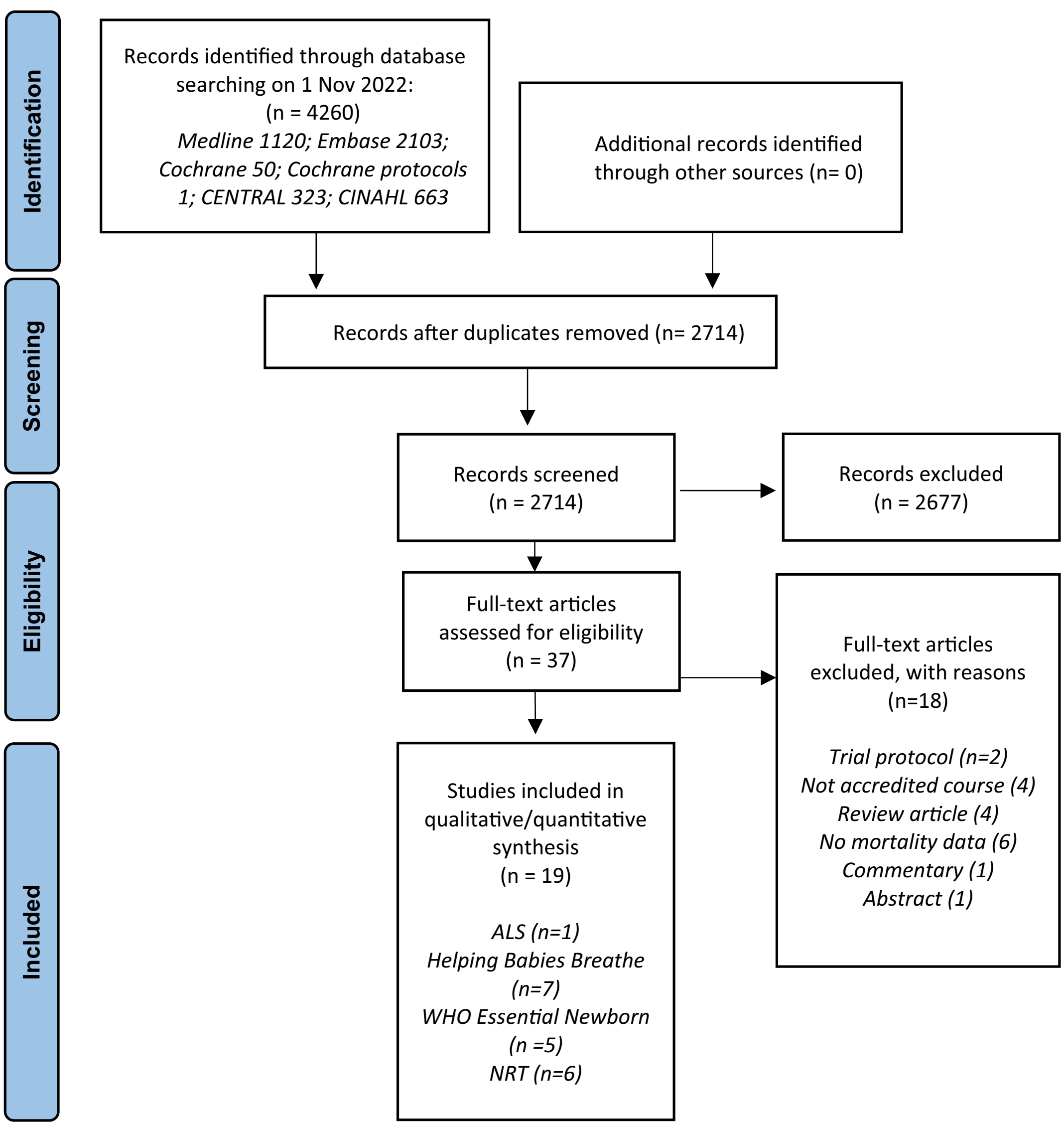

Fig. 1 – Prisma flow diagram.

Table 1 – Characteristics of newly identified studies for 'Advanced Life Support', and 'Helping Babies Breathe Training' (characteristics of all included studies are listed in Appendix 1).

Author Year Country	Study design	Setting	Number of patients	Outcome measures	Results
Advanced life support studies					
Pareek[15] 2018 India	Retrospective cohort study, pre- and post-AHA ACLS	750 bed tertiary care hospital	632 – 294 pre ACLS; 338 post ACLS; no data on age or sex	ROSC; Survival to hospital discharge	• ROSC increased from 19.7% to 30.1% (p = 0.003)
					• Significant increase in survival to hospital discharge post-BLS/ACLS training (p < 0.0001)
Helping babies breathe studies					
Innerdal[17] 2020 Mali	Pre-post training	Local district hospital	9769: 3125 pre-training; 6644 post-training	Fresh stillbirth rate, 1-day neonatal mortality, perinatal mortality	• Perinatal mortality rate (PMR) decreased from 21.7/1000 births to 6.0/1000 live births; RR 0.27, (95% CI 0.19–0.41; p < 0.0001).
					• 1-day neonatal mortality rate decreased from 6.3/1000 to 0.8/1000 live births; RR 0.12 (95% CI 0.05–0.33; p = 0.0006).
					• Fresh stillbirth rate decreased from 15.7/1000 to 5.3/1000, RR 0.33 (95% CI 0.22–0.52; p < 0.0001)
Patterson[16] 2021 Democratic Republic of Congo	Pre-post training	Three health facilities	24977: 13,840 pre-training; 11,137 post-training	Total stillbirth, fresh stillbirth, macerated stillbirth, neonatal death before discharge, perinatal death	• No change in total stillbirths following resuscitation training and continuous electronic HR monitoring of non-breathing newborns (aRR 1.15 [0.95, 1.39]).
					• Increased rate of macerated stillbirth (aRR 1.58 [1.24, 2.02]), death before discharge (aRR 3.31 [2.41,4.54]), and perinatal death (aRR 1.61 [1.38, 1.89]) during the intervention period.

BLS- Basic Life Support; ACLS- Advanced Cardiac Life Support; HBB – Helping Babies Breath.

Table 2 – ROBINS-I risk of bias assessment for 'Advanced Life Support'.

Study	Year	Design	Total Patients	Population	Industry Funding	Eligibility Criteria	Exposure/ Outcome	Confounding	Follow Up
Lowenstein[39]	1986	Non-RCT	90	AHA ACLS	No	Low	Low	Low	Low
Sanders[40]	1994	Non-RCT	64	AHA ACLS	No	High[b]	Low	Low	Low
Makker[41]	1995	Non-RCT	225	AHA ACLS	No	Unclear[c]	Low	High[d]	Low
Camp[42]	1997	Non-RCT	236	AHA ACLS	No	High[e]	Low	High[d]	Low
Pottle[43]	2000	Non-RCT	299	RC(UK) ALS	No	High[f]	Low	High[d]	Low
Dane[44]	2000	Non-RCT	117	AHA ACLS	Partial[a]	Low	Low	High[d]	Low
Moretti[45]	2007	Non-RCT	156	AHA ACLS	No	Low	Low	Low	Low
Sodhi[46]	2011	Non-RCT	627	AHA ACLS	No	Low	Low	High[d]	Low
Pareek[15]	2018	Non-RCT	632	AHA BLS/ ACLS	No	Low	Low	High[d]	Low

BLS- Basic Life Support; ACLS- Advanced Cardiac Life Support.

[a] Portions of the research were funded by a Teaching Methods Grant from AHA to the first author.

[b] Did not elaborate on exclusion criteria for cardiac arrest patients.

[c] All incidents analysed but not clear how identified.

[d] Prognostic factors not adjusted for in statistical analysis of most studies; considered low if they reported characteristics of patients in one group vs another and described p values.

[e] Differing and unclear eligibility criteria for three periods of study.

[f] Only those with completed audit form (86.5%) included.

Table 3 – Risk of bias assessment for 'Neonatal Resuscitation Training'.

Study	Incomplete outcome data addressed?	Free of selective reporting	Free of other bias?	Baseline outcomes similar?	Free of contamination?	Baseline characteristics similar?
Zhu[30]	Unclear risk	Low risk	Low risk	Unclear risk	Low risk	Unclear risk
Deorari[33]	Unclear risk	Low risk	Low risk	Unclear risk	Low risk	Unclear risk
Jeffery[22]	Unclear risk	Low risk	Low risk	Unclear risk	Unclear risk	Unclear risk
Vakrilova[31]	Low risk	Low risk	High risk	Unclear risk	High risk	Unclear risk
O'Hare[23]	Low risk	Low risk	Unclear risk	Unclear risk	Low risk	Unclear risk
Opiyo[24]	Unclear risk	Low risk	Unclear risk	Unclear risk	Low risk	Unclear risk
Boo[25]	Low risk	Low risk	Unclear risk	Unclear risk	High risk	Low risk
Hole[35]	High risk	Low risk	Unclear risk	Unclear risk	High risk	Unclear risk
Sorenson[26]	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Patel [12]	Low risk	Low risk	Unclear risk	Unclear risk	Low risk	Low risk
Msemo[28]	Unclear risk	Low risk	Low risk	Unclear risk	Low risk	Unclear risk
Bellad[29]	Low risk	Low risk	Low risk	Unclear risk	Low risk	High risk
Ashish[12]	Low risk	Low risk	Low risk	Unclear risk	Low risk	High risk
Goudar[27]	Unclear risk	Low risk	Unclear risk	Unclear risk	Low risk	Low risk

Risk of Bias assessed using the criteria suggested by Cochrane Effective Practice and Organization of Care[19] and criteria outlined in Chapter 8 of Cochrane Handbook for Systematic Reviews and interventions.

course participation and ROSC and survival to hospital discharge identified in the previous systematic review.[5]

Results of the updated analysis (Table 5) of all nine studies including 2,445 patients continue to show an association between course participation and ROSC, pooled OR of 1.66 (95% CI 1.24–2.21). The certainty of evidence for ROSC remains very low. The previous systematic review[15] showed a non-significant effect of course participation on patient survival to hospital discharge but a significant effect on course participation and patient survival to 30 days. In the updated analysis, these outcomes were combined and showed a significant association, OR 2.48 (95% CI 1.21–5.09). The updated analysis showed non-significant association between course participation and patient survival to 1 year pooled OR 3.61 (95% CI 0.11

Table 4 – McMaster critical review form for quantitative studies Risk of bias assessment for 'Helping Babies Breathe Training'.

		Arabi	Bellad	Goudar	KC	Mduma	Msemo	Wrammert	Innerdal	Patterson
Study purpose		+	+	+	+	+	+	+	+	+
Literature		+	+	+	-	+/-	+	+	+	+
Sample	Description	+	+	+	+	+/-	+	+/-	+	+
	Sample size justified	-	-	-	+	+	+	+	-	-
Outcomes	Reliable	+	+	+	+	+	-	+/-	-	+
	Valid	+	+	+	-	+	-	+	+	+
Intervention	Description	+	-	+	+	+	+	-	+	-
	Contamination	+	-	-	-	+	-	-	+	+
	Cointervention	+	-	-	-	+	+	-	-	+
	In terms of statistical significance	+	+	+	+	+	+	+	+	+
	Analysis appropriate	+	+	+	+	+	+	+	+	+
	Clinical importance	+	+	+	+	+	+	+	+	+
	Drop-outs reported	-	+	+	-	-	-	-	+	-
Conclusions and implications		+	+	+	+	+	+	+	+	
Score		13	11	12	10	12	11	8	11	

to 119.42). The quality of the studies for these outcomes remains very low.

Neonatal resuscitation training (NRT)

A summary of the studies for the NRT context is presented in Table 6.

One systematic review including fourteen community-based and in-hospital based interventions,[12] satisfied the AMSTAR-2 criteria for appropriate methodological quality. Consistent with our PICOST question, we examined only in-hospital based studies for this review. Our literature search did not identify any new studies. We report a summary of the in-hospital based sub-group analysis.

The fourteen in-hospital studies including 1,531,254 patients were conducted from 1993 to 2009. All the studies were retrospective pre- and post- intervention studies from low to middle resource settings.

Nine studies with a total of 1,334,307 patients assessed the risk of stillbirths where one or more members of the team had undergone NRT.[12,22–28] The data showed a significant decrease in the risk of all stillbirths. Six studies with a total of 231,455 patients assessed fresh stillbirths.[12,24,27–29] The data showed a significant decrease in the risk of fresh stillbirths where staff members had undertaken NRT. Five studies with a total of 216,373 patients assessed 1-day neonatal mortality.[12,28–30] The data showed a significant decrease in the risk of 1-day neonatal mortality. Five studies with a total of 296,300 patients assessed 7-day neonatal mortality.[22,29–32] The data showed a significant decrease in the risk of 7-day neonatal mortality. Six studies with a total of 1,090,594 patients assessed 28-day neonatal mortality.[24,27,29,33–35] There was no difference in the risk of 28-day neonatal mortality. Four studies with a total of 1,178,446 patients assessed perinatal mortality.[12,22,25,29] The data showed a significant decrease in the risk of perinatal mortality when attending team members had undertaken NRT.

Helping Babies Breathe (HBB)

One systematic review[14] satisfied the AMSTAR-2 criteria for appropriate methodological quality. Two additional studies[16,17] were identified in our search. These studies were appraised using the McMaster Critical Review form[21] and found to be of moderate quality, similar to the other studies in the systematic review identified for this context.

The additional studies were both pre- and post- intervention studies evaluating the impact of a HBB course on neonatal outcomes in Mali[17] and the Democratic Republic of Congo.[16] The study by Innerdal et al. (2020) further supported the association between course participation and decreased perinatal mortality, fresh stillbirth rate, and 1-day neonatal mortality.[17] The study by Patterson et al. (2021) found no difference in stillbirth rate but found increased perinatal mortality and death before discharge in the intervention group.[16] Overall, two out of four studies demonstrate decreased perinatal mortality, five out of eight studies show decreased fresh stillbirth rate, with HBB training.

Due to substantial clinical and methodological heterogeneity between the studies, no meta-analysis was performed.

Discussion

Our systematic review supports the understanding that participation of one or more members of the resuscitation team in an accredited advanced life support course, particularly those focused on the care of adult and neonatal patients, improves patient outcomes. The additional identified studies strengthen the conclusions of previous systematic reviews and add to the growing body of evidence in favour of advanced life support training for both these age groups.

Although we only identified three new studies, this work is still important. By examining a wider range of courses and patient populations, we were able to address the PICOST question and overcome the limitation of the previous systematic review more comprehensively.

For adult patients, the additional study strengthened the association between survival outcomes and advanced life support training attendance with a similar odds ratio but tighter confidence intervals. Considered together, the evidence suggests that ROSC, survival to discharge and survival to 30 days are consistently better with accredited advanced life support training, whereas survival to 1 year is inconclusive due to limited data and wide confidence intervals.

While no new studies were identified for NRT, previous analyses have examined data from both the community and hospital-based implementations. Our new analysis of data from only hospital-based studies demonstrates an effect in favour of training. We suggest that this may be because hospital-based implementations allow more consistent provision of training and accurate data acquisition as compared to community settings. Given that neonatal survival rates are particularly poor in resource limited settings,[36] it is even more important to clearly demonstrate improved outcomes from advanced life support training before diverting resources from other important public health interventions.

For HBB, one of the two new studies added further support for the association between training and reductions in stillbirths and early neonatal mortality.[17] The other study, which showed no difference in stillbirth rate and greater perinatal mortality in the intervention group, may have been impacted by a less rigorous implementation of HBB (monthly practice without external training support vs weekly practice with external training support in previous studies) and their retrospective collection of pre-intervention data which may have underreported death.[16] Furthermore, there is evidence to suggest that the women enrolled during the HBB intervention stage of this study may have included higher-risk pregnancies.[16] Despite HBB studies having substantial variability in setting, duration of training, varying study designs and lack of consistent outcomes contributing to substantial heterogeneity, analyses seem to show a treatment effect in favour of training, regardless of setting. A separate cost effectiveness analysis based on the implementation of HBB in rural Tanzania also determined it to be a highly cost-effective intervention.[32] Given that a quarter of global neonatal deaths are due to birth asphyxia,[37] the potential for lives saved appears to outweigh the costs of providing these courses.

In addition to improvements in patient outcomes, complex interventions such as advanced life support training have other benefits, particularly as a means of providing the opportunity to update healthcare professions on changes as new evidence emerges and is integrated into guidelines, algorithms, and teaching. Furthermore, training is an important means through which updated guidelines are implemented and integrated into practice.[38]

Our use of adolopment, whereby we justify the inclusion of existing systematic reviews by applying a transparent three-step process of (1) determining methodological rigour, (2) reviewing and revising literature searches; and (3) re-analysing data, is novel and reduces duplication of efforts allowing the systematic review process to be more resource efficient (e.g., reviewer and information specialist time).

Knowledge gaps and future research

Given significant heterogeneity in the included studies, future studies need to establish the best combination of settings, trainee characteristics, and training frequency to sustain existing effects on patient outcomes in all contexts. The published evidence only covers three accredited life support courses, so further research is needed for other courses (e.g. paediatric / trauma courses). Despite this, it is reasonable to assume that advanced life support training may offer comparable outcomes in other courses. Studies addressing longer-

Table 5 – GRADE Summary of findings table for 'Advanced life support'.

No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	No of patients: ACLS/ ALS	No of patients: No ACLS/ ALS	Effect: Relative (95% CI)	Certainty	Importance
ROSC											
7	Observational studies	serious[a]	serious[b]	serious[c]	serious[d]	none	480/ 1211 (39.6%)	261/ 882 (29.6%)	**OR 1.66** (1.24 to 2.21)	⊕◯◯◯ Very low	CRITICAL
Survival to discharge and 30 days											
8	Observational studies	serious[a]	serious[b]	serious[c]	serious[d]	none	309/ 995 (31.1%)	111/ 672 (16.5%)	**OR 2.48** (1.21 to 5.09)	⊕◯◯◯ Very low	CRITICAL
1 year survival											
2	Observational studies	serious[a]	serious[b]	serious[c]	serious[d]	none	51/ 262 (19.5%)	31/ 193 (16.1%)	**OR 3.61** (0.11 to 119.42)	⊕◯◯◯ Very low	CRITICAL

[a] Mixture of serious and low risk of bias studies.
[b] Some studies showed significant improvement, and some showed no improvement.
[c] Differences in patient type, hospital type, provider type and team composition, and nature of intervention.
[d] Absence of confidence intervals.

Table 6 – Pooled risk ratios from hospital based Neonatal Resuscitation Courses.

Outcome	Studies (n)	Participants (n)	RR	95% CI
All stillbirths	9	1,334,307	0.88	0.82 to 0.94
Fresh stillbirths	6	231,455	0.71	0.54 to 0.93
1-day neonatal mortality	5	216,373	0.58	0.38 to 0.90
7-day neonatal mortality	5	296,300	0.78	0.63 to 0.97
28-day mortality	6	1,090,594	0.89	0.65 to 1.22
Perinatal mortality	4	1,178,446	0.78	0.70 to 0.87

term outcomes (including favourable neurological outcomes) would be helpful. The finding that NRT and HBB did not affect mortality from day 7 to 28 suggests that training may not have as significant an impact in the absence of appropriate ongoing care. Further cost-effectiveness analyses would also be helpful in addressing the cost benefit of advanced life support interventions particularly in low resource settings where such courses have the potential to divert resources away from other valuable public health initiatives.

Limitations

All studies included in this review were non-randomised, the majority of which were pre-post studies. Pre-post studies without concurrent control groups carry a large risk of bias. There was significant heterogeneity in the intervention group with regards to course length, content, setting, and timing of outcome measurement. There are also some limitations to the adolopment approach: existing systematic reviews must be methodologically rigorous and have published/shared their search strategy (including date of last search), inclusion and exclusion criteria, data extraction tables, bias assessment tables (including criteria used), GRADE evidence profile tables and meta-analyses (where appropriate). Because of the stringent ($\leq$3 months) cut-off for recency of the existing systematic reviews search strategy, most adolopment processes will at a minimum need to re-run the existing search strategy. Furthermore, if the existing systematic review only addresses a part of the new PICOST (as was the case in this study) a new search strategy may be required. Despite these limitations, adolopment is a reasonable tool to consider in situations where a question has a recently published systematic review identified. Many courses, especially neonatal and pediatric courses, also focus on prevention of cardia arrest rather than CPR only which may affect cardiac arrest incidence bu not cardiac arrest survival outcomes.

Conclusion

This review found additional evidence in support of health care personnel attendance of advanced life support courses. Studies demonstrate that accredited advanced life support courses, specifically ALS, NRT, and HBB training, improve patient survival outcomes in both adult and neonatal cardiac arrest patients.

Funding

None.

Conflicts of Interest

This systematic review was part of the ILCOR continuous evidence evaluation process, which is guided by a rigorous conflict of interest policy (see www.ilcor.org). Andrew Lockey is President of Resuscitation Council UK and a member of the ILCOR Task Force on Education, Implementation and Teams (EIT). Robert Greif is the European Resuscitation Council (ERC) Director of Guidelines and ILCOR, and ILCOR's EIT Taskforce Chair. Catherine Patocka and Kasper G Lauridsen are members of ILCOR's EIT Task Force.

CRediT authorship contribution statement

Catherine Patocka: Writing – original draft, Investigation. **Andrew Lockey:** Conceptualization, Investigation, Data curation, Writing – review & editing. **Kasper G. Lauridsen:** Investigation, Writing – review & editing. **Robert Greif:** Conceptualization, Investigation, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2023.100389.

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