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| Question | |
| **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:** | None |

# Assessment

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| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know | Despite no evidence on the priority of this question was identified the use of in-situ simulation became popular, even so the evidence in in-situ simulation was poor. Therefore, a systematic review on the recent published data might get clarity about the value on its use in education resuscitation. | 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. |
| 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 identified one non-randomised prospective observational study with historical controls (1) reporting an association between the in situ simulation period and higher odds of survival at hospital discharge in pediatric patients who experience cardiac arrest [50/124 (40.3%) pre-intervention period vs. 28/46 (60.9%) post-intervention period; OR, 2.06 (95% CI, 1.02-4.25)].  **Patient outcomes**  For the critical outcome of patient outcomes we found one non-randomised study (2) reporting in the post intervention (in situ simulation) vs. pre-intervention period a 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 = 0.014] but no difference in the composite outcome of neonatal asphyxia or low apgar score [111 (0.8%) vs. 154 (0.97%), p = 0.128], and low Apgar score [23 (0.17%) vs. 21 (0.13%), p = 0.445].  **Clinical performance in actual resuscitation**  For the critical outcome of clinical performance in actual resuscitation outcomes, we found three non-randomised studies. One non-randomised before-after study (1) 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 the 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)] between the in situ simulation period vs. control. One non-randomised before-after study (3) 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% between the in situ simulation period vs. control. One non-randomised before-after study (4) reported non-adherence to PALS guidelines for subsequent epinephrine timing decreased by 39% and non-significant difference behaviors of administering epinephrine every 3 to 5 min (p = 0.30).  **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 (1) reported higher adherence to resuscitation standard operating performance as a measure of pediatric code team performance in the in situ simulation period [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-randomised study. One RCT (5) reported improved skill performance measured by the clinical performance tool [6.2 (± 4.3) vs (± 2.9); p = 0.004]. One RCT (6) 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 (7) reported better technical score assessing technical skills and adherence to guidelines in the two simulation scenarios in the in situ simulation group vs. control [Scenario I: 24.4 (18.7–26.6) vs. 17.4 (15.6–19.5), p= .01); Scenario II: 22.7 (21.3–25.0) vs. 17.5 (15.3–19.6), p=0.004], lower occurrence of hazardous events in the in situ simulation group vs. control [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%), =0.003] and 5 minutes [40 (68%) vs. 25 (47%), P= 0.06] in the in situ simulation group. vs. control. One RCT (8) reported better medical management test in the in situ simulation group vs. control [57.09 (±9.18) vs. 38.47 (±15.69), p < 0.001]. One non-randomised study (9) 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 (5) 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 (7) reported better team performance score in the in situ simulation group [31.1 (20.8–36.8) vs. 19.9 (13.3–25.0); p<0.001]. Another RCT (8) reported better teamwork in the in situ simulation group vs. control [10.84 (±3.26) vs 7.87 (±4.14), p < 0.001].  **CPR skill performance in simulation at course completion**  For the important outcome of CPR skill performance in simulation at course completion we found one non-randomised study (9). This study evaluated CPR fraction as measure of skill and found an improved overall trend of 1.8% per time interval of training (p = 0.02).  **Resources**  For the important outcome of resources, we did not find any study.  **CPR skill performance in actual resuscitation**  For the important outcome of CPR skill performance in actual resuscitation, we did not find any study. | The clinical patients’ outcome of the neonatal study was not presented in the original PICOST but was eventually considered after the inclusion/exclusion process by TF consensus.  The TF also decided to report the outcome of clinical performance and teamwork competencies outcomes during resuscitation separately from those only measured during simulations. |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ○ Small ○ Moderate ○ Large ○ Varies ● Don't know | No data was reported 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. However, we found data from included studies on patient survival, patients outcomes and clinical performance and teamwork competencies in actual resuscitation in favor of in situ simulation. These outcomes can be higher valued than outcomes evaluated in simulation setting only. |  |
| 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. | As no undesirable effects lock implications on cost or used resources we cannot judge that but despite that the available evidence seems to favour in-situ simulation. |
| 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. | Resources is one important outcome of this systematic review. We found no study that reported such 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 | As no study reporting such data was found we cannot judge that. |  |
| 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 available 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 specific evidence, especially for resources needed. |  |
| 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. | Simulation is part of the standard training for cardiopulmonary resuscitation and widely accepted. In situ simulation have may have theoretical advantages since the learning experience may be facilitated by the context. This may help dealing with obstacles and barriers. In addition, it allows for procedural assessments of team performance and the possibility of performance checks of new environments or institutions. 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. |  |

# Summary of judgements

|  | **Judgement** | | | | | | |
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| **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

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| 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

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| 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). |
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| Justification |
| We found evidence from RCTs and non-randomised studies supporting the effectiveness of in-situ simulation for cardiopulmonary resuscitation towards critical outcomes of patient survival, patients’ clinical outcomes, clinical performance in actual resuscitation and teamwork competencies in actual resuscitation, as well as outcomes during simulation.  The certainty of evidence is very low for all evaluated outcomes due to risk of bias, inconsistency, and imprecision.  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 studies addressing the critical outcomes of patient survival and patient outcomes were performed in the context of cardiopulmonary resuscitation training in the pediatric setting.  The balance between the benefit and the resources needed may be favorable, especially when critical outcomes are considered. |

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| 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. Due to very high heterogeneity in the interventions and outcome definitions no meta-analysis was possible, and no formal subgroup analysis according to the type of cardiopulmonary resuscitation training (i.e. BLS, ACLS, PALS, NLS) could be performed. |

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| 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. No study reported implementation strategies and methods to keep an in-situ program active. Moreover, most of the included studies are from USA and none from low-income countries. |

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| Monitoring and evaluation |
| No study reported monitoring of successful implementation of in-situ programs and long term outcomes. |

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| Research priorities |
| Since we did not perform a 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.  The overall risk of bias for the outcomes ranged from serious to very serious. Further high-quality research should strengthen the certainty of the evidence (i.e. adequate control for confounding factors in non-randomised studies, adequate randomization process in RCTs).  We found no data on the important outcome of resources that includes direct and indirect costs, workload, equipment needed to perform in situ simulation-based cardiopulmonary resuscitation training compared to traditional training. Further studies should include these outcomes to evaluate cost effectiveness balance.  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.  Research is needed on resources and methods for implementation and maintenance of in-situ simulation programs for resuscitation teaching.  Further studies should report data on feasibility in low and middle-income countries. |

# References Summary

1. Knight LJ, Gabhart M, Earnest KS, Leong KM, Anglemyer A, Franzon D. Improving code team performance and survival outcomes: implementation of pediatric resuscitation team training. Crit Care Med. 2014 Feb;42(2):243–51.

2. Xu C, Zhang Q, Xue Y, Chow C-B, Dong C, Xie Q, et al. Improved neonatal outcomes by multidisciplinary simulation-a contemporary practice in the demonstration area of China. Front Pediatr. 2023;11:1138633.

3. Herbers MD, Heaser JA. Implementing an in Situ Mock Code Quality Improvement Program. Am J Crit care an Off Publ Am Assoc Crit Nurses. 2016 Sep;25(5):393–9.

4. Hammontree J, Kinderknecht CG. An In Situ Mock Code Program in the Pediatric Intensive Care Unit: A Multimodal Nurse-Led Quality Improvement Initiative. Crit Care Nurse. 2022 Apr;42(2):42–55.

5. Kurosawa H, Ikeyama T, Achuff P, Perkel M, Watson C, Monachino A, et al. A randomized, controlled trial of in situ pediatric advanced life support recertification (“pediatric advanced life support reconstructed”) compared with standard pediatric advanced life support recertification for ICU frontline providers\*. Crit Care Med. 2014 Mar;42(3):610–8.

6. Sullivan NJ, Duval-Arnould J, Twilley M, Smith SP, Aksamit D, Boone-Guercio P, et al. Simulation exercise to improve retention of cardiopulmonary resuscitation priorities for in-hospital cardiac arrests: A randomized controlled trial. Resuscitation. 2015 Jan;86:6–13.

7. Rubio-Gurung S, Putet G, Touzet S, Gauthier-Moulinier H, Jordan I, Beissel A, et al. In situ simulation training for neonatal resuscitation: an RCT. Pediatrics. 2014 Sep;134(3):e790-7.

8. MEI Qimin, ZHANG Ting, CHAI Jingjing, LIU Anlei, LIU Yecheng ZH. Application of In Situ Scenario Simulation in Advanced Cardiac Life Support Training for Eight-year Medicinal Students. Med J Pekin Union Med Coll Hosp [Internet]. 2023;14(3):660–4. Available from: https://xhyxzz.pumch.cn/cn/article/doi/10.12290/xhyxzz.2022-0676

9. Clarke SO, Julie IM, Yao AP, Bang H, Barton JD, Alsomali SM, et al. Longitudinal exploration of in situ mock code events and the performance of cardiac arrest skills. BMJ Simul Technol Enhanc Learn. 2019 Jan;5(1):29–33.