EIT 2025 CoSTR Appendix A- Evidence To Decision Tables

Debriefing of resuscitation performance (EIT 6307)

Should post-event debriefing vs. no post-event debriefing be used for treatment of cardiac arrest patients?	
POPULATION:	Health care professionals who treat patients in any clinical setting in cardiac arrest of any age (adult, children, neonates)
INTERVENTION:	Post-event debriefing
COMPARISON:	No post-event debriefing
MAIN OUTCOMES:	Favourable neurological outcome; Survival to discharge; ROSC; Chest compression depth; Chest compression rate; Chest compression fraction; Adherence to guidelines;
SETTING:	Any clinical setting
PERSPECTIVE:	Post-event debriefing may improve survival and quality of cardiopulmonary resuscitation.
BACKGROUND:	Despite cardiopulmonary resuscitation training, clinical outcomes of patients remain limited. Rates of patients surviving with favourable neurological outcomes, survival to hospital discharge and ROSC are low after cardiac arrest and guideline-concordant cardiopulmonary resuscitation. Strategies to provide debriefing to cardiopulmonary resuscitation teams for optimized CPR delivery are available and often common practice. Intra-event real-time defibrillator feedback is used in various institutions. Despite this, we do not have solid evidence that these practices improve patient outcomes, or if there are any negative side effects, like increased cost, emotional impact on the professional team etc. However, to learn from the information provided, post-event debriefing might be a way to address this information and improve the resuscitation performance for the next patient, via improving team communication and teamwork and helping increase error detection during cardiopulmonary resuscitation attempts, as well as mitigating any psychological negative effects on the team.
CONFLICT OF INTERESTS:	None

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	ROSC, survival to discharge, survival with favourable neurologic outcome and cardiopulmonary resuscitation quality (e.g. chest compression depth, chest compression rate, chest compression fraction) as well as adherence to guidelines is often low. Use of debriefings after the event therefore has been implemented in various settings clinically to improve outcome and CPR quality.	Whether this implementation improves desirable outcomes is not known.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	For the critical outcome of favourable neurological outcome: • Couper (2020)[1] found a 77% probability that hot debriefings increased the odds of favourable neurological outcome, with an odds ratio of 1.11 (95% credible interval 0.83-1.44); however they also found a 1% probability that cold debriefings increased the odds of favourable neurological outcome, with an odds ratio of 0.69 (95% credible interval 0.49-0.93). • Wolfe (2014)[2] found that the intervention was associated with improved survival with favorable neurologic outcome in both univariate (50% vs 29%, p = 0.036) and multivariable analyses (aOR, 2.75; 95% CI, 1.01–7.5; p = 0.047). For the critical outcome of survival to hospital discharge: • Couper (2020)[1] found a 67% probability that hot debriefings increased the odds of survival to hospital discharge, with an odds ratio of 1.06 (95% credible interval 0.81 - 1.37); and an 11% probability that cold debriefings increased the odds of survival to hospital discharge, with an odds ratio of 0.83 (95% credible interval 0.62 - 1.11). • Wolfe (2014)[2] found that the intervention was associated with a trend toward improved survival to hospital discharge in both univariate analysis (52% vs 33%, p = 0.054) and after controlling for potential confounders (age, gender, first documented rhythm, and presence of vasoactive infusions at index arrest; adjusted odds ratio [aOR], 2.5; 95% CI, 0.91–6.8; p = 0.075). For the critical outcome of ROSC: • Couper (2020)[1] found a 48% probability that hot debriefings increased the odds of ROSC, with an odds ratio of 0.99 (95% credible interval 0.80-1.21); and a 89%	

	probability that cold debriefings increased the odds of ROSC, with an odds ratio of 1.15 (95% credible interval 0.90-1.43). • Edelson (2008)[3] showed ROSC rate of 59% in the intervention group, 45% in comparator group (p=0.03). No effect size reported. • Heydarzadeh (2020)[4] showed a shorter time for a neonate's color to return to normal state with debriefing: debriefing 144.8±88.6, NRP workshop 256.6±178.5, control 232.3±128.1 (p=0.004). Apgar scores at 1, 5, and 10 min were higher in the debriefing group compared to those reported for other groups; however, these changes were not statistically significant. No effect sizes reported. For the important outcome of chest compression depth: • Edelson (2008)[3] reported chest compression depth: 50 mm (10) in the intervention, 44 mm (10) in the comparator group (p<0.001). No effect size reported. For the important outcome of chest compression rate: • Bleijenberg (2017)[5] showed a mean chest compression rate that was 93 (9) /min with the intervention, and 81 (13) in the comparator group (p=0.03). No effect size reported. • Edelson (2008)[3] showed a chest compression rate: 105/min (10) in the intervention, 100/min (13) in the comparator group (p=0.003). No effect size reported. For the important outcome of chest compression fraction: • Bleijenberg (2017)[5] showed a median chest compression fraction that was significantly better with the intervention 79% (70-85%) vs. the comparator group 86% (82-89%). No effect size reported. • Edelson (2008)[3] showed a no-flow fraction: 0.13 (0.10) in the intervention vs. 0.20 (0.13) in the comparator group (p<0.001). No effect size reported. For the not important outcome of adherence to resuscitation guidelines:	

	• Skare (2018)[6] ACTA showed a median total NRPE-score of 89% (86, 93) in the intervention, vs. 77% (75, 81) in the comparator group (p<0.001). • Skare (2018)[7] Resuscitation showed an NRPE-score of 89 (86-92) % in the intervention, vs. 77% (75-81) in the comparator group, p < 0.001.	

Undesirable Effects
How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	We did not find any data in the studies reporting undesirable effects of hot debriefing after cardiopulmonary resuscitation. One study using in-hospital cardiac arrest audit data from the National Cardiac Arrest Audit (NCAA) and using a Bayesian hierarchical logistic regression model to explore the association between outcomes and pre-defined quality indicators reported a potential negative effect of cold debriefings on survival with favourable neurological outcome and survival to hospital discharge. However, the definitions of both are unclear and the same study shows a positive effect of hot debriefings.	We do not know what the additional costs and resources for hot and cold debriefings after cardiac arrests are. We also do not know what the cost of training the debriefers are. Since the review was focused on clinical debriefing none of the studies included reported on potential psychological effects on the team being debriefed but focused on patient outcomes and CPR quality and/or adherence to guidelines. A separate review and/or further studies are needed to explore the effects of debriefing on the psychological state and safety of the resuscitation team.

Certainty of evidence
What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	For the critical outcome of favourable neurological outcome we found very low certainty evidence (downgraded for serious risk of bias, and very serious risk of inconsistency).[1,2,8-10] For the critical outcome of survival to discharge we found very low certainty evidence (downgraded for serious risk of bias, and very serious risk of inconsistency).[1,2,5,8-10] For the critical outcome of ROSC we found very low certainty of evidence (downgraded for serious risk of bias, and serious inconsistency).[1-4,8-10] For the important outcome of chest compression depth we found very low certainty of evidence (downgraded for serious risk of bias, serious risk of	All studies included were non-randomized studies, there was no RCT identified. This means that certainty of evidence is per definition low to begin with. All studies were downgraded for serious risk of bias and serious to very serious inconsistency.

	inconsistency, and serious risk of imprecision).[3,8,9] For the important outcome of chest compression rate we found very low certainty of evidence (downgraded for serious risk of bias, very serious risk of inconsistency, and serious risk of imprecision).[3,5,8,9] For the important outcome of chest compression fraction we found very low certainty evidence (downgraded for serious risk of bias, very serious risk of inconsistency and serious risk of imprecision).[3,5,8,9] For the not important outcome of adherence to guideline we found very low certainty of evidence (downgraded for serious risk of bias). [6,7]	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	Favourable neurological outcome, survival to hospital discharge and ROSC are important clinical outcomes of effective cardiopulmonary resuscitation. Clinical CPR performance is considered a Kirkpatrick level 3 outcome and generally considered as clinically important and meaningful. Adherence to guidelines is a Kirkpatrick level 2 outcome and generally considered as less important.	The Kirkpatrick model consists of four levels of learning: Level 1: reaction: the degree to which participants find the training favorable, engaging, and relevant to their jobs. Level 2: learning: the degree to which participants acquire the intended knowledge, skills, attitude, confidence, and commitment based on their participation in the training. Level 3: behavior: the degree to which participants apply what they learned during training when they are back on the job. Level 4: results: the degree to which targeted organizational outcomes occur as a result of the training initiative and subsequent support and accountability package. Targeting Kirkpatick level 3 outcomes is important in the context of cardiopulmonary resuscitation interventions to ensure good outcomes for patients and not just an effect of training during the intervention.

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	The evidence was mixed either favouring the intervention or showing no effect. There was no evidence favouring the comparator (no debriefing).	

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● Don't know	No evidence on required resources for CPR debriefing was found.	In one study the cost of surveillance cameras was given with approximately 125 euros per camera. However, this is just the equipment cost. We do not have evidence for the cost of debriefing or the cost of time for team members to participate in debriefings. Cost and time constraints are a major health care resources constraint worldwide. Low-resource settings might be disadvantaged in implementing a debriefing system.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No evidence was identified.	

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There were no included studies on cost-effectiveness.	Despite some obvious costs for training debriefers and team members' time to attend debriefings, the positive effects of debriefings on patient outcome and CPR performance as well as adherence to guidelines, potentially outweigh those costs. But without reliable studies on cost-effectiveness we cannot rate this as favourable for the debriefing intervention.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ● Don't know	No evidence was identified.	We do not know if there is an effect on health equity with or without the use of debriefings.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	We found no evidence on acceptability.	Clinical debriefings are performed in many settings, including in-hospital and out-of hospital settings. The studies we identified did not report on acceptability. There were also no studies from low-resource settings and no study in an out-of-hospital setting. However, debriefing in education and the clinical environment is well established and a widely accepted practice.

Feasibility Is the intervention feasible to implement?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Clinical debriefings are already performed in several in-hospital and out-of-hospital settings. The availability of the resources to perform clinical debriefings (e.g., time, cost etc.) may vary in resource-limited settings and out-of-hospital settings. However there might be even more time to perform debriefings in the out-of-hospital setting compared to busy in-hospital resuscitations with intra-hospital resuscitation teams that might not be able to meet after the event, whereas an out-of-hospital team might be more easily able to debrief the event since the team is potentially working together more frequently.	For feasibility there are studies that report roadblocks to implementing debriefing programs due to cost, resources or problems with data inclusion from CPR feedback devices. We also know that sustainability of a debriefing program might be difficult. However, general feasibility of performing debriefings should be possible.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	Varies	**Don't know**
CERTAINTY OF EVIDENCE OF	Very low	Low	Moderate	High			**No included studies**

	JUDGEMENT						
REQUIRED RESOURCES							
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	Probably yes	Yes		Varies	**Don't know**
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

We suggest performing post-event debriefing after adult, paediatric and neonatal cardiac arrest in all settings (weak recommendation, very low certainty evidence).

Justification

Performance of post-event debriefing was either associated with no effect or with improved outcomes, including critical outcomes (favourable neurological outcome, survival to discharge, ROSC), important outcomes (chest compression depth, chest compression rate, chest compression fraction) and not-important outcomes (adherence to guidelines).

However, the certainty of evidence for the included outcomes was very low, because of serious risk of bias and serious to very serious risk of inconsistency.

The analysis revealed high heterogeneity across studies, reflecting variation in debriefing design, patient population (adults, children, neonates), and outcome measures evaluated within diverse studies. Therefore no statement can be issued on which kind of debriefing (like hot or cold debriefing) might be more effective. Also the studies lack a clear standardized definition of hot or cold debriefings, with only one study reporting on the two different modalities. All other studies need to be considered cold debriefings, as the debriefing was not performed at the time of the resuscitation.

This treatment recommendation is based on non-randomized studies. No study compared debriefing with no debriefing after cardiopulmonary resuscitation in a randomized controlled trial, which caused serious risk of bias.

We have not identified any undesirable effects (e.g., emotional trauma to the debriefed team, or the needed resources (incl. costs) for debriefing after cardiac arrest in the reviewed studies. However we have identified neutral to positive effects on our critical and important outcomes. Hence, we justify that the reported positive effects outweigh any possible undesirable effects.

Subgroup considerations

We did not identify evidence to address any subgroup analyses.

Implementation considerations

Defusing emotions of rescuers after stressful or traumatic events should be taken into account when assessing any potential risks related to debriefing.

The associated costs to implement debriefings are likely to be low in most institutions. The most important factors might be the time commitment of resuscitation team members and the cost of training the debriefers. However, the reviewed studies did not explore cost-effectiveness of debriefing. This is also applicable when referring to the required resources related with debriefing. Only one study mentioned the cost of surveillance cameras as 125 euros per camera.

Successful debriefing programs also will require training of debriefers. Use of video surveillance to inform debriefing might be a resource to consider.

Debriefings are likely acceptable to stakeholders (because of potential benefits such as improved teamwork, improved communication, improved identification of latent safety threats) and feasible in most institutions, including in- and out-of hospital settings. However, resource limited settings might be disadvantaged in implementation.

The role of CPR feedback device data might be beneficial to inform debriefings.

Monitoring and evaluation

Regular evaluation of the effectiveness and acceptability of debriefing programs should be considered.

Research priorities

The identified evidence was limited with all studies being non-randomized studies. This suggests the need for further evidence on debriefing after cardiopulmonary resuscitation including randomized controlled trials.

We identified insufficient evidence to address subgroup analyses, e.g. adult vs. pediatric cardiac arrest, or in- vs. out-of hospital setting.

We identified no study on cost-effectiveness or use of post-event debriefings in low-resource settings.

We identified no negative effects of debriefing on the resuscitation team, however minor they might be, they should be investigated in a further review and/or further studies on the effectiveness on resuscitation debriefing.

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Medical Emergency Systems for Adults (EIT 6309)

Should MES vs. no MES be used for hospitalized adults at risk of deterioration?	
POPULATION:	Adults who are at risk of cardiac or respiratory arrest in hospital
INTERVENTION:	Rapid Response System (includes Rapid Response Team (RRT) or Medical Emergency Team MET))
COMPARISON:	No Rapid Response System
MAIN OUTCOMES:	Survival to hospital discharge with good neurological outcome (critical); Survival to hospital discharge (critical); In-hospital incidence of cardiac/respiratory arrest (critical)
SETTING:	Adults, in-hospital
PERSPECTIVE:	There is uncertainty if Rapid Response Systems are effective in improving patient outcomes after cardiac arrest and patient survival or reducing the number of cardiac arrests.
BACKGROUND:	Patients admitted to hospital with serious health issues are at risk of deterioration that can lead to cardiac arrest. Frequently, these patients will exhibit signs and symptoms of deterioration for hours or days before cardiac arrest. (1) A Rapid Response System is a program designed to evaluate patients early in their clinical deterioration to prevent serious adverse events in hospitalized individuals. (2)
CONFLICT OF INTERESTS:	The ILCOR Continuous Evidence Evaluation process is guided by a rigorous ILCOR Conflict of Interest policy. The Task Force members and authors declare no conflict of interest.

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Up to 86% of in-hospital cardiac arrests are preceded by a period of physiological deterioration, and in-hospital cardiac arrest confers a high mortality. Rapid response systems are based upon the premise that intervention during this period of deterioration is likely to reduce the incidence of cardiac arrest and death.	The ability of a healthcare institute to demonstrate a means of detecting the physiologically deteriorating patient ('afferent limb'), a means of responding to this deterioration with a response team ('efferent limb'), an ongoing evaluative component and an ongoing administrative component is now utilized by some healthcare jurisdictions and regulatory organizations to credential/accredit healthcare institutions.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ● Large ○ Varies ○ Don't know	• There is low certainty of evidence that RRS improves survival to hospital discharge and reduces the incidence of cardiac arrests in adults. • There may be other desirable effects of rapid response systems, such as to improve end of life care for patients and in reduction of medical errors. (67, 68) • Included studies reported an expected increase in number of calls to rapid response system. • There was no report of increased mortality or harm caused by rapid response systems.	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	• There is low certainty of evidence that RRS improves survival to hospital discharge and reduces the incidence of cardiac arrests in adults. • There may be other desirable effects of rapid response systems such as to improve end of life care for patients and in reduction of medical errors. (67, 68) • Included studies reported an expected increase in number of calls to rapid response systems. • There was no report of increased mortality or harm caused by rapid response systems.	Studies have reported that increased number of calls did necessarily lead to change in treatment or patient admission to intensive care unit. (73)

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	There was high heterogeneity among studies. The overall certainty of evidence was rated as very low to low for all outcomes primarily due to a very serious risk of bias. The individual studies were all at a serious to critical risk of bias.	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	In-hospital cardiac arrest is a major adverse event with an incidence of 1–6/1000 admissions. Long term survival from IHCA is poor at 13.4%. (74) Abnormal vital signs are prevalent 1–4h before in-hospital cardiac arrest on hospital wards. In-hospital mortality increases with increasing number of pre-arrest abnormal vital signs. (1)	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Based on large desirable effects and small undesirable effects, rapid response systems are probably favored.	

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies	A 2016 survey of 207 Australian and New Zealand hospitals revealed that ICU staff provided staff for most RRTs, and oversight for more than 80% of RRTs. However, additional funding for ICU RRT staff and dedicated doctors was relatively uncommon. (75)	Resources required is likely to vary depending on healthcare setting, make up and context of different rapid response systems.

○ Don't know		

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No included studies reported on resource use of RRS.	

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ● Varies ○ No included studies	A study reported a cost analysis of an RRS on a surgical ward, including costs for implementation, a 1-day training program for nurses, nursing time for extra vital signs observation, medical emergency team (MET) consults and differences in unplanned ICU days before and after RRS implementation. (76) The authors reported mean RRS costs were €26.87 per patient-day: implementation €0.33 (1%), training €0.90 (3%), nursing time spent on extended observation of vital signs €2.20 (8%), MET consults €0.57 (2%) and increased number of unplanned ICU days after RRS implementation €22.87 (85%). In the scenario analysis mean costs per patient-day were €10.18. The costs for extra unplanned ICU days were relatively high but the remaining RRS costs were relatively low.	Costs for the number of unplanned ICU days can be reduced if RRS can detect clinical deterioration in time and less severely ill patients are referred to the ICU.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact		As rapid response systems should be available to all hospitalized patients, it is unlikely to impact on health equity, but that has not been studied yet.

○ Probably increased ○ Increased ○ Varies ● Don't know		

Acceptability
Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	High level of staff satisfaction has been reported by qualitative survey. (18) Clear leadership, interprofessional trust and collaboration are crucial for succeeding with a RRS. Clear protocols, feedback, continuous evaluation and interprofessional training were highlighted as facilitators. Reprimanding down the hierarchy, underestimating the importance of call-criteria, alarm fatigue and a lack of integration with other hospital systems were identified as barriers. (77)	Rapid response systems are recommended by the Institute for Healthcare Improvement. National initiatives such as National Safety Goals (2008 Joint Commission National Patient Safety Goal)

Feasibility
Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know		Rapid response systems are recommended by the Institute for Healthcare Improvement. The National Health Service in UK has adopted National Early Warning Scores 2 (NEWS2) widely as a system to recognize deteriorating patients (NHS England 2018). Many versions of rapid response systems exist in healthcare organizations around the world. It is unknown whether the provision of RRS service is universal across all patient types or during all hours of the day.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	Moderate	**Large**		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	**Varies**	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

We suggest that hospitals consider the introduction of a rapid response system to reduce the incidence of in-hospital cardiac arrest (weak recommendation, low-quality evidence).

Justification

- The task force emphasizes the importance of outcomes such as preventing in-hospital cardiac arrests and enhancing survival rates to hospital discharge, despite the considerable costs associated with these systems. Numerous healthcare institutions globally have effectively adopted rapid response systems. (78)
- The Institute for Healthcare Improvement (IHI) (http://www.ihi.org/Topics/RapidResponseTeams/Pages/default.aspx) and various national patient safety programs advocate for the use of rapid response systems to improve patient safety.
- Up to 33% of rapid response team activations involve patients nearing the end of life. Rapid response systems may also play a significant role in end-of-life care management and in mitigating medical errors. (67, 68)
- Implementing an effective rapid response system requires thoughtful integration of key components. Strong afferent (detection and activation) and efferent limbs (response by the RRS/MET team) should be supported by robust administrative and quality improvement measures.
- Adequate investment in resources is crucial, which includes:
  (a) comprehensive staff training on recognizing signs of patient decline;
  (b) consistent and appropriate monitoring of vital signs;
  (c) clear protocols such as alert systems or early warning scores to facilitate early detection; (d) a standardized, tiered clinical response structure; and
  (e) a systematic approach to responding to assistance calls.

  However, the best practices for patient monitoring and how to implement these components are still unclear.
- Monitoring the performance of rapid response systems is essential, and data should be utilized as part of a continuous quality improvement strategy. Healthcare organizations should follow the "Recommended Guidelines for Monitoring, Reporting, and Conducting Research on Medical Emergency Team, Outreach, and Rapid Response Systems: An Utstein-Style Scientific Statement" to gather meaningful data and enhance system effectiveness and clinical outcomes.

Subgroup considerations

Not done

Implementation considerations

· Careful consideration needs to be given to the elements of such system. Effective afferent and efferent limbs may need the support of administrative and quality improvement limbs. (79)

· Adequate resources should be dedicated to such systems to include (a) staff education about the signs of patient deterioration; (b) appropriate and regular vital signs monitoring of patients; (c) clear guidance (eg, alert systems or early warning scores) to assist staff in the early detection of patient deterioration; (d) a clear, uniform system of tiered clinical response; and (e) a clinical response to calls for assistance. The optimal method of patient monitoring and delivery of these components remains unclear. (70, 79)

Monitoring and evaluation

· The performance of rapid response systems should be monitored and used as part of quality improvement programs of healthcare organizations.

The "Recommended Guidelines for Monitoring, Reporting, and Conducting Research on Medical Emergency Team, Outreach, and Rapid Response Systems: An Utstein-Style Scientific Statement" should be used by hospitals to collect the most meaningful data to optimize system interventions and improve clinical outcomes. (80)

Research priorities

- *There is limited evidence regarding long-term survival with positive neurological outcomes with the application of RRT/MET.*
- *The role of technology in enhancing rapid response systems (e.g. use of remote monitoring, wearable devices) is unclear*
- *The essential components of the "afferent limb" in a rapid response system needs to be determined (e.g. which vital signs, clinical observations, laboratory parameters should be monitored, and what is the optimal frequency for these assessments).*
- *The most effective education program to improve the recognition of patient deterioration.*
- *The most effective mechanism for escalating assistance, and how conventional escalation methods compare to automated electronic escalation work needs further investigation.*
- *The ideal composition of the "efferent limb," or the response team needs to be defined.*
- *The primary reasons behind 'failure to rescue' scenarios or the underuse of rapid response systems needs to be clarified.*
- *The cost-effectiveness of rapid response systems in practice is unclear.*

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Systems Performance Improvements (EIT 6310)

POPULATION:	Population: Among resuscitation systems who are caring for patients in cardiac arrest in any setting
INTERVENTION:	System performance improvement initiatives
COMPARISON:	No system performance improvement initiatives
MAIN OUTCOMES:	Survival with favorable neurologic outcome at discharge (critical); Survival to hospital discharge (critical); Skill performance in actual resuscitations (important); Survival to admission (important); System level variables (important)
SETTING:	Prehospital or in-hospital settings
PERSPECTIVE:	
BACKGROUND:	Sudden cardiac arrest causes high mortality and remains a major event which affects millions of lives worldwide. The clinical outcomes of patients with cardiac arrest differ around the world, and there is a need to improve outcomes. Therefore, various interventions targeting cardiac arrest patients have been introduced. Nonetheless, many of these interventions are limited in scope, focusing on narrow patient groups, such as specific ambulance services, or individual hospital wards. This limitation prompts questions about the effectiveness of such interventions on a broader scale. Thus, there is a need for a systematic review of interventions that adopt a community-wide or system-wide approach to better understand their impact on a larger scale.
CONFLICT OF INTERESTS:	None

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Cardiac arrest is an important healthcare issue. Survival rates for IHCA and OHCA remain low. Therefore, it is paramount to increase the survival rate of cardiac arrest.	
Desirable Effects **How substantial are the desirable anticipated effects?**		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	In one RCT, Cases randomized to feedback-on (system performance improvement) compared with feedback-off (no system performance improvement) had better skill performance (significantly lower mean compression rate (103v 108 per minute, P<0.001), higher chest compression	The interventions and system settings across the included studies differed considerably, making it difficult to combine the outcomes meaningfully. System performance improvement could show a large effect size in a beneficial direction.

	fraction (66% v 64%, P=0.016), deeper chest compressions (40 v 38 mm, P=0.005), and fewer chest compressions with incomplete release (10%v15%, P<0.001)), whereas there was no significant difference in survival with favorable neurologic outcome at discharge (RR 1.01, 95% CI, 0.86-1.18) and survival to hospital discharge (RR 0.95, 95% CI, 0.81-1.10). (12) In the remaining forty-one non-RCT studies, seventeen interventions demonstrated a significantly higher chance of survival with favorable neurologic outcomes at discharge (2, 6, 7, 9, 10, 13, 15-17, 19, 21, 23, 28, 29, 31, 32, 36), twenty showed increased survival to hospital discharge (2-4, 6, 7, 9, 10, 13, 15, 17, 19-21, 23, 26-29, 32, 36), sixteen reported improved skill performance in actual resuscitations (5, 8, 10, 13-16, 20, 22, 24-26, 30, 33, 35, 36), three indicated a higher chance of survival to admission (7, 27, 29), and eighteen showed improvements in specific system-level variables after implementing system performance improvements (1, 3, 4, 6, 7, 10, 11, 15, 16, 18, 19, 21, 23, 24, 27, 28, 31, 34).	
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ○ Large ○ Varies ● Don't know	There was no information provided regarding resources such as costs, equipment, time requirements.	
Certainty of evidence What is the overall certainty of the evidence of effects?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	Certainty of evidence for all outcomes was rated from moderate to very low. We identified moderate certainty of evidence from one cluster-randomized trial (downgraded for risk of bias) and very low certainty of evidence from evidence from 41 non-RCTs (downgraded for risk of bias, inconsistency).	

Outcome	Relative importance	Certainty of the evidence (GRADE)
Survival with favorable neurologic outcome at discharge	Critical	moderate to very low
Survival to hospital discharge	Critical	moderate to very low
Skill performance in actual resuscitations	Important	moderate to very low
Survival to admission	Important	moderate to very low
System level variables	Important	very low

Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	There is no specific evidence of the variability in the value of the main outcomes. The outcomes that were chosen were commonly used in the resuscitation research.	

Balance of effects
Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the	Enhancing system performance has the potential to yield a substantial positive effect size, indicating significant improvements. Such advancements could lead to improved outcomes.	

intervention ○ Varies ○ Don't know		
Resources required		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know	No data was available from included studies.	A system-wide intervention may require more resources, including additional funding, staff, and time, to effectively implement changes across all relevant areas.
Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No data was available from included studies.	The cost of the initiative is expected to vary based on its specific nature. A system-wide intervention may carry a higher potential cost due to its broader scope and required resources.
Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	No data was available from included studies.	Interventions to improve system performance have been shown to increase survival among patients with cardiac arrest.

Equity What would be the impact on health equity?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	All the residents or patients in the system benefit from system performance improvement if such interventions are successfully implemented.	
Acceptability Is the intervention acceptable to key stakeholders?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	We found no evidence on acceptability in the studies.	While interventions to enhance system performance may initially increase personnel workload and raise some expenses, these upfront costs can be offset by long-term savings resulting from improved efficiency and performance.
Feasibility Is the intervention feasible to implement?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Numerous studies have demonstrated that many interventions aimed at improving system performance successfully enhance both processes and patient outcomes. However, some systems may lack the necessary resources to implement these performance improvements effectively.	

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	Small	Moderate	Large		Varies	**Don't know**
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies

	JUDGEMENT						
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	**Strong recommendation for the intervention**
○	○	○	○	○

CONCLUSIONS

Recommendation

We recommend that organizations or communities that treat cardiac arrest use system improvement strategies to improve patient outcomes. (strong recommendation, very low-certainty evidence).

Justification

We recognize that the evidence in support of this recommendation comes from studies that mostly provide low to very low certainty evidence. However, the majority of studies found that interventions to improve system performance not only improve system level variables and skill performance in actual resuscitations among rescuers, but also clinical outcomes of patients with out-of-hospital or in-hospital cardiac arrest, such as survival to hospital discharge and survival with favorable neurologic outcome at discharge. We acknowledge that these interventions demand funding, personnel, and stakeholder support to improve system performance. Varying levels of resources across settings may influence the effectiveness of implementing these performance improvements. Values and preferences statement: In making this recommendation, we prioritize the benefits of system performance improvements, recognizing that they present no known risks and hold substantial potential for positive impact.

Subgroup considerations

We included studies that evaluate system performance improvement in the context of out-of-hospital cardiac arrest (30) and in-hospital cardiac arrest (12).

Due to very high heterogeneity in the interventions, no meta-analysis was possible.

Implementation considerations

Improving system performance for cardiac arrest care often necessitates substantial resources and funding, as it may involve acquiring specialized equipment, training personnel, and enhancing protocols. These improvements can improve patient outcomes, but some healthcare systems may face limitations in the resources available to fully implement these interventions.

Monitoring and evaluation

Research priorities

To evaluate the cost-effectiveness of individual interventions aimed at improving system performance.

To assess the feasibility of implementing community interventions across diverse resource settings.

To investigate the effects of individual and bundled interventions in future studies to determine their impact on outcomes.

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Should prehospital critical care vs. advanced life support be used for patients with out-of-hospital cardiac arrest?	
POPULATION:	Adults and children with out-of-hospital non-traumatic cardiac arrest.
INTERVENTION:	Prehospital critical care teams, defined as any provider with clinical competencies beyond that of standard paramedics using advanced life support algorithms and dedicated dispatch to critically ill patients.
COMPARISON:	Advanced life support
MAIN OUTCOMES:	Survival to hospital discharge; Survival at 30 days; Favourable neurological outcome at hospital discharge; Favourable neurological outcome at 30 days; Survival to hospital admission / return of spontaneous circulation;
SETTING:	Out of hospital cardiac arrest (OHCA)
PERSPECTIVE:	Clinical recommendation for treatment
BACKGROUND:	The emergency medical service (EMS) system response is a critical element in the pathway of care for OHCA patients.[1,2] The optimal configuration of EMS systems is unclear and varies between countries.[3] Many countries utilize prehospital critical care teams as part of a tiered EMS response.[4–6] These teams are specialists in care of the critically ill patient and have greater exposure to resuscitation than standard EMS teams, potentially offering clinical benefit.[7] These teams have competencies beyond that of standard EMS teams delivering advanced life support. This may include advanced airway management, blood transfusion, central venous access, advanced inotropes/vasopressors, prehospital emergency anesthesia, sedation/paralysis, invasive monitoring, surgical procedures, and diagnostic ultrasound.[8] They can also facilitate transfer over extended distances, which may allow patients to receive hospital care at a more optimal location. They often attend in addition to a standard team or may attend in isolation dependent on the situation. Understanding the clinical efficacy associated with prehospital critical care teams is important to helping decide how they may be implemented into practice.
CONFLICT OF INTERESTS:	None

ASSESSMENT

Problem

Is the problem a priority?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Improving survival after out-of-hospital cardiac arrest is a priority for healthcare systems and could save thousands of lives worldwide every year. The configuration of emergency medical services varies worldwide and delivering the optimal configuration is a priority. The ILCOR EIT taskforce has prioritized this topic.	Critically appraising the evidence surrounding prehospital critical care teams will allow the clinical efficacy of these teams to be better understood and inform

		implementation decisions.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	The findings of this systematic review and meta-analysis indicate that the anticipated desirable treatment effects are moderate for all outcomes. The effect estimates show that prehospital critical care teams are associated with improved outcomes. The significant odds ratios for benefit range from 1.34 to 1.98.	A moderate desirable effect is beneficial to patients and may improve clinical outcomes.

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	prehospital critical care	advanced life support	Relative (95% CI)	Absolute (95% CI)		
Survival to hospital admission / return of spontaneous circulation - adult												
8	non-randomised studies	serious[a]	not serious	not serious	serious[b]	none	6035/31337 (19.3%)	50789/608423 (8.3%)	**OR 1.95** (1.35 to 2.82)	**67 more per 1,000** (from 26 more to 121 more)	⨁⨁◯◯ Low	CRITICAL
Survival to hospital admission / return of spontaneous circulation - paediatric												
1	non-randomised studies	serious[a]	not serious	not serious	very serious[c]	none	97/276 (35.1%)	240/911 (26.3%)	**OR 1.48** (1.08 to 2.04)	**83 more per 1,000** (from 15 more to 158 more)	⨁◯◯◯ Very low	CRITICAL
Survival to hospital discharge - adult												
7	non-randomised studies	serious[a]	not serious	not serious	serious[b]	none	253/1823 (13.8%)	896/10348 (8.7%)	**OR 1.34** (1.10 to 1.63)	**26 more per 1,000** (from 8 more to 47 more)	⨁⨁◯◯ Low	CRITICAL
Survival at 30 days - adult												
7	non-randomised studies	serious[a]	not serious	not serious	serious[b]	none	2824/33623 (8.4%)	33585/671257 (5.0%)	**OR 1.56** (1.38 to 1.75)	**26 more per 1,000** (from 18 more to 34 more)	⨁⨁◯◯ Low	CRITICAL
Survival at 30 days - paediatric												
1	non-randomised studies	serious[a]	not serious	not serious	very serious[c]	none	46/276 (16.7%)	115/911 (12.6%)	**OR 1.49** (0.97 to 2.88)	**51 more per 1,000** (from 3 fewer to 168 more)	⨁◯◯◯ Very low	CRITICAL
Favourable neurological outcome at hospital discharge - adult												
1	non-randomised studies	serious[a]	not serious	not serious	very serious[c]	none	29/232 (12.5%)	75/741 (10.1%)	**OR 1.35** (0.71 to 2.60)	**31 more per 1,000** (from 27 fewer to 125 more)	⨁⨁◯◯ Low	CRITICAL
Favourable neurological outcome at 30 days - adult												
6	non-randomised studies	serious[a]	not serious	not serious	serious[b]	none	1496/23785 (6.3%)	17146/665953 (2.6%)	**OR 1.48** (1.19 to 1.84)	**12 more per 1,000** (from 5 more to 21 more)	⨁⨁◯◯ Low	CRITICAL
Favourable neurological outcome at 30 days - paediatric												
1	non-randomised studies	serious[a]	not serious	not serious	very serious[c]	none	23/276 (8.3%)	33/911 (3.6%)	**OR 1.98** (1.08 to 3.66)	**33 more per 1,000** (from 3 more to 85 more)	⨁◯◯◯ Very low	CRITICAL

CI: confidence interval; **OR:** odds ratio

Explanations

a. ROBINS-I tool assessment.

b. Some studies not reporting number of events or totals. Some studies imprecise effect estimates with wide confidence intervals.

c. Neither study reported number of events or totals. Imprecise effect estimates with wide confidence intervals.

d. Unable to calculate as number of events and totals are not reported.

e. Single study with wide confidence interval.

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	There is no evidence found by this systematic review of undesirable effects. In meta-analyses of critical outcomes, all effect estimates favoured care with a prehospital critical care team. This review did not detect any adverse or undesirable effects associated with prehospital critical care teams.	

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	The certainty of evidence for each critical outcome was low for adults and very low for children. For adults with non-traumatic OHCA, critical outcomes of survival to hospital discharge, survival at 30 days, favourable neurological outcome at 30 days, and survival to hospital admission/return of spontaneous circulation were low certainty of evidence (downgraded for risk of bias). One study examined paediatric patients and the certainty of evidence was very low (downgraded for risk of bias and imprecision).	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● No important uncertainty or variability	No study included in this review investigated how much people value the main outcomes.	Previous research has demonstrated the critical importance of survival and favourable neurological outcome. These outcomes are included within the core outcome set for cardiac arrest and this systematic review.[9]

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	There is low certainty of evidence of moderate desirable effects. There is no evidence to suggest undesirable effects. The outcomes are considered critical and there is no important uncertainty or variability in the value of these outcomes.	Prehospital critical care is likely to incur greater resource costs, an undesirable effect.

Resources required

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	No studies were included that examined the resource implications and costs of prehospital critical care teams versus advanced life support.	Prehospital critical care teams are established in many EMS systems, as highlighted by this systematic review. However, they treat a minority of OHCA patients. Expanding their services to reach more patients will present resource

		implications. CCTs typically respond by helicopter or rapid response vehicle, and often carry specialist equipment such as mechanical CPR devices, highlighting the resources required. They must be integrated within established EMS systems and use a dispatch approach that may require specialist personnel within an operations centre, in addition to the CCT clinicians.[10] Expansion of CCTs requires training of specialist clinicians and may draw them away from other healthcare settings and roles. For example, the prehospital physicians responding with CCTs have specialist in-hospital backgrounds in emergency, anaesthesia, or intensive care. There was no evidence from low income

		settings. Given that CCTs are likely to be costly and present significant training and resource implications, this may not be the most efficient and optimal use of scarce resources.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies were included in this review examining this domain.	The certainty of costs is unclear and will vary between healthcare systems. This will be influenced on whether prehospital critical care services are already present within an EMS system, whether they are expanded to reach more patients, or whether they are introduced as a new service provision.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	No included studies examined cost-effectiveness.	It is likely that prehospital critical care teams will incur greater monetary costs than advanced life support. One previous study has calculated the prehospital costs in the UK at 2015/2016 costs (prehospital critical care £1711 versus advanced life support £347).[11] This study found that when the costs and outcomes of prehospital, in-hospital, and post discharge phases were included, prehospital advanced life support was cost effective at £11,407/quality-adjusted life year. The clinical efficacy of prehospital critical care was not known and therefore the cost-effectiveness could not be estimated, however the study suggested the minimally economically important

		difference in survival to hospital discharge would be 3%–5%. This study is UK-specific and generalisability to other healthcare systems is challenging.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ● Don't know	No study examined health equity.	It is unclear how prehospital critical care teams impact health inequities and reach disadvantaged groups. The desirable effects associated with prehospital critical care teams have the potential to address health inequities if targeted to groups in need of improvement in access to high quality cardiac arrest care and improvement in outcomes. If an EMS system is optimised to reach these groups then prehospital critical care teams could help address inequities.

		Conversely, if prehospital critical care teams are not optimally distributed or available to disadvantaged groups in an equitable manner then they could compound health inequities. There is no evidence in included studies to determine this in current practice and is likely to vary between EMS service and region.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	No studies examined acceptability to key stakeholders.	Prehospital critical care teams appears to have moderate desirable effects and no undesirable effects. The associated costs are unclear. Prehospital critical care teams are in use in many developed healthcare systems across the world and this review highlights the high number of patients that are currently

		receiving this intervention. Given its establishment in contemporary practice, the intervention is likely to be acceptable to key stakeholders.

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	No included study examined feasibility of implementing prehospital critical care teams.	The intervention is already delivered in many healthcare systems, and hence is feasible in some settings. Expanding these services to reach more patients or introducing this service in some settings will incur a resource costs, which may negatively impact feasibility. Implementation will require availability and training of specialist healthcare professionals, such as prehospital physicians and critical care paramedics. These teams will also require EMS infrastructure

		to respond effectively. Their presence in many EMS systems demonstrated the feasibility of their implementation, however this is specific to that setting. Their implementation in other settings may be challenging. In summary, the feasibility of implementing prehospital critical care teams is likely to be setting specific.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	Probably no important uncertainty or variability	**No important uncertainty or variability**			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know

	JUDGEMENT						
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	Probably yes	Yes		Varies	**Don't know**

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

We recommend that prehospital critical-care teams attend adults with nontraumatic, out-of-hospital cardiac arrest within EMS systems with sufficient resource infrastructure (weak recommendation, low certainty of evidence).

We suggest that prehospital critical-care teams attend children with out-of-hospital cardiac arrest within EMS systems with sufficient resource infrastructure (weak recommendation, very low certainty of evidence).

Justification

- This PICOST was prioritised by the ILCOR EIT taskforce to assess possible improvements in outcomes for out-of-hospital cardiac arrest patients as that is a priority for many healthcare systems. Prehospital critical care was considered as enhanced clinical competencies beyond advanced life support with dedicated EMS teams dispatched to critically ill patients. This was compared to standard advanced life support.
- Studies were included from multiple EMS systems across the world, with seven from Japan, three from the UK, and one each from Australia, Iceland, Norway, Poland, and the USA.
- Meta-analysis found moderate desirable effects for adult non-traumatic OHCA patients in all critical outcomes (survival, favourable neurological outcome, survival to hospital admission/ROSC) with low certainty of evidence from 14 studies reporting 1,187,100 patients. The ILCOR taskforce has made a

recommendation alongside low certainty of evidence for adults with non-traumatic OHCA in light of consistent moderate desirable effects across clinical outcomes in a large number of reported patients and studies from a variety of different health care systems.

- There were moderate desirable effects based on very low certainty of evidence for paediatric OHCA patients from one study reporting 1,187 patients. As there was only one study a limited number of patients, the ILCOR task issued a suggestion favouring prehospital critical care teams for paediatric OHCA patients.
- The associated resource costs, cost-effectiveness, impact on health equity, and feasibility of implementation were not reported by the included studies. These costs are likely to be healthcare system specific. This systematic review demonstrates that many settings have already implemented prehospital critical care teams and they are treating many OHCA patients in contemporary clinical practice. Expanding prehospital critical care services and implementing these services in other healthcare systems is likely to incur resource, training, and EMS infrastructure costs, and hence may not be universally available. Implementing prehospital critical care teams is likely to be setting specific.

Subgroup considerations

No subgroup analysis was performed as only one study reported children with out-of-hospital cardiac arrest and the certainty of evidence was very low.
Due to the specialist nature of prehospital critical care teams and the specialist nature of paediatric cardiac arrest subgroup, prehospital critical care teams may offer particular benefit.

Implementation considerations

Prehospital critical care teams have already been implemented in several healthcare systems, notably Japan, Australia, United Kingdom and other parts of Europe. They currently treat a minority of patients. However, implementing prehospital critical care teams such that more patients have access to this service will present resource implications, and may not be possible in all systems. There is insufficient evidence to understand the resource implications and cost effectiveness as no study investigated that.

Monitoring and evaluation

Currently there are no randomised controlled trials investigating prehospital critical care teams for out-of-hospital cardiac arrest patients. Observational studies using out-of-hospital cardiac arrest registries have supported most of the evidence gathering in this review.[4–6,12–22] Registries allow monitoring of clinical activity and effectiveness and will be valuable in supporting iterative quality improvement.

Research priorities

- The evidence on children with out-of-hospital cardiac arrest is based on only one study. More evidence is required to understand if the individualised and enhanced care provided by prehospital critical care teams confers clinical benefit.
- Which patient groups would benefit most from prehospital critical care teams in order to optimise emergency medical service systems and target care delivery.
- The optimal composition of prehospital critical care teams, their professional background, and training requirements are unknown. This may be EMS system specific.
- The enhanced interventions prehospital critical care teams are delivering and what interventions are resulting in the observed desirable effects.
- Cost-effectiveness of prehospital critical care teams and implementation costs. This may be EMS system specific.
- There is no data from RCTs investigating prehospital critical care teams for OHCA.

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CPR Coaching during adult and pediatric cardiac arrest (EIT 6314)

Should Resuscitation teams with a CPR Coach vs. Resuscitation teams without a CPR Coach be used for treatment of cardiac arrest patients?	
POPULATION:	Healthcare teams managing adult or pediatric cardiac arrest
INTERVENTION:	Resuscitation teams with a CPR Coach
COMPARISON:	Resuscitation teams without a CPR Coach
MAIN OUTCOMES:	Clinical CPR performance; CPR performance in simulation; Guideline adherence in simulation; Teamwork in simulation; Workload in simulation;
SETTING:	Any setting
PERSPECTIVE:	CPR Coaching may improve CPR quality during cardiac arrest resuscitation and hence contribute to improved survival outcomes.
BACKGROUND:	Despite CPR training, adherence to guidelines is low. Devices placed on the chest that provide visual feedback during CPR can improve chest compression (CC) quality, but there is substantial room for improvement. Resuscitation teams using visual feedback devices still have < 40% compliance for CC depth. Strategies are needed to help teams translate visual CPR feedback into optimized CPR delivery. Many institutions have introduced CPR feedback defibrillators into their acute care environments. Optimal incorporation of CPR feedback technology requires CPR providers receive information from the device and adjust CPR performance accordingly. To address this issue, researchers have proposed the integration of a CPR Coach within the resuscitation team. The CPR coach is a resuscitation team member whose primary responsibility is to provide real-time coaching and feedback of CC performance during cardiac arrest, thus allowing the team leader to focus on advanced life support and managing reversible causes.
CONFLICT OF INTERESTS:	A. Cheng, J. Duff, and Y Lin were authors of some articles included in this review. Therefore, they did not participate in article selection and were not involved in data extraction and ROB assessment of studies on which they were authors.

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Cardiopulmonary resuscitation quality is often substandard to guideline recommendations in spite of CPR feedback being used. CPR Coaching has therefore been implemented in some settings clinically to improve CPR performance.	

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	For the critical outcome of clinical CPR performance, Infinger 2014[1] found that implementation of a CPR Coach improved fraction of compressions at adequate depth from 69.8% to 80.4%; compression depth increased from 43.6mm to 47.2mm, and time to defibrillation was reduced from 13.2s to 7.2s. P-values or confidence intervals for comparisons were not reported. For the important outcome of CPR performance in simulation, Cheng 2018[2] found higher fraction of excellent chest compressions (63% vs 31%, Diff: 31.8 (17.7, 45.9); higher fraction of compressions within guideline recommendations 38.0 vs. 69.5, Diff: 31.5 (15.7, 47.4); guideline compliant rate (88% vs 80%, p=0.07); CCF (82% vs 77%, p=0.04) for coached vs non-coached teams. Kessler 2021[5] found shorter overall pause durations for coached vs non-coached teams 98.6 s vs 120.85 s, diff: 0.6–43.9 s, shorter pauses for intubation and defibrillation with no significant difference in mean pause frequency. Badke 2020[7] found shorter time to backboard placement (22s vs. 55s, p=0.02); no difference in compression rate, no flow time, time to first epi, time to first shock, or perishock pause duration although this study was likely underpowered to detect important differences in outcomes. For the important outcome of guideline adherence in simulation, Buyck 2021[6] measured a clinical performance tool for teams with vs. without a CPR coach. They found that scores were 73.4 for CPR coached teams vs 68.3 for non-coached teams, (difference: 5.2 points; 95% CI: 1.0-9.3; p=0.016). For the important outcome of teamwork in a simulated setting, Jones 2021[3] found that CPR coached teams had more words/min compared to non-coached teams (160vs134; p<0.05) overall; team leaders and others said less/min (70.2 vs 88.4 and 30.4 vs 45.6, p<0,05), and total questions/min was lower (2.84 vs 3.66, p<0,05).	

	For the important outcome of workload in a simulated setting, Tofil 2020[4] found that workload for team leaders measured using the NASA TLX questionnaire was 54.1 (9.8) vs 52.7 (11.6) for teams without vs with a coach, difference: 1.4 (–5.5 to 8.3). There was also no difference for chest compressors: 55.2 (11.2) vs. 55.6 (9.1), diff: 0.4 (–4.9 to 4.2). For chest compressors, there was lower mental demand and higher physical demand for coached teams vs non-coached teams. Badke 2020[7] found no significant differences on any subscales of the NASA TLX for team leaders between the coached vs. non-coached teams. No overall NASA TLX measurement was conducted.	

Undesirable Effects
How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	We did not find any data in the studies on undesirable effects of CPR Coaching.	In settings without adequate resources for a CPR Coach, it could potentially limit CPR task performance although none of the identified studies found this phenomenon.

Certainty of evidence
What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	For the critical outcome of clinical CPR performance, we found very low certainty evidence (downgraded for risk of bias, indirectness, and imprecision).[1] For the important outcome of CPR performance in a simulated setting, we found very low certainty evidence (downgraded for risk of bias and imprecision).[2,5,6,7] For the important outcome of guideline adherence in a simulated setting, we found low certainty evidence (downgraded for risk of bias, indirectness, and imprecision). For the important outcome of teamwork in a simulated setting, we found very low certainty evidence (downgraded for risk of bias, indirectness, and imprecision).[3] For the important outcome of workload in a simulated setting, we found very low	

	certainty evidence (downgraded for risk of bias, inconsistency, and indirectness).[4,7]	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	The outcome of clinical CPR performance is considered as a Kirkpatrick level 3 outcome that is generally considered as a clinically important and meaningful outcome. Measurement of teamwork and workload in simulated settings are considered Kirkpatrick level 2 and some may value such outcomes more than others.	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ● Favors the intervention ○ Varies ○ Don't know	The evidence generally favored the intervention with no findings favoring the comparator.	

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● Don't know	No evidence on required resources for a CPR Coach was found	In many hospital settings, over-crowding is a major issue during CPR.[9] Therefore, the resources required for implementing a CPR Coach on the team would likely already be there. Low-resource settings and out-of-hospital settings may differ. However, alternate models of CPR coaching, where CPR providers take turns coaching, may help to overcome this resource issue.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No evidence was identified.	

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There were no included studies on cost-effectiveness	In many hospital settings, over-crowding is a major issue during CPR.[9] Therefore, the costs of using a CPR coach would likely be negligible in such settings and cost-effectiveness would be good.

Equity
What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know	No evidence was identified	It is unlikely that use of a CPR Coach would affect equity in any way.

Acceptability
Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	We found no evidence on acceptability	CPR Coaches are already implemented as part of the resuscitation teams in several pediatric hospitals[8] and staff members to fill out this role are likely available[9] However, this may differ in low-resource settings and out-of-hospital settings.

Feasibility
Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	CPR Coaches are already implemented as part of the resuscitation teams in several pediatric hospitals[8] and staff members to fill out this role are likely available in most hospitals[9]. This may differ in limited resource settings and some out-of-hospital settings. However, alternate models of CPR coaching, where CPR providers take turns coaching, may help to overcome this resource issue. We found one clinical observational study in the out-of-hospital setting where a CPR Coach was implemented without evidence of lacking feasibility.	

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know

	JUDGEMENT						
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	**Possibly important uncertainty or variability**	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	Varies	**Don't know**
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	**Probably no impact**	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	Yes		Varies	**Don't know**
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

We recommend considering the inclusion of a CPR Coach as a member of the resuscitation team during cardiac arrest resuscitation in settings with adequate staffing (weak recommendation, very low–certainty evidence).

Justification

- Use of a CPR Coach was generally associated with improved outcomes and no harmful effects of using a CPR Coach were observed.
- The certainty of evidence for the included outcomes was low or very low.
- Most of the evidence was based on one randomized simulation-based trial[2]. In addition, one clinical observational study[1] and a small pilot randomized simulation-based study was identified.[7]
- CPR Coaches are already implemented as part of the resuscitation teams in many hospitals[8] and overcrowding is very frequent in the hospital setting why it is believed that staff members to fill out this role are available.[9] However, this may differ in low-resource settings and out-of-hospital settings.
- In addition to the included evidence, one single center clinical study found that implementation of a CPR Coach as part of a bundled intervention was associated with improved fraction of excellent chest compressions.[10]
- Use of a CPR Coach may be considered a specific way of using shared leadership in resuscitation teams. Shared leadership has been suggested to be useful in several studies on in-hospital cardiac arrest.[9,11,12]

Subgroup considerations

We did not identify evidence to address any of the prespecified subgroup analyses.

Implementation considerations

CPR Coaches are already implemented as part of the resuscitation teams in many hospitals[8] and overcrowding is very frequent in the hospital setting why it is believed that staff members to fill out this role are available.[9] However, this may differ in low-resource settings and out-of-hospital settings.

Successful implementation of a CPR Coach may require training. However, one small simulated pilot study[7] suggested some possible benefits of using an untrained CPR Coach.

The effect and utilization of a CPR Coach may depend on the availability of automated chest compression feedback devices. In studies with feedback devices, the CPR Coach further improved chest compression quality, whereas in one small pilot study, an untrained CPR Coach without access to feedback devices was associated with shorter time to backboard placement and non-significant improvements in chest compression pause durations whereas chest compression quality was comparable between groups. This suggests that the potential implementation, role, and benefit of a CPR Coach may depend on available feedback devices.

Monitoring and evaluation

No considerations.

Research priorities

- The identified evidence was limited with most studies being based on one randomized simulation-based trial.[2] In addition, one clinical observational study[1] and a small pilot randomized simulation-based study were identified.[7] This suggests an overall need for further evidence on CPR Coaches including randomized trials specifically.

- We identified no evidence for the critical outcomes of adherence to guidelines in real cardiac arrest and patient survival outcomes.
- We identified insufficient evidence to address the prespecified subgroup analyses of: A) Adult vs. pediatric cardiac arrest, B) Trained vs. untrained CPR Coaching, C) Use of CPR feedback devices vs. no CPR feedback devices during resuscitation.
- In addition, the optimal role of a CPR Coach in the out-of-hospital setting and in-hospital setting may differ and the effectiveness may differ as well. This warrants further research.
- We identified no studies on cost-effectiveness or utilization of CPR Coaches in limited resource settings.
- No randomized clinical trials were identified.

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OHCA termination of resuscitation (TOR) rules (EIT 6303)

Should termination of resuscitation rules be used to diagnose no chance of survival in adults and children with out-of-hospital cardiac arrest?	
POPULATION:	Adults and children with out-of-hospital cardiac arrest
INTERVENTION:	Termination of resuscitation rules
PURPOSE OF THE TEST:	To predict survival outcomes
ROLE OF THE TEST:	To facilitate reliable prehospital termination of resuscitation decisions
LINKED TREATMENTS:	None
ANTICIPATED OUTCOMES:	Termination of resuscitation on scene without transporting to hospital
SETTING:	Prehospital setting
PERSPECTIVE:	Patient, clinician and EMS system perspective
BACKGROUND:	This was systematically reviewed by ILCOR in 2020 identifying very-low certainty evidence for a conditional recommendation to use termination of resuscitation rules. In 2024, an updated systematic review was published based on the 2020 ILCOR review (1) In the present review, we have conducted an adolopment of the 2024 review by Smyth et al. and searched for additional studies.
SUBGROUPS:	We considered adults and pediatric patients as separate subgroups.
CONFLICT OF INTERESTS:	Kasper G. Lauridsen was a co-author on the Smyth 2024 review for which an adolopment was performed.

ASSESSMENT

Problem
Is the problem a priority?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Routine transport of all prehospital cardiac cases is becoming increasingly unacceptable in many parts of the world. The reasons for this are multifactorial but include: • Increasingly limited healthcare resources at hospital • Increased risk to rescuers during emergent transport • Recognition that failure to achieve prehospital ROSC is the strongest predictor of poor clinical outcome • Recognition that interruptions to CPR when transferring a patient from scene to the ambulance are likely to adversely impact patient outcome • Evidence suggesting quality of CPR may be affected during emergent ambulance transport.	

	These influences have led to the development and implementation of TOR rules however there has been little study of the impact of these rules in clinical practice	

Test accuracy
How accurate is the test?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very inaccurate ○ Inaccurate ○ Accurate ○ Very accurate ○ Varies ○ Don't know	Many TOR studies report on either the derivation and internal validation of a rule or external validation through historical cohorts. However, these TOR rules generally lack clinical implementation and clinical testing. Only 1 study (2) reported a validation of a TOR in clinical practice by ambulance clinicians. Due to heterogeneity across studies it was not possible to perform a meta-analysis in 2020 and the additional studies identified in this review did not change that. The estimated number of false positive cases (number of cases recommended for termination who survived) varies significantly across studies and TOR rules. Smyth et al. reported pooled specificities of external validation studies of TOR rules varying from 0.81-0.98 as point estimates indicating the inability to correctly classify all survivors (1). The varying accuracy for the TOR rules across studies indicates that the performance of a TOR rule depends on the setting, the population, and the survival outcomes in that population.	We prioritized high specificity (i.e. a low number of missed survivors) and in accordance with previous reviews we consider at least 1% of missed survivors as inappropriate. Therefore, we prioritized specificity and positive predictive values with confidence intervals of at least 0.99.

Desirable Effects
How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ● Large ○ Varies ○ Don't know	Maximizing patient clinical outcomes while reducing risk faced by ambulance clinicians during emergent transport, and preserving limited Emergency Department (ED) resources is highly desirable in all health care environments. Included studies indicated that TOR rules are cost-efficient.	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ● Large ○ Varies ○ Don't know	There is a lack of evidence reporting the use of TOR in clinical practice. Smyth et al. reported pooled specificities of external validation studies of TOR rules varying from 0.81-0.98 as point estimates indicating the inability to correctly classify all survivors (1). Several studies report only a few missed survivors while some reported a substantial amount. Although the proportions are small (often below the 1% medical futility threshold) such a scenario is likely to be unacceptable to society as a whole. The number of missed survivors for the TOR rules varies significantly across studies indicating that the performance of a TOR rule depends on the setting, the population, and the survival outcomes.	

Certainty of the evidence of test accuracy

What is the overall certainty of the evidence of test accuracy?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	The evidence derives from observational studies, mostly historical cohorts, downgraded due to risk of bias, indirectness, imprecision, inconsistency and significant heterogeneity across patient and clinician populations.	Patient selection and lower survival outcomes in the cohorts examined may represent a major driver for the accuracy of the TOR rules and limit the application to clinical practice.

Certainty of the evidence of test's effects

What is the overall certainty of the evidence for any critical or important direct benefits, adverse effects or burden of the test?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	There remains to be only 1 clinical application study of a TOR rule in 954 patients (2) reporting a sensitivity of 0.64 (95%CI 0.61 to 0.68) and specificity of 1.00 (95%CI 0.92 to 1.00). Several external validation studies of TOR rules report patients being misclassified as non-survivors even though they did survive (1).	

Certainty of the evidence of management's effects

What is the overall certainty of the evidence of effects of the management that is guided by the test results?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	We found one prospective study applying a TOR rule during out-of-hospital resuscitation (2). In this study non-compliance was high with 198/954 (20.7%) cases eligible for TOR transported to hospital.	

Certainty of the evidence of test result/management

How certain is the link between test results and management decisions?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	It is unclear if other prehospital clinicians would have similarly high non-compliance rates. It is unclear if other prehospital clinicians would have similarly high non-compliance rates.	

Certainty of effects

What is the overall certainty of the evidence of effects of the test?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	Only one prospective study applying a TOR rule during out-of-hospital resuscitation was identified (2). It is unclear if findings would be similar for other prehospital clinician groups.	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability	TOR rules to accurately discriminate between patients who will and will not survive are a research priority for many healthcare professionals and EMS Systems. However, in many cultures it may be impossible for non-physicians to terminate resuscitation due to legal constraints. In others, it may be socially unacceptable not to avail the patient of all possible resources (including hospital) before any decision is made to discontinue resuscitation.	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ● Varies ○ Don't know	The performance of TOR rules seems to vary significantly among different studies in different settings. Khan et al. and Nazeha et al. investigated cost-effectiveness of TOR rules finding varying cost-effectiveness for different TOR rules (3,4). Nazeha et al. estimated that If TOR is exercised for every eligible case, it could expect to save approximately $400,440 per QALY loss compared to no TOR (4).	

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know	Khan et al. estimated quality-adjusted life years for survivors based on data from a systematic review applied on OHCA in the United Kingdom and identified that the most cost-effective strategies were the ERC TOR rule (incremental cost-effectiveness ratio (ICER) of £8,111), the Korean Cardiac Arrest Research Consortium 2 (KOC 2) TOR rule (ICER of £17,548), and the universal Basic Life Support (BLS) TOR rule (ICER of £19,498,216). (3) The KOC 2 TOR rule was cost-effective at the established cost-effectiveness threshold of £20,000–£30,000 per QALY. Nazeha et al. investigated the cost-effectiveness following implementation of TOR rules in Singapore based on cases that were terminated in the field and all cases applicable for TOR although clinicians decided transport to hospital (4). They found that terminating CPR on all patients eligible for the TOR rule would result in 31 additional deaths per 10,000 patients compared to No TOR. If TOR is exercised for every eligible case, it could expect to save approximately $400,440 per QALY loss compared to no TOR.	

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	Only two studies investigated cost-effectiveness based on historical cohort data and various assumptions. The evidence was downgraded for risk of bias, indirectness, and imprecision.	

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ● Varies ○ No included studies	Khan et al. estimated quality-adjusted life years for survivors based on data from a systematic review applied on OHCA in the United Kingdom and identified that the most cost-effective strategies were the ERC TOR rule (incremental cost-effectiveness ratio (ICER) of £8,111), the Korean Cardiac Arrest Research Consortium 2 (KOC 2) TOR rule (ICER of £17,548), and the universal Basic Life Support (BLS) TOR rule (ICER of £19,498,216). (3) The KOC 2 TOR rule was cost-effective at the established cost-effectiveness threshold of £20,000–£30,000 per QALY. Nazeha et al. investigated the cost-effectiveness following implementation of TOR rules in Singapore based on cases that were terminated in the field and all cases applicable for TOR although clinicians decided transport to hospital (4). They found that terminating CPR on all patients eligible for the TOR rule would result in 31 additional deaths per 10,000 patients compared to No TOR. If TOR is exercised for every eligible case, it could expect to save approximately $400,440 per QALY loss compared to no TOR.	The performance of the TOR rule depends on the setting, population, and survival outcomes. Thus, the cost-effectiveness would likely differ significantly based on the setting.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ● Don't know	No identified studies	

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know	In countries where prehospital termination of resuscitation is established practice studies suggest it is acceptable to prehospital clinicians, Emergency Department physicians and the families of non-survivors of cardiac arrest.(5-10) Only one study suggesting prehospital TOR is acceptable for clinicians and ED physicians was identified (2)	Internationally there may be cultural and legal barriers to prehospital termination of resuscitation. A TOR that misclassifies a patient as a non-survivor (i.e. an avoidable death) is unlikely to be acceptable to stake holders.

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know	Only one clinical study was identified.	Likely to be feasible in mature EMS systems with effective governance arrangements and where legislation does not prohibit non-physicians making termination of resuscitation decisions.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
TEST ACCURACY	**Very inaccurate**	Inaccurate	Accurate	Very accurate		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	Moderate	**Large**		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	Small	Moderate	**Large**		Varies	Don't know
CERTAINTY OF THE EVIDENCE OF TEST ACCURACY	**Very low**	Low	Moderate	High			No included studies
CERTAINTY OF THE EVIDENCE OF TEST'S EFFECTS	**Very low**	Low	Moderate	High			No included studies
CERTAINTY OF THE EVIDENCE OF MANAGEMENT'S EFFECTS	**Very low**	Low	Moderate	High			No included studies

	JUDGEMENT						
CERTAINTY OF THE EVIDENCE OF TEST RESULT/MANAGEMENT	**Very low**	Low	Moderate	High			No included studies
CERTAINTY OF EFFECTS	**Very low**	Low	Moderate	High			No included studies
VALUES	**Important uncertainty or variability**	Possibly important uncertainty or variability	Probably no important uncertainty or variability	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	**Varies**	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	**Very low**	Low	Moderate	High			No included studies
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	**Varies**	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	Probably yes	Yes		**Varies**	Don't know
FEASIBILITY	No	Probably no	Probably yes	Yes		**Varies**	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	**Conditional recommendation for either the intervention or the comparison**	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	○	●	○	○

CONCLUSIONS

Recommendation

For adult out-of-hospital cardiac arrest, we conditionally recommend that emergency medical service systems may implement termination of resuscitation (TOR) rules to assist clinicians in deciding whether to discontinue resuscitation efforts at the scene or to transport to hospital with ongoing CPR. We suggest that TOR rules may only be implemented following local validation of the TOR rule with acceptable specificity considering local culture, values, and setting (conditional recommendation, very-low certainty evidence).
For pediatric out-of-hospital cardiac arrest because of insufficient evidence, we suggest against the use of TOR rules to decide whether to terminate resuscitation efforts (conditional recommendation, very-low certainty evidence).

Justification

The task force made a conditional recommendation for the use of termination of resuscitation (TOR) rules for adult OHCA in line with the last CoSTR on termination of resuscitation. The values in making this recommendation remain largely unchanged. In making this recommendation, we recognize variation in patient values, resources available, and performance of TOR rules in different settings.
We note that the certainty of evidence is very low and limited by a lack of clinical validation studies. The task force recognizes that application of TOR rules may result in missed survivors but has the potential to reduce variation in practice associated with clinician judgement and prevent premature terminations by clinicians.
We recognize that termination of resuscitation rules are already implemented in some EMS systems. In settings where EMS personnel will transport all patients to the hospital, the use of TOR rules may be associated with reduced costs. In contrast, the potential economic benefit in EMS systems with physician-staffed ambulances competent of terminating CPR may be absent. The task force recognizes that the performance of TOR rules varies depending on the EMS system, the setting, and the survival rate in the population. TOR rules should not be implemented without assessing the local validity of a TOR rule and the validity should be reassessed as survival outcomes change over time.
We considered pediatric OHCA as a separate population, and we value that missed survivors in this population may be valued differently from the adult population. Several missed survivors were seen when applying adult TOR rules to the pediatric population and the two TOR rules derived specifically for the pediatric population remains to be externally validated.

Subgroup considerations

We considered insufficient evidence for use of TOR rules for pediatric patients.

Implementation considerations

We suggest that implementation should be preceded by local validation of the performance of the TOR rule.

Monitoring and evaluation

We suggest that survival rates should be monitored when implementing TOR rules and the performance and appropriateness of TOR rules should be reconsidered as survival rates increase.

Research priorities

There is a paucity of evidence addressing use of TOR rules in clinical practice. Studies are required to address:
· Accuracy of TOR rules in clinical practice
· Compliance with OOH-TOR rules
· Implementation strategies of TOR rules for EMS based on evidence
· Societal perceptions and acceptability of TOR rules
· Validation of TOR rules specific for children
· Impact of TOR rules on non-heart-beating organ donation
· Risk associated with emergent transport of futile cases with ongoing resuscitation

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CPR feedback devices during training (EIT 6404)

Amongst healthcare providers and lay providers, does the use of CPR feedback devices during training, compared with no CPR feedback device, improved quality of CPR?	
POPULATION:	Healthcare providers and lay providers
INTERVENTION:	CPR Feedback device used during resuscitation training
COMPARISON:	No CPR feedback device used during resuscitation training
MAIN OUTCOMES:	Mean compression depth; Depth compliance (Percentage of compression depth meeting guidelines); Mean compression rate; Rate compliance (percentage of compression rate meeting guidelines); Recoil compliance (percentage of compression with complete recoil); Overall compression quality; Overall Excellent Compression (depth, rate, and recoil all meeting guideline)
SETTING:	Any educational setting
PERSPECTIVE:	Chest compression skills are an important component of resuscitation skills training. CPR feedback devices provide immediate, real-time feedback on quality of chest compressions during practice. Use of CPR feedback devices during resuscitation skills training has the potential to enhance CPR skill acquisition and retention.
BACKGROUND:	High-quality CPR is strongly linked to the survival and neurological outcomes of patients experiencing cardiac arrest. Recent scientific statements emphasize an increasing trend in the use of CPR feedback devices during resuscitation training. Current evidence suggests that using CPR feedback devices enhances short-term learning outcomes. However, the impact of incorporating feedback devices during training on the chest compression quality of learners remains uncertain.
CONFLICT OF INTERESTS:	None

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Recent scientific statements highlight a growing trend in the use of CPR feedback devices during resuscitation training courses.(1) While earlier reviews showed that these devices can improve short-term educational outcomes, the results have been inconsistent.(2) Additionally, there is limited evidence on how they affect learners' CPR skills, the cost-effectiveness of training, and, most importantly, patient outcomes. These factors are essential for evaluating their true effectiveness.	

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ● Large ○ Varies ○ Don't know	None of the studies examined the impact of CPR feedback device during resuscitation training on the outcomes of patient survival or quality of performance in actual resuscitation. Three studies were conducted in lay providers(3-5) and 17 in healthcare providers.(6-22) **CPR skills** <u>Compression depth</u> Fifteen randomized controlled trials (RCTs) with a total of 4,185 participants (2,189 in the non-feedback group and 1,996 in the feedback group) evaluated the effect of CPR feedback devices on objectively measured mean compression depth.(3, 4, 6, 8-12, 16-22) The results indicated that participants trained with feedback devices had significantly greater mean compression depth compared to those trained without them (SMD = 0.76, 95% CI: 0.02–1.50, p = 0.04), although there was substantial heterogeneity (I^2 = 94%). Subgroup analysis showed that the effect of feedback device was larger in the healthcare providers (SMD 0.86, 95%CI: 0.01-1.72) than in the lay providers (SMD 0.15, 95%CI: 0.07 – 0.22), but the difference was not statistically significant (p =0.10). (Figure 2) Additionally, 16 RCTs involving 4,304 participants (2,272 in the non-feedback group and 2,032 in the feedback group) examined the effect of CPR feedback devices during resuscitation training on compression depth compliance. (3-5, 7-17, 21, 22) Compression depth compliance was quantitatively measured as the percentage of compressions meeting the resuscitation guidelines during assessment. The results showed that using CPR feedback devices during training had a large impact on depth compliance (SMD = 0.98, 95% CI: 0.10–1.87, p = 0.03, I^2 = 94%). Subgroup analysis showed that the effect of feedback device was larger in the healthcare providers (SMD 1.14, 95%CI: 0.04-2.24) than in the lay providers (SMD 0.17, 95%CI: 0.01 – 0.32), but the difference was not statistically significant (p =0.09). (Figure 3)	

	<u>Compression rate</u> Seventeen randomized controlled trials (RCTs) involving a total of 4,327 participants (2,286 in the non-feedback group and 2,041 in the feedback group) evaluated the effect of CPR feedback devices on objectively measured mean compression rate. (3-6, 8-13, 16-22) The results indicated that participants trained with feedback devices had a significantly lower mean compression rate compared to those trained without them, as participants in the non-feedback group tended to compress too quickly (>120 bpm) (SMD = -0.29, 95% CI: -0.49 to -0.10, $p < 0.01$, $I^2 = 73\%$). Subgroup analysis showed the effect of the feedback device on mean compression rate was not statistically significant between healthcare providers and lay providers ($p = 0.67$). (Figure 4) Additionally, nine RCTs involving 905 participants (460 in the non-feedback group and 445 in the feedback group) examined the effect of CPR feedback devices during resuscitation training on compression rate compliance. (3, 7, 10, 12-15, 21, 22) Compression rate compliance was quantitatively measured as the percentage of compressions within the guideline-recommended rate of 100–120 bpm. The results demonstrated that using CPR feedback devices during training had a substantial impact on rate compliance (SMD = 0.45, 95% CI: 0.23–0.66, $p < 0.01$, $I^2 = 61\%$). Subgroup analysis showed the effect of the feedback device on rate compliance was not statistically significant between healthcare providers and lay providers ($p = 0.80$) (Figure 5) <u>Chest recoil</u> Ten randomized controlled trials (RCTs) involving a total of 3,496 participants (1,803 in the non-feedback group and 1,693 in the feedback group) evaluated the effect of CPR feedback devices during training on chest recoil.(3, 4, 7, 8, 12, 14, 15, 19, 21, 22) Chest recoil was quantitatively measured as the percentage of compressions with full chest recoil. The results demonstrated that using CPR feedback devices during training had a significant impact on recoil compliance (SMD = 0.53, 95% CI: 0.31–0.75, $p < 0.01$, $I^2 = 87\%$). Subgroup analysis showed that the effect of the feedback device on recoil	

	compliance was significantly in the healthcare providers (SMD: 0.67, 95%CI: 0.52-0.82), but not statistically significant in the lay providers (SMD: 0.20, 95%CI: -0.24, 0.64). (Figure 6) <u>Overall quality CPR</u> Eight RCTs involving a total of 3261 participants (1687 in the non-feedback group and 1574 in the feedback group) evaluated the effect of CPR feedback devices on overall CPR quality during resuscitation training. (3, 4, 8, 12-14, 19, 21) Overall quality of CPR was assessed by computer software integrating all three metrics of chest compression (depth, rate and recoil) with limited validity evidence. The results showed that the use of feedback devices significantly improved the overall quality of CPR, with a pooled effect size of 0.71 (95% CI: 0.40–1.05, $p < 0.01$), although heterogeneity was high ($I^2 = 86\%$). Subgroup analysis showed that the effect of the feedback device on the overall CPR score was significantly higher in the healthcare providers (SMD: 0.87, 95%CI: 0.53 – 1.21) than in the lay providers (SMD: 0.33, 95%CI: 0.03 – 0.63), and the difference was statistically significant ($p = 0.02$). (figure 7) Three randomized controlled trials (RCTs) involving a total of 349 participants (178 in the non-feedback group and 171 in the feedback group) evaluated the effect of CPR feedback devices on overall CPR quality during resuscitation training.(15, 17, 20) CPR quality was assessed dichotomously, based on whether compression depth, rate, and recoil all met guideline standards. The results showed that the use of feedback devices significantly improved the overall quality of CPR, with a pooled effect size of 0.19 (95% CI: 0.01–0.38, $p = 0.04$, $I^2 = 78\%$). (Figure 8) *See Appendix 1*	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	None of the studies included in this review reported any detrimental effects from using real-time feedback during CPR.	Although the use of feedback devices was associated with a reduction in chest compression rate, it effectively brought the rate into the guideline-recommended range of 100-120 compressions per

		minute, rather than being too slow (i.e., below 100 compressions per minute).

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ● Moderate ○ High ○ No included studies	Twenty studies examined CPR skills as the outcomes, 8 of which were rated as minor concerns for risk of bias, (3-5, 9, 10, 13, 15, 21) 9 of them with some concerns for risk of bias, (6, 8, 11, 12, 14, 17, 19, 20, 22) and 3 of them with serious concerns for risk of bias.(7, 16, 18) The quality of evidence was moderate for mean compression depth and high for depth compliance, downgraded for risk of bias and inconsistency, but upgraded for strong association. The quality of evidence was weak for mean compression rate, downgraded for risk of bias and inconsistency; the quality of evidence was moderate for rate compliance, downgraded for risk of bias. The quality of evidence was moderate for compression recoil, downgraded for inconsistency. The quality of evidence was high for overall excellent CPR quality, and moderate for CPR quality score, downgraded for inconsistency and indirectness, but upgraded for strong association.	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● No important uncertainty or variability	There is no important uncertainty about how people value the main outcome (i.e. CPR quality)	Clinical performance outcomes (e.g. CPR quality measured during real resuscitation) are desirable but perhaps not the most relevant for this research question due to other possible confounders

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ● Favors the intervention ○ Varies ○ Don't know	All meta-analyses yield significant results favoring intervention. There is no evidence to support undesirable effects.	

Resources required

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate ○ costs Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know	CPR feedback devices are relatively low in cost compared to other material resources required to deliver resuscitation training. No studies directly compared the costs of training with feedback device vs no feedback devices.	It is reasonable to assume that the costs of training with feedback devices are slightly higher than those without. The extent of these cost differences depends on the specific type of feedback devices used.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies directly compared the costs of training with feedback device vs no feedback devices.	

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	One study conducted in Canada reported the cost-effectiveness of distributed CPR training with real-time feedback compared with conventional CPR training and concluded that the intervention is likely more cost-effective than conventional training.(23) However, the intervention of the study is a combination of distributed training and real-time feedback during training. Given the potential confounding factors, the cost-effectiveness of feedback device during training is not conclusive.	

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know	There is no data available evaluating the impact on health equity.	Mandatory use of feedback devices may potentially be a barrier to training in developing world due to extra costs for feedback devices. Fortunately, there are several low-cost options available, which likely make this a minor issue.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	CPR feedback devices have been in use across resuscitation training programs for many years. The growing body of literature on this topic suggests that the intervention is acceptable to key stakeholders.	

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	CPR feedback devices have been in use across resuscitation training programs for many years, suggesting that it is easy to implement in resuscitation training programs.	

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	Moderate	**Large**		Varies	Don't know
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	Low	**Moderate**	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	Probably no important uncertainty or variability	**No important uncertainty or variability**			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	**Probably no impact**	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	**Strong recommendation for the intervention**
○	○	○	○	●

CONCLUSIONS

Recommendation

We recommend the use of CPR feedback devices during resuscitation training for healthcare providers and lay providers (Strong recommendation, moderate certainty of evidence).

Justification

Overall Justification
In the meta-analyses, we found the results strongly favor the use of feedback devices during training across all CPR quality outcomes.
Detailed justification
Desirable Effects
In the meta-analyses, we found the results favor the use of feedback devices during training in all CPR quality outcomes.
Undesirable Effects
No undesirable effects were detected in this review.
Certainty of evidence
Certainty of evidence for most of the metrics was moderate to high.

Subgroup considerations

Subgroup analyses showed that using feedback devices during resuscitation improves CPR quality for both healthcare providers and laypersons, with a larger effect size observed among healthcare providers.

Implementation considerations

When implementing CPR feedback devices during resuscitation training, instructors should be familiar with proper use of the device and aim to integrate device use into both CPR practice sessions and simulated clinical scenarios (when applicable). Course participants should receive an orientation of device use and how to adjust chest compressions based on device feedback. When possible, use of CPR feedback devices during training should be coupled with CPR Coaching.

Monitoring and evaluation

Not applicable

Research priorities

We identified several research gaps
- The relative and synergistic effect of feedback device use when combined with other educational strategies and instructional design features is unclear.
- Further studies exploring CPR skill retention and transfer of CPR skills to the real clinical environment (e.g. CPR quality during real cardiac arrest) would further clarify the true effectiveness of CPR feedback device use during training.
- The costs associated with implementing feedback devices during resuscitation training, as well as its cost effectiveness needs to be explored further.

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Appendix 1

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects* (95% CI)	
				Risk with No CPR feedback device used during resuscitation training	Risk difference with CPR Feedback device used during resuscitation training
Mean compression depth	4185 (15 RCTs)	⨁⨁⨁◯ Moderate[a,b]	-	The mean of mean compression depth was **0** SD	SMD **0.76 SD higher** (0.02 higher to 1.50 higher)
Depth compliance (Percentage of compression depth meeting guidelines)	4304 (16 RCTs)	⨁⨁⨁⨁ High[a,b]	-	The mean depth compliance (Percentage of compression depth meeting guidelines) was **0** SD	SMD **0.98 SD higher** (0.1 higher to 1.87 higher)
Mean compression rate	4327 (17 RCTs)	⨁⨁⨁◯ Moderate [a]	-	The mean of mean compression rate was **0** SD	SMD **0.29 SD lower** (0.49 lower to 0.1 lower)
Rate compliance (percentage of compression rate meeting guidelines)	905 (9 RCTs)	⨁⨁⨁◯ Moderate [c]	-	The mean rate compliance (percentage of compression rate meeting guidelines) was **0** SD	SMD **0.44 SD higher** (0.23 higher to 0.66 higher)
Recoil compliance (percentage of compression with complete recoil)	3944 (10 RCTs)	⨁⨁⨁◯ Moderate [c]	-	The mean recoil compliance (percentage of compression with complete recoil) was **0** SD	SMD **0.53 SD higher** (0.31 higher to 0.75 higher)
Overall compression quality assessed with computer software	3261 (8 RCTs)	⨁⨁⨁◯ Moderate[b,d]	-	The mean overall compression quality was **0** SD	SMD **0.71 SD higher** (0.40 higher to 1.03 higher)
Overall Excellent Compression (depth, rate, and recoil all meeting guideline)	349 (3 RCTs)	⨁⨁⨁⨁ High	not estimable	Study population	
				32 per 100	**19 more per 100** (1 more to 38 more)

a. 2 studies with serious risk of bias concerns.
b. High heterogeneity
c. 1 study with serious risk of bias concern
d. Lack of strong validity evidence for the outcome measure

CPR self-instruction vs instructor guided (EIT 6406)

Should Self-directed digital CPR training vs. Instructor-led CPR training be used for Adults and children undertaking CPR training?	
POPULATION:	Adults and children undertaking CPR training
INTERVENTION:	Self-directed digital CPR training
COMPARISON:	Instructor-led CPR training
MAIN OUTCOMES:	Patient outcomes: Good neurological outcome at hospital discharge/30-days; Survival at hospital discharge/30-days; Return of spontaneous circulation (ROSC); Rates of bystander CPR; Bystander CPR quality during an OHCA (any available CPR metrics); Rates of automated external defibrillator (AED) use. Educational outcomes at the end of training and within 12 months: CPR quality (chest compression depth and rate; chest compression fraction; full chest recoil, hand position, ventilation rate) and AED competency; CPR and AED knowledge; Confidence and willingness to perform CPR.
SETTING:	Any
BACKGROUND:	Bystander CPR more than doubles the chance of surviving an out-of-hospital cardiac arrest (OHCA). CPR and AED training is known to improve the willingness and confidence in someone performing bystander CPR. Little is known about whether self-directed digital CPR training is superior to instructor-led training in developing sufficient skills to provide adequate CPR.
CONFLICT OF INTERESTS:	The following Task Force members declared an intellectual conflict of interest and this was acknowledged and managed by the Task Force Chairs and Conflict of Interest committees: Andrew Lockey, Joyce Yeung, and Robert Greif.

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Out-of-hospital cardiac arrest (OHCA) is a significant cause of death. Given the recent pandemic, with issues in attending training, the EIT Task Force considered this question a priority. Two related PICOS were performed as part of the 2015 ILCOR review: # 647 (CPR instruction methods: self-instruction versus traditional) and #651 (AED training methods). A significant number of RCTs on this topic have been conducted since that time.	Access to digital self-direct training is important during periods where access to training can be limited e.g. pandemics, low-resource settings, or when geographical barriers exist because 1) more OHCA occur in the home and 2) access to instructor-led training may not be possible or is restricted.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Patient outcomes** No studies were identified reporting on the subsequent use of skills and patient outcomes. **Educational outcomes (CPR, AED skills, knowledge, confidence and willingness)** Educational outcomes of CPR quality, automated external defibrillator (AED) use, knowledge, confidence and willingness were examined in 29 RCTs.(1-29) For CPR quality there was 27 studies(1-4, 6-19, 21-29), AED use (10 studies(2, 5, 6, 9, 18, 20-22, 24, 25), knowledge (7 studies(7, 12, 17, 23, 24, 26, 27)), confidence (10 studies(1, 10, 12-14, 16, 18, 20, 22, 29)) and willingness (6 studies(4, 14, 16, 18-20)). 25 studies tested participants immediately to <1 month(1, 3-13, 15-25, 28, 29), three studies conducted their first assessment at delayed intervals (4 months(14); 6 months (2) and between 2-6 months(26)) and 11 studies conducted follow-up testing between one to six months after training(3, 5, 8, 11, 12, 20, 22-24, 28, 29). Significant heterogeneity exists across all the studies in population, interventions, comparators, outcomes and measurement methods precluding any pooling of data or meta-analysis. For the important CPR skills outcome of compression rate we found 15 studies. (1, 3, 4, 6, 9, 11, 13, 18, 19, 21, 22, 25, 27-29) Eleven studies showed no difference between the self-directed digital training versus instructor-led training(1, 3, 4, 6, 9, 13, 19, 21, 22, 28, 29), favored instructor-led training three studies(11, 18, 25); and favored self-directed digital training in two studies(11, 27) (low certainty of evidence downgraded for risk of bias and indirectness). For the important CPR skills outcome of compression depth we found 15 studies(1, 3, 4, 6, 8, 9, 11, 15, 18, 21, 22, 24, 27-29). Ten of these studies found no difference between self-directed digital training versus instructor-led training(1, 3, 6, 8, 9, 11, 15, 22, 27, 28), six studies favored instructor-led training(4, 11, 18, 21, 24, 29) and one study favored self-directed digital training(9) (very low certainty of evidence, downgraded for serious risk of bias, inconsistency, and indirectness). For the important CPR skills outcome of chest compression fraction we found four studies, (1, 3,	The significant variation in all aspects of the studies limits in-depth interpretation. Despite most outcomes demonstrating no difference between the groups (potentially suggesting a trivial effect), the population are still receiving the educational outcomes. Therefore, the desirable effects are listed as moderate.

	21, 29) with three finding no difference between self-directed digital training versus instructor-led training(1, 3, 29) and one favoring instructor-led training(21). For the important outcome of chest recoil we found five studies(1, 9, 18, 21, 22) with two studies finding no difference between self-directed digital training versus instructor-led training(1, 22), two favoring self-directed digital training(9, 18) and one favoring instructor-led training(21) (very low certainty of evidence downgraded for very serious inconsistency and serious risk of bias, indirectness and imprecision). For the important CPR skills outcome of hand position 14 studies were identified(1, 4, 6, 8, 9, 11, 15, 18, 19, 22, 24, 25, 27, 28). Nine studies found no difference between self-directed digital training versus instructor-led training,(1, 6, 9, 11, 18, 22, 25, 27, 28) four studies favored instructor-led training (4, 8, 19, 24) and two studies favoured self-directed digital training(11, 15). (Very low certainty of evidence downgraded for very serious risk of bias, indirectness and imprecision). For the important CPR skills outcome of ventilation rate seven studies were identified and all found no difference between self-directed digital training versus instructor-led training(4, 6, 8, 9, 13, 22, 27)(low certainty of evidence downgraded for serious risk of bias and imprecision). For the important AED skills outcome eight studies were identified,(5, 6, 9, 20-22, 24, 25) with five identifying no difference between self-directed digital training versus instructor-led training(9, 20, 22, 24, 25) and three studies favored instructor-led training(5, 6, 21) (very low certainty of evidence downgraded for very low for serious risk of bias, indirectness and imprecision). For the important outcome of knowledge, six studies were identified(7, 12, 17, 23, 24, 27). Three studies found no difference between self-directed digital training versus instructor-led training,(17, 23, 27) two studies favored instructor-led training(7, 12) and one study favored self-directed digital training(23) (very low certainty of evidence (downgraded for very serious risk of bias and inconsistency, and serious indirectness and imprecision). For the important outcome of confidence, nine studies were identified(1, 10, 12, 13, 16, 18, 20, 22, 29). Five studies found no difference between self-directed digital training versus instructor-led training(13, 16, 18, 20, 29), three studies favored instructor-led training(10, 12, 22) and one study	

	favored self-directed digital training(1) (very low certainty of evidence downgraded for very serious risk of bias, indirectness and imprecision). For the important outcome of willingness, five studies were identified and all found no difference between self-directed digital training versus instructor-led training(4, 16, 18-20) (very low certainty of evidence downgraded for very serious indirectness and serious risk of bias and imprecision).	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	Some studies showed a statistical difference for chest compression depth favouring instructor-led training. However, it is difficult to know how clinically significant these differences were, because in some studies compression depth was low in both groups and most differences were marginal. Furthermore: • Use of feedback devices for compression depth varied widely. • Manikins vary with respect to the maximum allowable depth (e.g. some allow compressions beyond depth guidelines, while others do not), force required to generate guideline compliant depth (i.e. resistance), and chest size.	

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	The overall certainty of evidence was very low for this study.	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	There is little uncertainty or variability in how much people value the main outcomes. However, there was significant uncertainty in the findings from the studies included in this review due to the vast heterogeneity in all aspects of the study methodologies.	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	As shown in the Desirable Effects section, for each outcome, the vast majority of findings do not favor either the intervention or comparison irrespective of the significant heterogeneity in all aspects of the study methodologies.	

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	One study(4) compared costs to users and determined digital self-directed learning to be more expensive –but this included the costs of purchasing a separate manikin (which is now sold as part of video kits) and assessment. Van Raemdonck used low-cost tools instead of manikins to conduct CPR training and identified an ability to train many people at some expense to the quality of skills produced.(28) Digital training requires viewing equipment and the cost of training materials. Video-kits with manikins are generally cheap and comparable in costs to instructor-led classes. Most currently available digital training allows free multiple viewings, viewing at the learners convenience, the potential for training others (e.g. kits trained 2.5 people), and free retraining. Instructor-led training resources include personnel, space and equipment. Learner's time and travel costs to classes.	Some of the digital resources may have a high initial cost, however, they can be reused and may be more economical in the long run, particularly when factoring in events such as the COVID-19 pandemic.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	Across all outcomes there was low, or very low certainty of evidence.	Some of the digital resources may have a high initial cost, however, they can be reused and may be more economical in the long run, particularly when factoring in events such as the COVID-19 pandemic.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ No included studies	Hasselager(10) reported a cost-effectiveness analyses of video CPR training with an infant manikin (clicker feedback). They accounted for participant time costs, cleaning, equipment and instructor time) Each 10,000 USD spent: 233 laypersons trained using self-directed digital training and 71 will be competent after training. For instructor-led training, 109 can be trained and 65 will be competent. They identified self-directed digital training to be more cost effective than instructor-led training, but less effective.(10)	Digital self-training is becoming cheaper and can allow for free re-training and provide opportunities to train others.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	The convenience and accessibility of digital self-directed training is likely to be more equitable than instructor-led training.	

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Digital training methods scored higher by participants for acceptability(1, 2).	

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Most people have access to equipment to view digital training. Many self-directed kits can be mailed or made digitally accessible.	

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	Small	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	**Does not favor either the intervention or the comparison**	Probably favors the intervention	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	**Negligible costs and savings**	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	**Very low**	Low	Moderate	High			No included studies
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	**Conditional recommendation for either the intervention or the comparison**	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	○	●	○	○

CONCLUSIONS

Recommendation

We suggest the use of either instructor-led training or self-directed digital training with for the acquisition of CPR or AED skills in lay-adults and high school aged (>10 years) children (weak recommendation, very low quality of evidence).

We suggest self-directed digital training be used when instructor-led training is not accessible, or when quantity over quality of CPR training is needed in adults and children (weak recommendation, very low quality of evidence).

There was insufficient evidence to make a recommendation on game-in-film, virtual reality, computer programs, online tutorials or app-based training as a CPR or AED training method.

Justification

In making these recommendations the Education, Implementation and Teams (EIT) considered the following:

- Significant variation in all aspects of the study methodologies exists and therefore limits definitive recommendations.
- That any form of CPR/AED training is likely improve knowledge, confidence and willingness in simulated settings, however, this may not translate to real-life situations.
- Cost-effectiveness analysis performed typically favored digital-training(10, 28). Instructor-led classes require human resources, organization, location and equipment.
- Acquisition of different CPR skills may vary across different mediums and age groups.
- The known barriers that exist to attend instructor-led CPR classes (e.g. time, costs, and accessibility) and the need to make CPR training available to everyone.
- The need and ease for updating digital and instructor-led materials to ensure training complies with CPR recommendations.
- Digital training allows skills to be refreshed at any time, and at no additional cost, and provide the opportunity to teach others.
- Digital training enables more people to be educated in periods of need (e.g. pandemics).

Subgroup considerations

No consideration has been given to subgroups in arriving at the treatment recommendations, however future research should consider population differences as well as resourcing and setting factors.

Implementation considerations

The initial cost of developing self-directed digital training may be large, however over time, this may prove to be a more economical means of delivering CPR and AED education to large populations.

Monitoring and evaluation

Ongoing monitoring of self-directed CPR and AED digital education methods should occur and future studies should compare these interventions to standardised accepted instructor-led training programmes to determine their efficacy.

Research priorities

Future research should focus on standardised outcome measures to allowing for pooling of data. Comparator groups should be aligned using standardised, accepted instructor-led training programmes to reduce inconsistency and uncertainty. Future research should also investigate the ability of these interventions and comparators to produce findings that meet accepted standards for adequate CPR that are maintained at defined time intervals. Regarding specific self-directed digital interventions, further research is required for methods such as game-in-film, virtual reality, computer programmes, online tutorials or app-based training to determine their effectiveness. Finally, the treatment effect on bystander CPR rates and patient outcomes needs to be included in future research.

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Should In situ simulation-based training vs. Traditional traininig be used for Cardiopulmonary resuscitation training?	
POPULATION:	Cardiopulmonary resuscitation training
INTERVENTION:	In situ simulation-based training
COMPARISON:	Traditional training
MAIN OUTCOMES:	Patient survival; Patient outcomes; Clinical performance in actual resuscitation; Teamwork competencies in actual resuscitation at course completion <1yr ; Clinical performance in simulation; Teamwork competencies in simulation at course completion <1yr ; CPR skill performance in simulation at course completion; Resource; CPR skill performance in actual resuscitation;
SETTING:	Educational setting
PERSPECTIVE:	
BACKGROUND:	Simulation-based learning is a widely accepted educational strategy used in courses to train cardiopulmonary resuscitation. Traditionally, such courses are performed in classrooms or laboratories specifically equipped with mannequins, monitoring simulators and equipment needed for running cardiac arrest scenarios. For logistic reasons, these placed are usually located in places outside the areas dedicated to patients care. Providing such training *within* the specific areas dedicated to patient care have, theoretical advantages: • The learning experience may be facilitated by the context where the experience is taking place ("situativity theory"); • Training *in situ* may help in experiencing the interaction with the environment and organizational characteristics. This may help dealing with obstacles and barriers, improving team performance and non-technical skills. Previous Evidence updates (2020, 2021, 2022) did not find sufficient evidence to issue a treatment recommendation. Considering newly published evidence and the potential impact on the quality of training and the subsequent effect on patient outcomes, the TF decided to perform a formal systematic review for the 2025 CoSTR cycle.
CONFLICT OF INTERESTS:	

ASSESSMENT

Problem
Is the problem a priority?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	No evidence was identified on the priority of this question.	Simulation-based learning is a widely accepted educational strategy used in courses of cardiopulmonary resuscitation. Traditionally, such courses are performed in classrooms or laboratories specifically equipped with mannequins, monitoring simulators and equipment needed for running cardiac arrest scenarios. For logistic reasons, these training

		locations are usually located in places outside the areas dedicated to patients care. Providing such training *within* the specific areas dedicated to patient care may have theoretical advantages.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Patient survival** For the critical outcome of patient survival we found one non-randomised study (**Knight 2013**) that reported an association between the post-intervention period and higher unadjusted odds of survival at hospital discharge [OR, 2.06 (95% CI, 1.02-4.25). **Patient outcomes** For the critical outcome of patient outcomes we found one non-randomised study (**Xu 2023**) reporting lower incidence of neonatal asphyxia [88 (0.64%) vs. 133 (0.84%), P=.045], severe asphyxia [8 (0.058%) vs. 22 (0.138%), p =.029], hypoxic-ischemic encephalopathy [2 (0.01%) vs. 16 (0.1%), p = 0.003], and meconium aspiration syndrome [12 (0.09%) vs. 31 (0.19%), p = .014] in the after arm but no difference in the composite outcome of neonatal asphyxia or low apgar score [111 (0.8%) vs. 154 (0.97%), p = .128], and low Apgar score [23 (0.17%) vs. 21 (0.13%), p = .445]. This outcome was not presente in the PICOST but was eventually considered after the inclusion/exclusion process by TF consensus. **Clinical performance in actual resuscitation** For the critical outcome of clinical performance in actual resucutation outcomes. we found three non-randomised studies. One non-randomised before-after study (**Knight 2013**) reported no significant difference in neurologic morbidity from admission to discharge assessed by pediatric cerebral performance category in the intervention group (0.11 vs 0.27; p = 0.37), no significant improvement in performance of chest compressions < 60 s from heart rate < 60 s [OR, 0.63 (95% CI, 0.29-1.35)], significant improvement in Performance	

	of 2 min continuous chest compressions between rhythm checks [OR, 2.23 (95% CI, 1.18-4.22] and no significant difference in the performance of shock < 3 min from recognized ventricular fibrillation/pulseless ventricular tachycardia [OR, 1.51 (95% CI, 0.38-5.96)]. One nonrandomised before-after study (**Herbers 2016**) reported improved time for calling for help by 12% between baseline and final evaluation, improved time elapsed by initiation of chest compressions by 52% and improved time to initial defibrillation 37%. One non-randomised before-after study (**Hammontree 2022**) reported nonadherence to PALS guidelines for subsequent epinephrine timing decreased by 39% and nonsignificant difference behaviors of administering epinephrine every 3 to 5 min (p = .30). **Teamwork competencies in actual resuscitation at course completion <1yr** For the important outcome teamwork competencies in actual resuscitation at course completion <1yr we found one relevant non-randomised study. This study (**Knight 2013**) reported higher adherence to resuscitation standard operating performance as measure of pediatric code team performance in the after arm [38/183 (20.8%) (23/64 (35.9); OR 2.14 (95% CI, 1.15-3.99)]. **Clinical performance in simulation** For the important outcome of clinical performance in simulation outcomes we found four RCTs and one non-ranomised study. One RCT (**Kurosawa 2014**) reported improved skill performance measured by the clinical perforance tool [6.2 (± 4.3) vs (± 2.9); p = 0.004]. One RCT (**Sullivan 2014**) compared different intervention groups involving in situ simulation training sessions performed at different follow-ups compared to standard training. This RCT reported shorted time elapse to call for help and initiation of chest compression in the intervention groups vs. control (p < 0.001), time elapse to successful defibrillation (p < 0.001) and better score in the composite outcome of key priorities, compressions within 20 s defibrillation within 180 s and use of a backboard (p < 0.001). One RCT (**Gurung 2015**) reported better technical score	

	assessing technical skills and adherence to guidelines in the two simulation scenarios in the intervention group [Scenario 1 17.4 (15.6–19.5), vs. 24.4 (18.7–26.6), p= .01); Scenario 2 17.5 (15.3–19.6) vs. 22.7 (21.3–25.0), p= .004], lower occurrence of hazardous events in the intervention group [23 (8%) vs. 52 (21%), P=<0.001], higher percentage of scenarios in which the heart rate was considered as the result of efficient resuscitation at 3 minutes [14 (24%) vs. 2 (4%), =.003] and 5 minutes [40 (68%) vs. 25 (47%), P= .06]. One RCT (**Mei 2023**) reported better medical management test in the intervention group [57.09 (±9.18) vs. 38.47 (±15.69), p < 0.001]. One non-randomised study (**Clarke 2018**) reported no difference through the course of in situ mock code training in time to first epinephrine dosing and time to first defibrillation). **Teamwork competencies in simulation at course completion <1yr** For the important outcome of teamwork competencies in simulation at course completion <1yr we found three relevant RCTs. One RCT (**Kurosawa 2014**) reported no difference in teamwork assessed by the Behavioral Assessment Score in the intervention group [2.8 (± 3.6) vs. 3.0 (± 4.0); p: 0.69]. One RCT (**Gurung 2015**) reported better team performance score in the intervention group [31.1 (20.8–36.8) vs. 19.9 (13.3–25.0); p<.001]. Another RCT (**Mei 2023**) reported better teamwork in the intervention group [10.84 (±3.26) vs 7.87 (±4.14), p < 0.001]. **CPR skill performance in smulation at course completition** For the important outcome of CPR skill performance in simulation at course completition we found one non-randomised study (**Clarke 2018**). This study evaluated CPR fraction as measure of skill and found an improved overall trend of 1.8% per time interval of training (p = .02). **Resources** For the important outcome of resources, we found no studies.	

	CPR skill performance in actual resuscitation For the important outcome of CPR skill performance in actual resuscitation, we found no studies.	

Undesirable Effects
How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ○ Large ○ Varies ● Don't know	No data on Resources including costs, equipment, time needed, and workload.	In situ simulation may be associated with a higher workload, more time needed for the organization of the training course, potential disruption of clinical schedules, and direct and indirect costs compared to traditional training performed in dedicated simulation labs or centers.

Certainty of evidence
What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	Certainty of evidence for all outcomes was rated very low due to risk of bias, inconsistency, and imprecision.	

Values
Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	There is no specific evidence of the variability in the value of the main outcomes.	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Most included studies reported advantages in terms of effectiveness towards our relevant outcomes, including the critical outcome of patient survival, patient outcomes, clinical performance in actual resuscitation, and teamwork competencies in actual resuscitation. However, no undesirable effects have been measured as outcomes in the included studies.	

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● Don't know	No data from included studies.	Resources is one important outcome of this Systematic review. We found no data. This outcome is relevant due to the potential higher need for resources for managing in situ simulation programs compared to traditional training for cardiopulmonary resuscitation.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No data from included studies	

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	No data from included studies	In situ simulation may have direct and indirect costs that have not been evaluated in included studies.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ● Don't know	We found no evidence	

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	We found no evidence on acceptability.	Simulation is part of the standard training for cardiopulmonary resuscitation. In situ simulation may have theoretical advantages since the learning experience may be facilitated by the context. This may help dealing with obstacles and barriers. For this reasons acceptability may be high.

Feasibility Is the intervention feasible to implement?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	We found nine studies and others have been excluded for not being in line with our PICOST. This may support the feasibility of the intervention. However, no study reported data on resources needed, costs, and workload. Indeed, most of the included studies are from the USA and no data are available from low-income countries.	In situ simulation for cardiopulmonary resuscitation training in adult, pediatric and newborn seems to be widely adopted. However, feasibility in centers with unfavourable balance between clinical workload and resources is uncertainty.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	Small	Moderate	Large		Varies	**Don't know**
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	Varies	**Don't know**
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention	Probably favors the intervention	Favors the intervention	Varies	**No included studies**

	JUDGEMENT						
			or the comparison				
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	Probably yes	Yes		Varies	**Don't know**

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

We recommend that in situ simulation may be considered as an option for cardiopulmonary resuscitation training where resources are readily available (weak recommendation, very low–certainty evidence).

Justification

We found data from RCTs and non-randomised studies that show the effectiveness of in situ simulation for cardiopulmonary resuscitation towards relevant outcomes, including the critical outcomes of patient survival, patient outcomes, clinical performance in actual resuscitation and teamwork competencies in actual resuscitation.

The certainty of evidence is very low for all evaluated outcomes due to risk of bias of included studies, inconsistency, and imprecision.

The balance between the benefit and the resources needed may be favorable, especially when critical outcomes are considered.

Subgroup considerations

We included studies that evaluate in situ simulation-based training in the context of adult (four), pediatric (three), or neonatal (two) cardiopulmonary resuscitation training and there is evidence of effectiveness in all. Of note, the only study included for the critical outcome of patient survival evaluated in situ simulation in the context of cardiopulmonary resuscitation training in the pediatric setting. Since we did not perform meta-analysis due to very high heterogeneity in the interventions and outcome definitions, formal subgroup analysis according to the type of cardiopulmonary resuscitation training (i.e. BLS, ACLS, PALS, NLS) could not be done. Further research may identify training settings that benefit the most.

Implementation considerations

Although in situ simulation is widely implemented, we found no data on the important outcome of Resources that includes direct and indirect costs, workload, equipment needed. Moreover, most of the included studies are from USA and none from low-income countries.

Monitoring and evaluation

No monitoring needed.

Research priorities

We found only one non-randomised study reporting data on the association between the intervention and patient survival. High-quality evidence on the effectiveness of in situ simulation for cardiopulmonary resuscitation towards patient survival after cardiac arrest at different ages is needed.

We found several before-after or longitudinal studies, Evidence from parallel-group randomized controlled trials is needed to isolate the effect of the intervention from confounders.

We were unable to evaluate if the type of cardiopulmonary resuscitation training (adult, pediatric, neonatal) or the role of the participants in the training (physicians, nurses, midwives, students) act as effect modifiers in the association between the interventions and the outcomes of interests. Further research should evaluate if the effectiveness of in situ simulation varies in different training contexts.

We found high heterogeneity in terms of the characteristics of the interventions. Further research should define the minimal standard for in situ simulation and explore characteristics of the training in the setting of cardiopulmonary resuscitation.

There is a need to define the cost-effectiveness of in situ simulation-based training since no data are available on resources, costs, and workload compared to standard cardiopulmonary resuscitation training.

Further studies should report data on feasibility in low and middle-income countries.

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Manikin fidelity in resuscitation education (EIT 6410)

Should higher fidelity manikins vs. lower fidelity manikins be used for life support education?	
POPULATION:	**For participants undertaking basic and advanced life support training in an education setting**
INTERVENTION:	Use of high-fidelity manikins
COMPARISON:	Use of low-fidelity manikins
MAIN OUTCOMES:	Patient outcomes, change skill performance in actual resuscitations, change skill/knowledge at 1 year, skill/knowledge at time between course conclusion and 1 year, skill/knowledge at course conclusion; learner confidence, learner preference, cost/resource utilization?
SETTING:	Life support education settings
PERSPECTIVE:	This research question is conducted from the perspective of life support training learners (either laypeople or healthcare professionals) as well as life support instructors and training centers with a goal of optimizing the realism, and hence the engagement and educational effectiveness, of the physical devices used in training.
BACKGROUND:	Higher fidelity manikins have physical features that make them more realistically resemble actual patients, including changes in simulated physical states and pathophysiology. A greater degree of realism during life support training may enhance learner engagement and make it easier for them to 'suspend disbelief'. Previous published evidence suggests that higher fidelity manikins may be associated with better clinical performance at course conclusion. However, using higher fidelity manikins depends on the availability of resources to purchase, properly implement, and maintain them; additionally, center require trained personnel who can operate such manikins.
CONFLICT OF INTERESTS:	Members of the review team were first authors and/or co-authors of two of the included studies; those individuals were recused from any data extraction or risk of bias assessment on their own studies. Additionally, the previous publication summarizing the 2015 ILCOR systematic review on this topic was authored by two review team members; the assessment of that systematic review for inclusion (via AMSTAR-2) was performed by two other review team members.

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Higher fidelity in simulation may be associated with a greater degree of engagement and "suspension of disbelief"	Simulating a cardiac arrest victim does not require any physical features to be present. Cost and resources (material and personnel) are necessary to implement properly.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	Meta-analysis of available studies found a slight benefit in clinical performance at course conclusion with higher fidelity manikins Meta-analysis of available studies found no significant effect on knowledge at course conclusion Most studies reporting on affective responses (confidence, learner preference) found positive findings	No studies demonstrated a negative effect of higher fidelity simulation on educational outcomes. Few studies examined longer-term impact (i.e. skill or knowledge retention). No studies reported on patient outcomes

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ○ Moderate ○ Large ○ Varies ● Don't know	No studies demonstrated a negative effect of higher fidelity simulation on educational outcomes Learners generally expressed favorable responses to questions about higher fidelity simulation's effectiveness	No studies balanced the impact of fidelity with the cost of equipment, instructor training, and infrastructure maintenance involved with higher fidelity

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	Six out of seven selected outcomes exhibited very low certainty evidence, based on risk of bias, inconsistency, and imprecision Both meta-analyses (skill at course conclusion, knowledge at course conclusion) demonstrated very high degree of heterogeneity	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no		

important uncertainty or variability ● No important uncertainty or variability		

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	While results were mixed for all outcomes, there was a significant increase in clinical performance at course conclusion as a positive outcome from one meta-analysis	Cost, training, personnel, and infrastructure are very important logistical considerations that could amount to obstacles to implementation; none of those phenomena were directly studied

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● Don't know	No studies examined cost or savings with regard to higher fidelity manikin use	Most of the manikins used in the included studies require electricity and/or connection to a computer interface. Additionally, instructors and facilitators need to be trained in their use and maintenance.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies		Even if detailed data from research studies are missing, there are definitively increased costs with the use of high fidelity manikins for resuscitation training.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies		Increased cost is implied with high-fidelity manikins, but we have no data on that.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ● Don't know	No studies examined issues of equity directly	The inability to utilize high fidelity simulation based on cost and/or availability could amount to a source of inequity.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Among the included studies, the responses from learners were generally favorable	No studies examined responses from simulation instructors or facilitators with regard to ease of use, etc.

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	No studies examined implementation directly	Implementation of high fidelity simulators involves cost, available infrastructure (e.g. space, computer support, etc.) and trained instructors and facilitators

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	**Probably yes**	Yes		Varies	Don't know
DESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	Small	Moderate	Large		Varies	**Don't know**
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	Probably no important uncertainty or variability	**No important uncertainty or variability**			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	Varies	**Don't know**
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	Probably yes	Yes		Varies	**Don't know**

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	**Conditional recommendation for the intervention**	Strong recommendation for the intervention
○	○	○	●	○

CONCLUSIONS

Recommendation

We suggest the use of high-fidelity manikins when training centers/organizations have the infrastructure, trained personnel, and resources to use them (weak recommendations based on very-low-quality evidence).

If high-fidelity manikins are not available, we suggest that the use of low-fidelity manikins is acceptable for standard life support training in an educational setting (weak recommendations based on low-quality evidence).

Justification

A majority of studies found a positive impact on skill and/or knowledge at course conclusion. There were no studies that demonstrated a negative effect of higher fidelity manikins on educational outcomes. Given that resource utilization and cost were not directly studied, along with the fact that higher fidelity manikins are likely more expensive to obtain and maintain, we limit our recommendation to centers where these resources are available.

Four RCTs were identified that demonstrated improvement from pre- to post- training in all subject groups, irrespective of what level of fidelity of manikin was used for training. These studies are the basis of the second recommendation above (that low fidelity manikins are acceptable for training).

Subgroup considerations

Implementation considerations

No studies reported on cost or on resources needed to implement higher fidelity manikins. Our recommendation is predicated on the higher fidelity manikins being used in a setting with appropriate space, infrastructure, personnel, and resources to use them properly. Educational settings where these resources are less available might make implementation difficult.

Monitoring and evaluation

Research priorities

- Cost-effectiveness and implementation studies
- Studies examining longer term educational outcomes (skill and/or knowledge retention and/or decay)
- Specific simulation features that are most associated with improved learning
- Translational research from simulation to actual patient care processes and patient outcomes