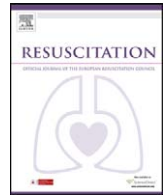




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## Part 12: Education, implementation, and teams 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations<sup>☆,☆☆</sup>

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Application of resuscitation science to improve patient care and outcomes requires effective strategies for education and implementation. Systematic reviews suggest that there are significant opportunities to improve education, enhance individual and team performance, and avoid delays in implementation of guidelines into practice. It is within this context that the International Liaison Consensus on Resuscitation (ILCOR) Education, Implementation, and Teams (EIT) Task Force was established and addressed 32 worksheet topics. Reviewers selected topics from the 2005 *International Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) Science With Treatment Recommendations*<sup>1</sup> and new topics identified by an expert group.

One challenge for the EIT Task Force was extrapolating outcomes from simulation studies to actual patient outcomes. During the evidence evaluation, if the PICO (Population, Intervention, Comparator, Outcome) question outcomes were limited to training outcomes such as improved performance on a manikin or simulator, studies were classified to a level of evidence (LOE) according to study design (e.g., a randomised controlled trial [RCT] on a manikin would be LOE 1). Manikin or simulator studies were labeled as LOE 5 irrespective of the study design if the PICO question also included patient outcomes.

<sup>☆</sup> *Note from the writing group:* Throughout this article, the reader will notice combinations of superscripted letters and numbers (e.g., "Precourse Preparation<sup>EIT-018A</sup>"). These callouts are hyperlinked to evidence-based worksheets, which were used in the development of this article. An appendix of worksheets, applicable to this article, is located at the end of the text. The worksheets are available in PDF format and are open access.

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The following is a summary of key 2010 recommendations or changes related to EIT:

- Efforts to implement new resuscitation guidelines are likely to be more successful if a carefully planned, multifaceted implementation strategy is used. Education, while essential, is *only one* element of a comprehensive implementation strategy.
- All courses should be evaluated to ensure that they reliably achieve the program objectives. Training should aim to ensure that learners acquire and retain the skills and knowledge that will enable them to act correctly in actual cardiac arrests.
- Life support knowledge and skills, both basic and advanced, can deteriorate in as little as 3–6 months. Frequent assessments and, when needed, refresher training are recommended to maintain knowledge and skills.
- Short video/computer self-instruction courses with minimal or no instructor coaching, combined with hands-on practice (practice-while-you-watch), can be considered as an effective alternative to instructor-led basic life support (cardiopulmonary resuscitation [CPR] and automated external defibrillator [AED]) courses.
- Laypeople and healthcare providers (HCPs) should be trained to start CPR with chest compressions for adult victims of cardiac arrest. If they are trained to do so, they should perform ventilations. Performing chest compressions alone is reasonable for trained individuals if they are incapable of delivering airway and breathing maneuvers to cardiac arrest victims.
- AED use should not be restricted to trained personnel. Allowing use of AEDs by individuals without prior formal training can be beneficial and may be lifesaving. Since even brief training improves performance (e.g., speed of use, correct pad placement), it is recommended that training in the use of AEDs be provided.
- CPR prompt or feedback devices improve CPR skill acquisition and retention and may be considered during CPR training for laypeople and healthcare professionals. These devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR.
- It is reasonable to wear personal protective equipment (PPE) (e.g., gloves) when performing CPR. CPR should not be delayed or with-

held if PPE is not available unless there is a clear risk to the rescuer.

- Manual chest compressions should not continue during the delivery of a shock because safety has not been established.

Several important knowledge gaps were identified during the evidence review process:

- The optimal duration and type of initial training to acquire resuscitation knowledge and skills.
- The optimal frequency and type of refresher training required to maintain resuscitation knowledge and skills.
- The optimal use of assessment as a tool to promote the learning of resuscitation knowledge and skills.
- The impact of experience in actual resuscitation attempts on skill decay and the need for refresher training.
- The impact of specific training interventions on patient outcomes.
- A standardised nomenclature and definitions for different types of simulation training and terms such as 'high fidelity simulation,' 'feedback,' 'briefing' and 'debriefing.'
- The most effective and efficient methods of disseminating information about new resuscitation interventions or guidelines to reduce time to implementation.
- For cardiac resuscitation centres (facilities providing a comprehensive package of post resuscitation care), the optimal emergency medical services (EMS) system characteristics, safe patient transport interval (time taken to travel from scene to hospital), optimal mode of transport (e.g., ground ambulance, helicopter), and role of secondary transport (transfer from receiving hospital to a resuscitation centre).

The EIT Task Force organised its work into five major sections:

- Education—including who should be trained and how to prepare for training, the use of specific instructional strategies and techniques, retraining intervals, retention of knowledge and skills, and assessment methods.
- Risks and effects on the rescuer of CPR training and actual CPR performance.
- Rescuer willingness to respond.
- Implementation and teams—including a framework for implementation efforts as well as individual and team factors associated with success.
- Ethics and outcomes.

## Education

Effective and efficient resuscitation education is one of the essential elements in the translation of guidelines into clinical practice. Educational interventions need to be population specific (e.g., lay rescuers, HCPs) and evaluated to ensure that they achieve the desired educational outcomes—not just at the end of the course but also during actual resuscitation events. Retention of knowledge and skills should be confirmed through assessment and not be assumed to persist for pre-established time intervals.

### Populations

Who should be trained and how should they prepare for training?

*Focused training*<sup>EIT-012A,EIT-012B</sup>

For lay providers requiring basic life support training, does focusing training on high-risk populations, compared with no such targeting improve outcomes (e.g., bystander CPR, survival)?

### Consensus on science

In three studies (LOE 1<sup>2</sup>; LOE 2<sup>3,4</sup>), people reported that they would be more willing to perform bystander CPR on family members than on nonrelatives.

One LOE 2 study<sup>5</sup> of people who called 911 found that unless family members had received CPR training, they were less likely to perform CPR than unrelated bystanders. Computer modeling (LOE 5)<sup>6</sup> suggested that very large numbers of older adults would need to be trained to achieve a sufficient increase in private residence bystander CPR rates to improve survival. Twelve studies (LOE 1<sup>2,7–11</sup>; LOE 2<sup>3,12</sup>; LOE 4<sup>13,14</sup>; LOE 5<sup>15,16</sup>) reported that training of patients and family members in CPR provided psychological benefit. Two LOE 1 studies<sup>7,17</sup> reported that negative psychological effects on patients can be avoided by providing social support.

### Treatment recommendation

There is insufficient evidence to support or refute the use of training interventions that focus on high-risk populations. Training with social support reduces family member and patient anxiety, improves emotional adjustment, and increases feelings of empowerment.

### Precourse preparation

<sup>EIT-018A</sup>

For advanced life support providers undergoing advanced life support courses, does the inclusion of specific precourse preparation (e.g., e-learning and pretesting), as opposed to no such preparation, improve outcomes (e.g., same skill assessment but with less face-to-face [instructor] hands-on training)?

### Consensus on science

Eight studies (LOE 1<sup>18</sup>; LOE 4<sup>19</sup>; LOE 5<sup>20–25</sup>) reported that a diverse range of precourse preparatory actions (e.g., computer-assisted learning, pretests, video-based learning, textbook reading) improved learner outcomes in advanced life support courses.

One large LOE 1 RCT<sup>26</sup> of use of a commercially available e-learning simulation program before attending an advanced life support course, compared with standard preparation with a course manual, did not improve either cognitive or psychomotor skill performance during cardiac arrest simulation testing.

Eighteen studies (LOE 2<sup>27</sup>; LOE 4<sup>19,28</sup>; LOE 5<sup>20,25,29–41</sup>) showed that alternative course delivery formats such as electronically delivered (CD or Internet-based) courses produced as good or better learner outcomes compared with traditional courses, and also reduced instructor-to-learner face-to-face time.

### Treatment recommendation

Precourse preparation including, but not limited to, use of computer-assisted learning tutorials, written self-instruction materials, video-based learning, textbook reading, and pretests are recommended as part of advanced life support courses. Any method of precourse preparation that is aimed at improving knowledge and skills or reducing instructor-to-learner face-to-face time should be formally assessed to ensure equivalent or improved learning outcomes compared with standard instructor-led courses.

### Instructional methods

There are multiple methods to deliver course content. This section examines specific instructional methods and strategies that may have an impact on course outcomes.

*Alternative instructor methods*<sup>EIT-002A,EIT-002B</sup>

For lay rescuers and HCPs, does the use of specific instructional methods (video/computer self-instruction), compared with traditional instructor-led courses, improve skill acquisition and retention?

*Consensus on science*

Twelve studies (LOE 1<sup>42–47</sup>; LOE 2 or 3<sup>48–53</sup>) demonstrated that basic life support skills can be acquired and retained at least as well and, in some cases, better using video-based self-instruction (practice-while-you-watch) compared with traditional instructor-led courses. Video-based self-instruction lasted from 8 to 34 min, whereas instructor-led courses were usually 4–6 h in duration. One LOE 1 study<sup>54</sup> demonstrated that prior viewing of a video on infant CPR before an instructor-led course improved skill acquisition.

When compared with traditional instructor-led CPR courses, various self-instructional and shortened programs have been demonstrated to be efficient (from the perspective of time) and effective (from the perspective of skill acquisition) in teaching CPR skills to various populations.

*Treatment recommendation*

Short video/computer self-instruction (with minimal or no instructor coaching) that includes synchronous hands-on practice (practice-while-you-watch) in basic life support can be considered as an effective alternative to instructor-led courses.

*AED training interventions*<sup>>EIT-013A, EIT-013B</sup>

For basic life support providers (lay or HCP) requiring AED training, are there any specific training interventions, compared with traditional lecture/practice sessions, that increase outcomes (e.g., skill acquisition and retention, actual AED use)?

*Consensus on science*

One LOE 2 study<sup>55</sup> demonstrated that training delivered by laypeople is as effective as training by HCPs. One LOE 1 study<sup>56</sup> reported that instruction by nurses, as compared with physicians, resulted in better skill acquisition. Four studies (LOE 2<sup>46,51,57</sup>; LOE 4<sup>58</sup>) reported that the use of computer-based AED training improved skill acquisition and retention, particularly when combined with manikin practice. One LOE 1 study<sup>47</sup> supported the use of video-self instruction when compared with instructor-led training. Three LOE 1 studies<sup>59–61</sup> showed that the use of video self-instruction was less effective for some elements when compared with instructor-led training. One LOE 1 study<sup>62</sup> supported the use of a training poster and manikin for learning AED skills. Three studies (LOE 2<sup>46,63</sup>; LOE 4<sup>64</sup>) reported that laypeople and HCPs could use an AED without training. Three LOE 2 studies<sup>65–67</sup> reported that untrained individuals could deliver a shock with an AED. However, even minimal training (15-min lecture, 1-h lecture with manikin practice, or reading instructions) improved performance (e.g., time to shock delivery, correct pad placement, safety).

*Treatment recommendation*

AED use should not be restricted to trained personnel. Allowing use of AEDs by individuals without prior formal training can be beneficial and may be lifesaving. Since even brief training improves performance (e.g., speed of use, correct pad placement), it is recommended that training in the use of AEDs be provided. Laypeople can be used as AED instructors. Short video/computer self-instruction (with minimal or no instructor coaching) that includes synchronous hands-on practice in AED use (practice-while-you-watch) may be considered as an effective alternative to instructor-led AED courses.

*Advanced life support leadership/team training*<sup>EIT-017A</sup>

For advanced life support providers undergoing advanced life support courses, does the inclusion of specific leadership/team training, as opposed to no such specific training, improve outcomes (e.g., performance during cardiac arrest)?

*Consensus on science*

Four studies (LOE 1<sup>68,69</sup>; LOE 2<sup>70,71</sup>) of advanced life support in simulated in-hospital cardiac arrest and seven LOE 5 studies<sup>72–78</sup> of actual and simulated arrest demonstrated improved resuscitation team performance when specific team and/or leadership training was added to advanced life support courses.

*Treatment recommendation*

Specific teamwork training, including leadership skills, should be included in advanced life support courses.

*Teaching chest compressions to achieve recoil*<sup>EIT-032</sup>

Is there a method for teaching chest compressions, compared with current teaching, to achieve full chest recoil (complete release) after each compression?

*Consensus on science*

One LOE 5 clinical case series<sup>79</sup> documented a 46% incidence of incomplete chest recoil by professional rescuers using the 2005-recommended CPR technique. One LOE 4 study<sup>80</sup> electronically recorded chest recoil during in-hospital paediatric cardiac arrests, and found that leaning on the chest (>2.5 kg; an adult feedback threshold) occurred in 50% of chest compressions/decompressions using the recommended hand position, and that incomplete recoil was reduced with real-time automated feedback. Another LOE 4 in-hospital paediatric study<sup>81</sup> demonstrated a 23.4% incidence of incomplete recoil. One LOE 5 study<sup>82</sup> has shown that without specific training in complete chest recoil technique, 22% of trained rescuers leaned on the chest when performing CPR. Two LOE 5 studies<sup>79,83</sup> demonstrated that incomplete chest recoil was significantly reduced with three techniques (i.e., 'two-finger fulcrum,' 'five-finger fulcrum,' and 'hands-off') of lifting the heel of the hand slightly but completely off the chest during CPR in a manikin model. However, duty cycle and compression depth were reduced when professional and lay rescuers applied these techniques.

*Treatment recommendation*

There is insufficient evidence to recommend teaching any specific technique to optimise complete chest recoil during actual CPR.

*Use of CPR prompt/feedback devices*<sup>EIT-005A, EIT-005B</sup>

For lay rescuers and HCPs performing CPR, does the use of CPR prompt/feedback devices, compared with no device, improve acquisition, retention, and actual performance of CPR skills?

*Consensus on science*

Most devices considered in this review combine prompting (a signal to perform an action, e.g., metronome for compression rate) with feedback (after-event information about the effect of an action, e.g., visual display of compression depth). The effects have been considered together in this question and devices are referred to as prompt/feedback devices.

Seven LOE 5 manikin studies<sup>84–90</sup> demonstrated that CPR prompt/feedback devices either in addition to or in place of instructor-led training improved basic CPR skill acquisition (tested without use of the device). Another LOE 5 manikin study<sup>85</sup> showed that automated feedback might be less effective than instructor feedback for more complex skills (e.g., bag-mask ventilation).

Two LOE 5 manikin studies<sup>84,87</sup> showed improved skill retention when a CPR prompt/feedback device was used during initial training. An additional LOE 5 manikin study<sup>89</sup> showed that unsupervised refresher training with a CPR prompt/feedback device, compared with no refresher training, also improved skill retention. The LOE 5 follow-up arm of the manikin study of bag-mask

ventilation/CPR<sup>85</sup> continued to show poorer ventilation skills in the voice-activated manikin-feedback arm compared with the instructor-feedback arm.

Evidence from 21 manikin studies (LOE 5)<sup>84,86,89–107</sup> consistently demonstrated that CPR prompt/feedback devices used during CPR improved the quality of CPR performance on manikins. Three additional manikin studies (LOE 5) examined the utility of video/animations on mobile-phone devices: two studies showed improved checklist scores and quality of CPR<sup>92,95</sup> and faster initiation of CPR,<sup>92</sup> while the third study showed that participants using multimedia phone CPR instruction took longer to complete tasks than dispatcher-assisted CPR.<sup>103</sup> Two manikin studies (LOE 5)<sup>108,109</sup> that used two-way video communication to enable the dispatcher to review and comment on CPR in real time produced equivocal findings.

There are no studies demonstrating improved patient outcomes with CPR prompt/feedback devices. One study each in children (LOE 2)<sup>110</sup> and adults (LOE 2)<sup>111</sup> showed that metronomes improved chest compression rate and increased end-tidal carbon dioxide (thought to correlate with improved cardiac output and blood flow to the lungs). Five studies evaluating the introduction of CPR prompt/feedback devices in clinical practice (pre/post comparisons) found improved CPR performance (LOE 3)<sup>80,112–115</sup>.

There may be some limitations to the use of CPR prompt/feedback devices. Two LOE 5 manikin studies<sup>116,117</sup> reported that chest-compression devices may overestimate compression depth if CPR is being performed on a compressible surface such as a mattress on a bed. One LOE 5 study<sup>100</sup> reported harm to a single participant when a hand got stuck in moving parts of the CPR feedback device. Another LOE 5 manikin study<sup>118</sup> demonstrated that additional mechanical work from the CPR provider was required to compress the spring in one of the pressure-sensing feedback devices. One case report (LOE 5)<sup>119</sup> documented soft tissue injury to a patient's chest when an accelerometer device was used for prolonged CPR.

#### *Treatment recommendation*

CPR prompt/feedback devices may be considered during CPR training for laypeople and HCPs. CPR prompt/feedback devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR. Instructors and rescuers should be made aware that a compressible support surface (e.g., mattress) may cause a feedback device to overestimate depth of compression.

#### *Training interventions*<sup>EIT-009A</sup>

For adult and paediatric advanced life support providers, are there any specific training interventions (e.g., duration of session, interactive computer programs, e-learning, video self-instruction) compared with traditional lecture/practice sessions that increase outcomes (e.g., skill acquisition and retention)?

#### *Consensus on science*

There is limited evidence about interventions that enhance learning and retention from advanced life support courses. One LOE 3 study<sup>120</sup> suggested that the 2005 Guidelines have helped to improve “no-flow” fraction (i.e., percent of total resuscitation time that compressions are not performed) but not other elements of quality of CPR performance. One LOE 1 study<sup>121</sup> demonstrated that clinical training before an advanced life support (ALS) course might improve long-term retention of ALS knowledge and skills. One LOE 5 advanced trauma life support (ATLS) study<sup>122</sup> suggested that postcourse experience might play a role in knowledge and skill retention. In one LOE 3 study<sup>123</sup> unscheduled mock-codes improved mock-code performance in hospital personnel. One LOE

2 study<sup>124</sup> found no difference in knowledge retention when live actors were used in ALS course training compared with manikins.

#### *Treatment recommendation*

There is insufficient evidence to recommend any specific training intervention, compared with traditional lecture/practice sessions, to improve learning, retention, and use of advanced life support skills.

#### *Realistic training techniques*<sup>EIT-019A,EIT-019B</sup>

For participants undergoing basic or advanced life support courses, does the inclusion of more realistic techniques (e.g., high-fidelity manikins, in situ training), as opposed to standard training (e.g., low-fidelity manikins, education centre), improve outcomes (e.g., skill performance on manikins, skill performance in an actual arrest, willingness to perform)?

#### *Consensus on science*

Studies report conflicting data on the effect of increasing realism (e.g., use of actual resuscitation settings, high-fidelity manikins) on learning, and few data on patient outcomes. Two studies (LOE 1<sup>125</sup>; LOE 2<sup>126</sup>) supported an improvement in performance of skills in actual arrest, but were underpowered to identify improved survival rate. One small LOE 1 study<sup>127</sup> showed no overall effect on performance, although the simulation-trained group demonstrated superior teamwork skills. Thirteen studies (LOE 1<sup>125,128–132</sup>; LOE 2<sup>133–135</sup>; LOE 3<sup>136,137</sup>; LOE 4<sup>138,139</sup>) reported an improvement in skills assessed using a manikin. Seven LOE 1 studies<sup>140–146</sup> reported no effect on skills assessed using a manikin. Eleven LOE 1 studies tested the effect of simulation fidelity on the participants' knowledge using multiple-choice questions; nine of these studies found no effect<sup>124,127,128,130,140,141,143,144,147</sup> and two of the 11 studies demonstrated an improvement in participant knowledge with the more realistic techniques.<sup>148,149</sup>

Two studies (LOE 3<sup>136</sup>; LOE 4<sup>138</sup>) that focused on resuscitation in trauma reported improved skill performance (on a manikin) with higher-fidelity simulation. One LOE 1 study<sup>140</sup> found no difference in skill performance or knowledge in advanced trauma life support (ATLS) with the use of high-fidelity simulation. One LOE 1 study<sup>148</sup> reported a significant increase in knowledge when using manikins or live patient models for trauma teaching compared with no manikins or no live models. In this study there was no difference in knowledge acquisition between using manikins or live patient models, although learners preferred using the manikins.

Four studies (LOE 1<sup>128,140,141</sup>; LOE 2<sup>148</sup>) reported that higher fidelity simulation was associated with improved learner satisfaction rate compared with a traditional curriculum. One LOE 1 study<sup>144</sup> questioned the cost-effectiveness of higher fidelity approaches compared with standard manikins.

Three studies (LOE 1<sup>125</sup>; LOE 2<sup>134</sup>; LOE 3<sup>137</sup>) reported that requiring learners to perform all of the steps of psychomotor skills in simulation as they would in an actual clinical situation could reveal inadequacies in training.

#### *Treatment recommendation*

There is insufficient evidence to support or refute the use of more realistic techniques (e.g., high-fidelity manikins, in situ training) to improve outcomes (e.g., skill performance on manikins, skill performance in actual arrest, willingness to perform) compared with standard training (e.g., low-fidelity manikins, education centre) in basic and advanced life support courses.

## Course format and duration

Resuscitation training courses vary widely in their duration and how different elements of the curriculum are taught. This section examines the effect of course format and duration on learning outcomes.

### Course duration<sup>EIT-029A,EIT-029B</sup>

For basic life support providers (lay or HCP), does a longer duration instructor-led course, compared with a shorter course, improve skill acquisition and retention?

### Consensus on science

A single, randomised manikin LOE 1 study<sup>150</sup> demonstrated that a 7-h basic life support (with AED) instructor-led course resulted in better initial skill acquisition than a 4-h instructor-led course; and a 4-h instructor-led course resulted in better skill acquisition than a 2-h course. Retesting at 6 months after a 2-h course resulted in skill retention at 12 months that was equivalent to a 7-h course with no intermediate testing. This study<sup>150</sup> along with two LOE 2 manikin studies<sup>151,152</sup> demonstrated that for periods between 4 and 12 months, skill retention is higher for longer courses, but deterioration is at similar rates. The differences in learning outcomes for courses of different durations may not be significant, particularly if assessment and refresher training are undertaken.

### Treatment recommendation

It is reasonable to consider shortening the duration of traditional instructor-led basic life support courses. Brief reassessment (e.g., at 6 months) should be considered to improve skills and retention. The optimal duration of an instructor-led basic life support course has not been determined. New course formats should be assessed to ensure that they achieve their objectives.

### Nontraditional scheduling formats<sup>EIT-020</sup>

For participants undergoing advanced life support courses, does the use of nontraditional scheduling formats such as random scheduling (introducing station cases in a random manner) or modular courses, as opposed to traditional scheduling, improve outcomes (e.g., skills performance)?

### Consensus on science

There are no published studies addressing the impact of different ALS course scheduling formats, compared with the traditional 2-day course format, that demonstrated improved learning outcomes (knowledge and skill acquisition and/or retention).

### Treatment recommendation

There is insufficient evidence to support or refute the use of alternative advanced life support course scheduling formats compared with the traditional 2-day course format.

## Retraining intervals

It is recognised that knowledge and skill retention declines within weeks after initial resuscitation training. Refresher training is invariably required to maintain knowledge and skills; however, the optimal frequency for refresher training is unclear. This section examines the evidence addressing the optimal frequency for refresher training to maintain adequate knowledge and skills.

## Specific intervals for basic life support<sup>EIT-010</sup>

For basic life support providers (lay and HCP), are there any specific intervals for update/retraining, compared with standard practice (i.e., 12 or 24 monthly), that increase outcomes (e.g., skill acquisition and retention)?

### Consensus on science

Six studies (LOE 1<sup>44,87</sup>; LOE 2<sup>150</sup>; LOE 4<sup>47,153,154</sup>) using different training approaches demonstrated that CPR skills (e.g., alerting EMS, chest compressions, ventilations) decay rapidly (within 3–6 months) after initial training. Two studies (LOE 1<sup>155</sup>; LOE 4<sup>156</sup>) reported skill decay within 7–12 months after initial training. Four studies (LOE 2<sup>150</sup>; LOE 4<sup>157–159</sup>) demonstrated that CPR performance was retained or improved with reevaluation, refresher, and/or retraining after as little as three months. Three LOE 2 studies<sup>66,150,160</sup> demonstrated that AED skills are retained longer than CPR skills. One LOE 2 study<sup>160</sup> reported higher levels of retention from a program that achieved initial training to a high (mastery) level. However, deterioration of CPR skills was still reported at three months.

### Treatment recommendation

For basic life support providers (lay and HCP), skills assessment and, if required, a skills refresher should be undertaken more often than the current commonly recommended training interval of 12–24 months.

## Specific intervals for advanced life support<sup>EIT-011A,EIT-011B</sup>

For adult and paediatric advanced life support providers, do any specific intervals for update/retraining, compared with standard practice (i.e., 12 or 24 months), increase outcomes (e.g., skill acquisition and retention)?

### Consensus on science

One LOE 1 trial<sup>161</sup> and one LOE 3 study<sup>162</sup> suggested that refresher training may enhance resuscitation knowledge retention but did not maintain motor skills. Two RCTs (LOE 1)<sup>163,164</sup> showed no benefit of refresher training.

Nine studies (LOE 3<sup>165</sup>; LOE 4<sup>153,166–172</sup>) reported decreased resuscitation knowledge and/or skills performance when tested 3–6 months after initial training. Two LOE 4 studies<sup>173,174</sup> reported decreased performance when tested 7–12 months following training. One LOE 4 study<sup>175</sup> reported decay of practical skill performance when participants were tested 18 months after training.

### Treatment recommendation

For advanced life support providers there should be more frequent assessment of skill performance and/or refresher training than is currently recommended in established advanced life support programs. There is insufficient evidence to recommend an optimal interval and form of assessment and/or refresher training.

## Assessment

### Written examination<sup>EIT-004</sup>

For students of adult and paediatric advanced level courses, does success in the written examination, compared with lack of success, predict success in completing the practical skills testing associated with the course or in cardiac arrest management performance in actual or simulated cardiac arrest events?

### Consensus on science

Four observational studies (LOE P4)<sup>176–179</sup> did not support the ability of a written test to predict clinical skill performance in an advanced life support course. Twelve LOE P5 studies<sup>180–191</sup> supported using written tests as a predictor of nonresuscitation clinical skills, with variable levels of correlation ranging from 0.19 to 0.65. Three LOE P5 studies<sup>192–194</sup> were either neutral or did not support the ability of a written test to predict clinical skill performance.

### Treatment recommendation

A written test in an advanced life support course should not be used as a substitute for demonstration of clinical skill performance.

### Testing versus continuous assessment<sup>EIT-021A</sup>

For participants undergoing basic or advanced life support courses, does end-of-course testing, as opposed to continuous assessment and feedback, improve outcomes (e.g., improve learning/performance)?

### Assessment versus no assessment<sup>EIT-030A</sup>

For lay and HCP, does the use of assessment, as opposed to no such assessment, improve CPR knowledge, skills, and learning/retention?

### Consensus on science

No studies have compared outcomes of continuous versus end-of-course assessments for resuscitation training.

One LOE 1 manikin study<sup>195</sup> showed that including assessment during advanced life support training, compared with a control group without assessment, moderately improved performance at the 2-week postcourse scenario assessment. In another LOE 1 study<sup>195</sup> performance assessment after 6 months in the “testing” group compared with the control group failed to show a statistically significant improvement.

### Treatment recommendation

Summative assessment at the end of advanced life support training should be considered as a strategy to improve learning outcomes. There is insufficient evidence to recommend an optimal method of assessment during life support training.

## Education knowledge gaps

- Effect of targeting training to family and friends of those at “high risk” of cardiac arrest.
- Potential for tailoring preparation and training to individual learning styles.
- Optimal assessment tools and strategy to promote learning resuscitation skills.
- Optimal format and duration of self-instruction.
- Impact of resuscitation training on performance in actual cardiac arrest.
- Motivating bystanders to use AEDs.
- Optimal training (alternative, minimal, no training, standardised instructor-led training) for use of AEDs in actual events.
- Governmental, social, and political measures needed to improve public participation in life support programs.
- Optimal ways to teach and assess leadership and team skills.
- Specific techniques to optimise complete chest recoil during CPR without impacting depth, rate, and duty cycle of compression, including the use of prompt and feedback devices to achieve this.
- Optimal method for implementing feedback devices into practice.

- Specific advantages of prompt devices versus feedback devices and feedback timing (real time or immediately post-event).
- Optimal method for learning and retention of knowledge/skills.
- Standardization in simulation nomenclature and research methods.
- Influence of equipment or manikin fidelity, environmental fidelity, and psychological fidelity on learning outcomes.
- Optimal length of an instructor-led course.
- Comparison of different course formats (e.g., a 2-day course versus four half-day modules).
- Effect of ongoing clinical experience on retention of skills and need for assessment and/or refresher training.
- Optimal interval and form for assessment.
- Optimal format for refresher training when the need is identified.
- Effect of type of measurement/assessment.
- Effect of complexity on retention.
- Optimal intervals and strategies for refresher courses for various populations.
- Levels of knowledge/skill deterioration tolerable (clinically significant) before a refresher course is needed.
- Correlation between rescuer knowledge/skill competencies and patient survival.
- Modalities to increase knowledge/skill retention (clinical exposure, simulation, video learning).
- Economy and logistics of shorter intervals for update/retraining.
- Optimal form and timing of assessment to optimise learning, retention, and application of resuscitation skills.

## Risks and effects on the rescuer of CPR training and actual CPR performance

The safety of rescuers is essential during training and actual CPR performance.

### CPR and AED training and experience<sup>EIT-014A, BLS-002A</sup>

For providers (lay or HCP), does undertaking training/performing actual CPR or use of a defibrillator (manual or AED), compared with no such training/performance, increase harm to the rescuer?

### Compression-only CPR<sup>BLS-005A, BLS-005B</sup>

For rescuers performing CPR on adults or children, does compression-only CPR, compared with traditional CPR, result in an increase in adverse outcomes (e.g., fatigue)?

### Use of barrier devices<sup>BLS-002A</sup>

For rescuers performing CPR on adults or children (out-of-hospital and in-hospital), does the use of a barrier device, as opposed to no such use, improve outcomes (e.g., lower infection risk)?

## Physical effects

### Consensus on science

CPR is very rarely associated with adverse events to the rescuer during training or actual performance. An observational study (LOE 4)<sup>196</sup> reported one muscle strain during a large public access defibrillation trial.<sup>197</sup> One prospective observational study (LOE 4)<sup>198</sup> described five musculoskeletal injuries (four back-related) associated with performing chest compressions in 1265 medical emergency team (MET) call participants. Two retrospective sur-

veys of nurses and ambulance officers (LOE 4)<sup>199,200</sup> reported a high incidence of back symptoms attributed to performing CPR.

Three small simulation studies (LOE 4)<sup>201–203</sup> using a greater number of ventilations per minute than those provided with the currently recommended compression-ventilation ratio (30:2) described hyperventilation-related symptoms during rescue breathing. Five single or small case series (LOE 5)<sup>204–208</sup> described isolated adverse events from training or performing actual CPR (myocardial infarction, pneumothorax, chest pain, shortness of breath, nerve injury, allergy, vertigo). In one case report (LOE 5)<sup>209</sup> a rescuer suffered a puncture wound to her left hand from a victim's sternotomy wires when performing chest compressions.

One simulation study (LOE 5)<sup>210</sup> of six physicians (aged 25–40 years) and another study (LOE 5)<sup>211</sup> of 10 healthy medical students showed that performing chest compressions increased rescuer oxygen consumption. The authors considered that this increase in oxygen consumption was sufficient to cause myocardial ischaemia in individuals with coronary heart disease. A small randomised trial of cardiac rehabilitation patients (LOE 5)<sup>9</sup>, however, reported no adverse physical events during CPR training.

#### *Treatment recommendation*

CPR training and actual performance is safe in most circumstances. Learners and rescuers should consider personal and environmental risks before starting CPR. Individuals undertaking CPR training should be advised of the nature and extent of the physical activity required during the training program. Learners who develop significant symptoms (e.g., chest pain, severe shortness of breath) during CPR should be advised to stop. Rescuers who develop significant symptoms during actual CPR should consider stopping CPR.

#### **Rescuer fatigue**

A single LOE 4 in-hospital patient study<sup>212</sup> of 3 min of continuous chest compressions with real-time feedback to the rescuer showed that the mean depth of compression deteriorated between 90 and 180 s, but compression rate was maintained. Three LOE 5 studies showed that some rescuers were unable to complete 5 min (laypeople),<sup>213</sup> 5–6 min (lay females),<sup>214</sup> or 18 min (HCPs)<sup>215</sup> of continuous chest compressions because of physical exhaustion. Two manikin studies (LOE 5)<sup>215,216</sup> demonstrated that performing chest compressions increases heart rate and oxygen consumption in HCPs. Two randomised manikin studies (LOE 5)<sup>213,214</sup> demonstrated that >5 to 10 min of continuous chest compressions by laypeople resulted in significantly less compression depth compared with standard 30:2 CPR, and no difference in compression rate. In one LOE 5 manikin study<sup>217</sup> experienced paramedics demonstrated no decline in chest compression quality below guideline recommendations during 10 min of BLS with any of three different compression-ventilation ratios (15:2, 30:2, and 50:2).

Four manikin studies (LOE 5)<sup>218–221</sup> showed a time-related deterioration in chest compression quality (mainly depth) during continuous compressions by HCPs. A single manikin study (LOE 5)<sup>222</sup> demonstrated that medical students performed better-quality chest compressions during the first 2 min of continuous chest compressions compared with 15:2 CPR, although there was deterioration in quality after 2 min. An LOE 5 manikin study<sup>223</sup> of HCPs showed that the number of effective compressions (depth >38 mm) was the same if the rescuer changed every minute or every 2 min during 8 min of continuous chest compressions. Fatigue was reported more frequently after a 2-min period of compressions.

#### *Treatment recommendation*

When performing chest compressions, if feasible, it is reasonable to consider changing rescuers after about 2 min to prevent rescuer fatigue (demonstrated by deterioration in chest compression quality—in particular, depth of compressions). The change of rescuers performing chest compressions should be done with minimum interruption to the compressions.

#### **Risks during defibrillation attempts**

##### *Consensus on science*

Harm to the rescuer or a bystander is extremely rare during defibrillation attempts. A large randomised trial of public access defibrillation (LOE 1)<sup>197</sup> and four prospective studies of first-responder AED use (LOE 4)<sup>224–226</sup>; (LOE 5)<sup>227</sup> demonstrated that AEDs can be used safely by laypeople and first responders. One LOE 4 manikin study<sup>228</sup> observed that laypeople using an AED touched the manikin during shock delivery in one third of defibrillation attempts.

An observational study (LOE 4)<sup>229</sup> of 43 patients undergoing cardioversion measured only a small current leakage through “mock rescuers” wearing polyethylene gloves and simulating chest compression during shock delivery. One LOE 5 systematic review<sup>230</sup> identified eight articles that reported a total of 29 adverse events associated with defibrillation. Only one case (LOE 5)<sup>231</sup> has been published since 1997. A 150-J biphasic shock was delivered during chest compressions. The rescuer doing chest compressions felt the electric discharge and did not suffer any harm. Seven cases were due to accidental or intentional defibrillator misuse (LOE 5)<sup>232–236</sup>, one was due to device malfunction (LOE 5)<sup>237</sup>, and four occurred during training/maintenance procedures (LOE 5)<sup>237,238</sup>. A case series (LOE 5)<sup>237</sup> identified 14 adverse events during actual resuscitation; all caused only minor harm.

The risks to individuals in contact with a patient during implanted cardioverter defibrillator (ICD) discharge are difficult to quantify. Four single case reports (LOE 5)<sup>239–242</sup> described shocks to the rescuer from discharging ICDs. ICD discharge was associated with a significant jolt to rescuers and in one case resulted in a peripheral nerve injury.<sup>242</sup>

Three animal studies suggested that the use of defibrillators in wet environments is safe (LOE 5)<sup>243–245</sup>.

There are no reports of harm to rescuers from attempting defibrillation in wet environments.

##### *Treatment recommendation*

The risks associated with defibrillation are less than previously thought. There is insufficient evidence to recommend that continuing manual chest compressions during shock delivery for defibrillation is safe. It is reasonable for rescuers to wear gloves when performing CPR and attempting defibrillation (manual and/or AED) but resuscitation should not be delayed/withheld if gloves are not available.

There is insufficient evidence to make a recommendation about the safety of contacting a patient during ICD discharge. There is insufficient evidence to make a recommendation about the best method of avoiding shocks to the rescuer from an ICD discharge during CPR.

Although there are no reports of harm to rescuers, there is insufficient evidence to make a recommendation about the safety of defibrillation in wet environments.



## Psychological effects

### Consensus on science

One large prospective trial of PAD (LOE 4)<sup>196</sup> reported a few adverse psychological effects requiring intervention that were associated with CPR or AED use. One prospective analysis of stress reactions associated with a trial of public access defibrillation (LOE 4)<sup>246</sup> reported low levels of stress in those responding to an emergency in this setting. One prospective observational study of 1265 MET calls (LOE 4)<sup>198</sup> described “psychological injury” related to CPR performance in one rescuer. Two large retrospective questionnaire-based reports relating to performance of CPR by a bystander (LOE 4)<sup>247,248</sup> reported that nearly all respondents regarded their intervention as a positive experience. Two small retrospective studies of nurses involved in delivery of CPR (LOE 4<sup>249</sup>; LOE 5<sup>250</sup>) noted the stress involved and the importance of recognition and management of this stress.

### Treatment recommendation

There are few reports of psychological harm to rescuers after involvement in a resuscitative attempt. There is insufficient evidence to support or refute any recommendation about minimizing the incidence of psychological harm to rescuers.

## Disease transmission

### Consensus on science

There are only a very few cases reported (LOE 5) where performing CPR has been implicated in disease transmission. Salmonella infantis,<sup>251</sup> panton-valentine leucocidin staphylococcus aureus,<sup>252</sup> severe acute respiratory syndrome (SARS),<sup>253</sup> meningococcal meningitis,<sup>254</sup> helicobacter pylori,<sup>255</sup> herpes simplex virus,<sup>256,257</sup> cutaneous tuberculosis,<sup>258</sup> stomatitis,<sup>259</sup> tracheitis,<sup>260</sup> shigella,<sup>261</sup> and streptococcus pyogenes<sup>262</sup> have been implicated. One report described herpes simplex virus infection as a result of training in CPR (LOE 5)<sup>263</sup>. One systematic review found that in the absence of high-risk activities, such as intravenous cannulation, there were no reports of transmission of hepatitis B, hepatitis C, human immunodeficiency virus (HIV), or cytomegalovirus during either training or actual CPR (LOE 5)<sup>264</sup>.

### Treatment recommendation

The risk of disease transmission during training and actual CPR performance is very low. Rescuers should take appropriate safety precautions, especially if a victim is known to have a serious infection (e.g., HIV, tuberculosis, hepatitis B virus, or SARS).

## Barrier devices

### Consensus on science

No human studies have addressed the safety, effectiveness, or feasibility of using barrier devices to prevent patient contact during rescue breathing. Nine clinical reports (LOE 5)<sup>257,258,264–268</sup> proposed or advocated the use of barrier devices to protect the rescuer from transmitted disease. Three LOE 5 studies<sup>269–271</sup> showed that barrier devices can decrease transmission of bacteria in controlled laboratory settings.

### Treatment recommendation

The risk of disease transmission is very low and initiating rescue breathing without a barrier device is reasonable. If available, rescuers may consider using a barrier device. Safety precautions should be taken if the victim is known to have a serious infection (e.g., HIV, tuberculosis, hepatitis B virus, or SARS).

### Knowledge gaps

- Actual incidence of disease transmission and other harm during CPR
- Safety of hands-on defibrillation
- Safest type of glove
- CPR in patients with ICDs
- Role of barrier devices

## Rescuer willingness to respond

Increasing the willingness of individuals to respond to a cardiac arrest with early recognition, calling for help, and initiation of CPR is essential to improve survival rates.

### Factors that increase outcomes<sup>EIT-008A,EIT-008B</sup>

Among bystanders (lay or HCP), are there any specific factors, compared with standard interventions, that increase outcomes (e.g., willingness to provide CPR or the actual performance of CPR [standard or chest compression only]) in adults or children with cardiac arrest (prehospital)?

### Consensus on science

Sixteen LOE 4 studies<sup>5,246,272–285</sup> have suggested that many factors decrease the willingness of bystanders to start CPR, including bystander characteristics (panic, fear of disease or harming the victim or performing CPR incorrectly) and victim characteristics (stranger, being unkempt, evidence of drug use, blood, or vomit).

Two studies (LOE 1<sup>131</sup>; LOE 4<sup>286</sup>) have suggested that training rescuers to recognise gasping as a sign of cardiac arrest improves identification of cardiac arrest victims. Ten studies (LOE 2<sup>10</sup>; LOE 4<sup>5,272,274,280–282,287–289</sup>) showed increased bystander CPR rate in those trained in CPR, especially if training had occurred within five years. Three LOE 5 studies<sup>272,275,290</sup> showed that willingness to perform CPR was increased when emergency dispatchers provided telephone CPR instructions. Eight LOE 4 studies<sup>273,277,280,284,285,287,291,292</sup> provided evidence that potential rescuers would be more likely to start CPR if they had the option to use compression-only CPR.

### Treatment recommendation

To increase willingness to perform CPR

- Laypeople should receive training in CPR. This training should include the recognition of gasping or abnormal breathing as a sign of cardiac arrest when other signs of life are absent.
- Laypeople should be trained to start resuscitation with chest compressions in adult and paediatric victims.
- If unwilling or unable to perform ventilations, rescuers should be instructed to continue compression-only CPR.
- EMS dispatchers should provide CPR instructions to callers who report cardiac arrest.
- When providing CPR instructions, EMS dispatchers should include recognition of gasping and abnormal breathing.

### Knowledge gaps

- Optimal method for teaching recognition of cardiac arrest including gasping, agonal, and abnormal breathing.
- Optimal method for laypeople to recognise return of spontaneous circulation (ROSC).
- Optimal methods for mass education of laypeople.

### Implementation and teams

The best scientific evidence for resuscitation will have little impact on patient outcomes if it is not effectively translated into clinical practice. Successful implementation is dependent on effective educational strategies to ensure that resuscitation providers have the necessary knowledge and skills in combination with the provision of necessary infrastructure and resources.<sup>293</sup> Education itself is only one strategy for implementing changes. This section addresses the need for a framework for successful implementation of guidelines, including broad implementation strategies that include educational activities.

### Implementation strategies

Little is known about what strategies work best for implementing evidence-based guidelines in communities, institutions, or units. Implementation of the 2005 resuscitation guidelines in emergency medical services agencies was reported to take a mean of  $416 \pm 172$  days in the Resuscitation Outcomes Consortium (ROC) sites<sup>294</sup> and 18 months in the Netherlands.<sup>295</sup> Identified barriers to rapid implementation included delays in getting staff trained, equipment delays, and organisational decision making.<sup>294,295</sup> This section provides insight into several elements that appear to facilitate successful implementation.

### Implementation factors<sup>EIT-022, EIT-022B</sup>

In communities where processes/guidelines are being implemented, does the use of any specific factors, compared with no such use, improve outcomes (e.g., success of implementation)?

### Consensus on science

Using the implementation of therapeutic hypothermia as an example, two LOE 3<sup>296,297</sup> and one LOE 5<sup>298</sup> single-institution interventional studies supported the use of a written protocol, pathway, or standard operating procedure as part of a comprehensive approach to implementing the therapeutic hypothermia guideline. One LOE 2 survey<sup>299</sup> and one LOE 3 single-institution intervention<sup>300</sup> also supported the use of written protocols, although Hay<sup>300</sup> only briefly described cointerventions used.

A wide spectrum of evidence supports the use of a comprehensive, multifaceted approach to guideline implementation, including identification and use of clinical champions, a consensus-building process, multidisciplinary involvement, written protocols, detailed process descriptions, practical logistic support, multimodality/multilevel education, and rapid cycle improvement (e.g., Plan, Do, Study, Act) to respond to problems as they arise. The evidence supporting this multifaceted approach includes one LOE 3 study,<sup>296</sup> one LOE 5 intervention description,<sup>298</sup> two LOE 5 theoretical reviews,<sup>301,302</sup> and four LOE 5 studies extrapolated from nonhypothermia nonarrest settings (2 RCTs,<sup>303,304</sup> one concurrent controlled trial,<sup>305</sup> and one retrospective controlled trial<sup>306</sup>).

### Treatment recommendation

Institutions or communities planning to implement complex guidelines such as therapeutic hypothermia should consider using a comprehensive, multifaceted approach including clinical champions, a consensus-building process, multidisciplinary involvement, written protocols, detailed process description, practical logistic support, multimodality/multilevel education, and rapid cycle improvement methods.

Investigators studying implementation of guidelines should consider using a framework for implementing guidelines (e.g., Brach-AHRQ, 2008)<sup>302</sup> and report whether results were measured or estimated, and whether they were sustained.

### Knowledge gaps

- Which specific factors (such as consensus-building, logistic support, rapid cycle improvement) are most critical for successful guidelines implementation?
- Differences between in-hospital and EMS implementations.
- Effectiveness of a multilevel approach (country, community, organisation, unit, individual).
- Importance of describing all cointerventions during implementation studies.
- Repeat surveys over time with same population to assess progress in implementation and to identify success factors and barriers.

### Individual and team factors

Individual and team factors impact performance during resuscitative attempts. This section describes specific factors that have an impact on performance during simulated or actual cardiac arrest.

### Prehospital physicians<sup>ALS-SC-077</sup>

In adult cardiac arrest (prehospital), does the performance of advanced life support procedures by experienced physicians, as opposed to standard care (without physicians), improve outcomes (e.g., ROSC, survival)?

### Consensus on science

In adult cardiac arrest, physician presence during resuscitation, compared with paramedics alone, has been reported to increase compliance with guidelines (LOE 2<sup>307</sup>; LOE 4<sup>308</sup>) and physicians in some systems can perform advanced resuscitation procedures more successfully (LOE 2<sup>307,309</sup>; LOE 4<sup>310–312</sup>).

When compared within individual systems, four studies suggested improved survival to hospital discharge when physicians were part of the resuscitation team (LOE 2<sup>313,314</sup>; LOE 3<sup>315,316</sup>) and 10 studies suggested no difference in survival of the event (LOE 2)<sup>307,313</sup> or survival to hospital discharge (LOE 2)<sup>307,315,317–323</sup>. One study found lower survival of the event when physicians were part of the resuscitation team (LOE 2)<sup>323</sup>.

Studies indirectly comparing resuscitation outcomes between physician-staffed and other systems are difficult to interpret because of the heterogeneity among systems, independent of physician-staffing (LOE 5)<sup>324</sup>. High survival rates after cardiac arrest have been reported from systems that employ experienced physicians as part of the EMS response (LOE 3<sup>325,326</sup>; LOE 4<sup>310,312,327</sup>) and these survival rates may be higher than in systems that rely on nonphysician providers (LOE 2<sup>328</sup>; LOE 3<sup>325,326,329</sup>). Other comparisons noted no difference in survival between systems using paramedics or physicians as part of the response (LOE 3)<sup>330,331</sup>. Well-organised nonphysician systems with highly trained

paramedics also reported high survival rates (LOE 5)<sup>324</sup>. There are no RCTs to address this question.

#### Treatment recommendation

There is insufficient evidence to make a recommendation for or against physician versus nonphysician providers of ALS during out-of-hospital CPR.

#### Knowledge gaps

More data are required to determine the training required to achieve best outcomes, the level of training and experience required to maintain competence in procedural skills, and the cost-effectiveness of physicians compared with nonphysicians.

#### Advanced life support checklists<sup>EIT-031A,EIT-031B</sup>

Does the use of a checklist during adult and paediatric advanced life support as opposed to no checklist, improve outcomes (e.g., compliance with guidelines, other outcomes)?

#### Consensus on science

Four LOE 5 randomised trials of cognitive aids/checklists for simulated basic life support,<sup>92,95,332,333</sup> three LOE 5 randomised trials of cognitive aids in simulated anaesthetic emergency or advanced resuscitation,<sup>334–336</sup> and one LOE 5 observational study<sup>337</sup> showed improvement in proxy outcomes (e.g., proper dosing of medications or performance of correct CPR procedures). One randomised<sup>338</sup> and one nonrandomised<sup>339</sup> trial (LOE 5) of cognitive aids showed improved recall of factual information important for effective advanced life support. Two LOE 4 surveys<sup>340,341</sup> on the use of checklists in actual resuscitations reported that physicians perceived cognitive aids to be useful. One LOE 5 retrospective analysis of actual anaesthesia emergency<sup>342</sup> suggested that a cognitive aid algorithm might be helpful in diagnosis and management. One LOE 5, three-armed study of simulated basic life support<sup>333</sup> demonstrated no difference in CPR performance between the short-checklist arm and the no-checklist arm, but a positive outcome in the long-checklist arm. One LOE 5 study of neonatal resuscitation<sup>343</sup> did not demonstrate any benefit from using a poster prompt.

Potential harm was found in one LOE 5 randomised trial of simulated basic life support<sup>103</sup> in which participants with a mobile-phone cognitive aid had >1-min delay in starting CPR. An LOE 5 simulated PALS study<sup>344</sup> showed potential harm because a significant portion of hand-held cognitive aid users applied the wrong algorithm. The outcome of using a cognitive aid such as a checklist may be specific to the aid or the situation.

#### Treatment recommendation

It is reasonable to use cognitive aids (e.g., checklists) during resuscitation, provided that they do not delay the start of resuscitative efforts. Aids should be validated using simulation or patient trials, both before and after implementation, to guide rapid cycle improvement.

#### Knowledge gaps

- The value of cognitive aids in simulated and actual resuscitation.
- Potential for unintended consequences associated with the use of a cognitive aid (especially delay to initiation of intervention or use of incorrect algorithm).

- Utility of specific cognitive aids with specific providers or in specific situations.
- Human factors issues in solo and team resuscitation.
- Optimal model for follow-up quality assurance (assessment of efficacy and rapid cycle improvement) after introduction of a cognitive aid.
- Transferability or generalizability of cognitive aids across settings.
- Can cognitive aids such as simple checklists be used without training?

#### Team briefings/debriefings<sup>EIT-001A,EIT-001B</sup>

For resuscitation teams, do briefings/debriefings, when compared to no briefings/debriefings, improve performance or outcomes?

#### HCP briefings/debriefings<sup>NRP-033A,NRP-033B</sup>

For HCPs, do briefings (before a learning or patient-care experience) and/or debriefings (after a learning or patient care experience), when compared to no briefings or debriefings, improve the acquisition of content knowledge, technical skills and behavioral skills required for effective and safe resuscitation?

#### Consensus on science

The terms ‘briefing,’ ‘debriefing,’ and ‘feedback’ are often used interchangeably in studies and have therefore been grouped as ‘briefings/debriefings’ in the Consensus on Science. Debriefings tend to occur after the event. Debriefing is an integral part of the actual training intervention in many studies. This makes it difficult to measure the effect of the debriefing.

Evidence from one LOE 1 prospective RCT<sup>345</sup> and 16 other studies (LOE 3–4)<sup>71,73,93,125,126,132,346–355</sup> documented improvement with briefings/debriefings in the acquisition of the content knowledge, technical skills, and/or behavioral skills required for effective and safe resuscitation. One LOE 4 study<sup>356</sup> revealed no effect of briefings/debriefings on performance. No studies indicated that the use of briefings/debriefings had any negative effect.

#### Treatment recommendation

It is reasonable to recommend the use of briefings and debriefings during both learning and actual clinical activities.

#### Knowledge gaps

- Relative benefits of team versus individual briefings/debriefings.
- Differential effectiveness of video, verbal, and other measures of feedback.
- Effects of briefings/debriefings on technical versus nontechnical skills.

#### System factors

This section describes broader resuscitation programs and implementation strategies that have an impact at a system level.

#### AED program factors<sup>EIT-015</sup>

In AED programs, what specific factors when included (e.g., linkage to 911 registries, location of program [including home]), compared with not included predict an effective outcome for the program?

## Outcomes of AED programs<sup>BLS-004B</sup>

In adults and children with out-of-hospital cardiac arrest (including residential settings), does implementation of a public access AED program, as opposed to traditional EMS response, improve successful outcomes (e.g., ROSC)?

### Consensus on science

One RCT (LOE 1)<sup>197</sup>, four prospective controlled cohort studies (LOE 2)<sup>357–360</sup>, one study using historical controls (LOE 3)<sup>361</sup>, nine observational studies (LOE 4)<sup>226,227,362–368</sup>, and one mathematical modeling study (LOE 5)<sup>369</sup> showed that AED programs are safe and feasible and significantly increase survival of out-of-hospital ventricular fibrillation (VF) cardiac arrest if the emergency response plan is effectively implemented and sustained.

For EMS programs, 10 studies (LOE 1<sup>370</sup>; LOE 2<sup>358</sup>; LOE 3<sup>224,371,372</sup>; LOE 4<sup>373–377</sup>) supported AED use; 11 studies (LOE 2<sup>378,379</sup>; LOE 3<sup>380–383</sup>; LOE 4<sup>384–388</sup>) were neutral, and two meta-analyses<sup>359,389</sup> suggested benefit.

For first-responder use, two studies (LOE 2<sup>390</sup>; LOE 3<sup>391</sup>) supported use of AEDs by fire or police first responders, but six studies (LOE 1<sup>392</sup>; LOE 2<sup>393</sup>; LOE 3<sup>394–396</sup>; LOE 4<sup>397</sup>) were neutral.

In public access trials, six studies (LOE 1<sup>197</sup>; LOE 2<sup>357</sup>; LOE 3<sup>361,362</sup>; LOE 4<sup>365,367</sup>) supported PAD. Two studies (LOE 3<sup>398</sup>; LOE 5<sup>399</sup>) were neutral. Five LOE 4 studies<sup>226,363,364,400,401</sup> demonstrated survival attributed to AED programs in casinos, airplanes, or airports. One LOE 4 study<sup>402</sup> was neutral.

For home AED deployment, three studies (LOE 1<sup>197,403</sup>; LOE 2<sup>404</sup>) showed that home AED programs are safe and feasible but were unlikely to result in a significant increase in survival of out-of-hospital VF cardiac arrest.

For on-site AEDs in public places, 11 studies (LOE 1<sup>197</sup>; LOE 2<sup>357</sup>; LOE 3<sup>224,361,362</sup>; LOE 4<sup>226,363–366,405</sup>) supported on-site AEDs. This approach demonstrates high survival at low deployment rates. Four studies (LOE 1<sup>392</sup>; LOE 2<sup>406</sup>; LOE 3<sup>395,398</sup>) did not demonstrate improvement in survival to discharge compared with EMS, despite better response time.

For mobile AEDs, three studies (LOE 2<sup>357,358</sup>; LOE 3<sup>391</sup>) reported that community first responders (CFRs) equipped with AEDs achieved improvement in survival when they arrived at the patient's side sooner than traditional EMS responders.

In one LOE 2 study<sup>358</sup> first responders were trained only in AED use; however, most survivors received CPR and AED, suggesting a role for CPR. There is no evidence to support a specific type of rescuer as better than another. One LOE 3 study<sup>361</sup> noted that even untrained bystanders achieved good results.

One LOE 3 study<sup>398</sup> reported that use of a restrictive dispatch protocol (unresponsive and not breathing) to summon first responders reduced the frequency of deployment, by reducing not only false alarms (false-positives) but also legitimate calls (true positives). In contrast, in one LOE 2 study<sup>358</sup> a less-restrictive dispatch protocol (unresponsive patient) yielded more false-positives as part of a wider involvement of first responders and increased survival. No difference in response interval appeared to be related to instrument of dispatch (telephone compared with pager).

### Treatment recommendation

Implementation of AED programs in public settings should be based on the characteristics of published reports of successful programs in similar settings.

Home AED use for high-risk individuals who do not have an ICD is safe and feasible and may be considered on an individual basis, but has not been shown to change overall survival rates.

Because population-specific (e.g., rate of witnessed arrest) and program-specific (e.g., response time) characteristics affect survival, when implementing an AED program, community and program leaders should consider factors such as location, development of a team with responsibility for monitoring and maintaining the devices, training and retraining programs for those who are likely to use the AED, coordination with the local EMS agency, and identification of a group of paid or volunteer individuals who are committed to using the AED for victims of arrest.

### Knowledge gaps

- Community or program characteristics of effective AED programs

Other specific worksheets that would be helpful are:

- Evaluating AED deployment strategies
- Should communities perform cardiac arrest surveillance to inform placement of public AEDs?

### Cardiac arrest centres<sup>ETT-027</sup>

In adults and children with out-of-hospital cardiac arrest, does transport to a specialist cardiac arrest centre (i.e., one providing a comprehensive package of post resuscitation care), compared with no such directed transport, improve outcomes (e.g., survival)?

### Consensus on science

Seven observational studies showed wide variability in survival to hospital discharge,<sup>407–411</sup> one-month survival,<sup>412</sup> or length of intensive care unit (ICU) stay<sup>413</sup> among hospitals caring for patients after resuscitation from cardiac arrest. One North American observational study<sup>411</sup> showed that higher-volume centres (>50 ICU admissions following cardiac arrest per year) had a better survival to hospital discharge than low-volume centres (<20 cases admitted to ICU following cardiac arrest) for patients treated for either in- or out-of-hospital cardiac arrest. Another observational study<sup>414</sup> showed that unadjusted survival to discharge was greater in hospitals that received  $\geq 40$  cardiac arrest patients/year compared with those that received <40 per year, but this difference disappeared after adjustment for patient factors.

Three LOE 3 observational studies<sup>297,415,416</sup> with historic control groups showed improved survival after implementation of a comprehensive package of post resuscitation care that included therapeutic hypothermia and percutaneous coronary intervention (PCI). Two small LOE 3 observational studies<sup>417,418</sup> demonstrated a trend toward improvement that was not statistically significant when comparing historic controls with the introduction of a comprehensive package of post resuscitation care, which included therapeutic hypothermia, PCI, and goal-directed therapy. One LOE 4 observational study<sup>409</sup> suggested improved survival to discharge after out of hospital cardiac arrest in large hospitals with cardiac catheter facilities compared with smaller hospitals with no cardiac catheter facilities. Another LOE 4 observational study<sup>414</sup> also showed improved outcome in hospitals with cardiac catheter facilities that was not statistically significant after adjustment for other variables. Three LOE 3 studies of out-of-hospital adult cardiac arrest<sup>419–421</sup> with short transport intervals (3–11 min) failed to demonstrate any effect of transport interval from the scene to the receiving hospital on survival to hospital discharge if ROSC was achieved at the scene.

Although there is no direct evidence that regional cardiac resuscitation systems of care (SOCs) improve outcomes compared with no SOC, extrapolation from multiple studies (LOE 5 for this question) evaluating SOC for other acute time-sensitive condi-

tions suggested a potential benefit. High-quality randomised trials and prospective observational studies of ST elevation myocardial infarction (STEMI) SOCs demonstrated improved<sup>422–425</sup> or neutral<sup>426–431</sup> outcomes compared with no SOC. Many case-control studies of regionalised care for trauma patients demonstrated improved<sup>432–450</sup> or neutral outcomes<sup>451–457</sup> when comparing an SOC with no SOC. One study that evaluated a trauma SOC<sup>458</sup> showed a higher mortality in the trauma centre. Observational studies and randomised trials<sup>459,460</sup> showed that organised care improves outcomes after acute stroke.

#### Treatment recommendation

While extrapolation from randomised and observational studies of SOCs for other acute time-sensitive conditions (trauma, STEMI, stroke) suggests that specialist cardiac arrest centres and systems of care may be effective, there is insufficient direct evidence to recommend for or against their use.

#### Knowledge gaps

- Safe journey time or distance for patient transport under various conditions
- Essential treatments that a cardiac resuscitation centre should offer
- Role of secondary transport from receiving hospital to a regional centre
- Ethics of conducting an RCT of standard care versus transport to a cardiac resuscitation centre
- Conditions under which a cardiac resuscitation centre is worthwhile (e.g., in areas where the other links in the Chain of Survival are optimised)
- Cost-effectiveness of cardiac arrest centres

*What resuscitation training interventions are practical, feasible, and effective in low-income countries?*<sup>EIT-028A, EIT-028B</sup>

#### Consensus on science

**Trauma resuscitation.** Trauma resuscitation studies constitute extrapolated evidence (LOE 5) for cardiac arrest patients. One study in Tanzania,<sup>461</sup> two studies in Trinidad and Tobago<sup>462</sup> and Ecuador,<sup>463</sup> and one study in Nigeria<sup>464</sup> reported that implementation of standard ATLS or trauma team training and modified trauma training programs were effective in developing trauma skill competencies in hospital providers. A study from Trinidad and Tobago<sup>465</sup> and two studies comparing Cambodia and Northern Iraq<sup>466,467</sup> demonstrated that the delivery of standard or appropriately modified ATLS training to the local community improved hospital mortality from trauma. Another study in Trinidad and Tobago<sup>468</sup> showed no difference in 6-h mortality after standard ATLS training when compared with pretraining.

One study in Trinidad and Tobago<sup>469</sup> showed that implementation of standard prehospital trauma life support (PHTLS) programs were effective in imparting competency in trauma skills to prehospital providers. Another study in Trinidad and Tobago<sup>470</sup> and 1 study in Mexico<sup>471</sup> demonstrated improved trauma patient survival to hospital admission when prehospital providers were trained in PHTLS and basic trauma life support (BTLS).

**Neonatal resuscitation.** One LOE 3 study in India<sup>472</sup> and one LOE 3 study in Zambia<sup>473</sup> demonstrated that neonatal resuscitation training improved neonatal mortality when incorporated into neonatal care training of midwives and traditional birth attendants, respectively. One LOE 2 study<sup>474</sup> in Argentina, the Democratic Republic of Congo, Guatemala, Pakistan, and Zambia and one LOE 3 study<sup>475</sup> in 14 centres in India did not demonstrate similar mortality reductions when training hospital physicians and nurses in neonatal resuscitation. In one LOE 3 study<sup>476</sup> in

Kenya, healthcare workers significantly improved operational performance immediately after a 1-day modified Resuscitation Council (UK) neonatal resuscitation course. One LOE 3 study<sup>474</sup> in Zambia demonstrated that midwives trained in neonatal resuscitation (American Academy of Pediatrics and American Heart Association Neonatal Resuscitation Program) maintained their psychomotor skills at 6 months, while cognitive skills declined to baseline.

*Paediatric advanced, adult cardiac, basic life, first aid.* Currently there is little evidence to address the hypothesis that basic, adult cardiac, or paediatric advance life support training programs provide the necessary training for the learners to achieve the significant improvement in cognitive, psychomotor, or team skills required to impact self-efficacy, competence, operational performance, or patient outcomes in developing countries. One LOE 2 study in Brazil<sup>477</sup> demonstrated a significant improvement in ROSC if a member of the resuscitation team was trained in ACLS, but survival to hospital discharge was not significantly different. One LOE 2 study<sup>471</sup> showed that implementation of standard ACLS in addition to BTLT training of prehospital providers in Mexico was not more effective in improving prehospital mortality from trauma compared with PHTLS alone.

One LOE 1 study in Brazil<sup>478</sup> demonstrated that video training was effective in training laypeople in basic skills of first aid, but was not effective in training the more complex skills of CPR.

#### Treatment recommendation

There is insufficient evidence to recommend for or against paediatric or adult basic or advanced level life support training programs in low-income countries. However, there is evidence that emergency medical training programs in neonatal and trauma resuscitation should be considered in these countries.

When delivering programs in low-income countries, consideration should be given to local adaptation of training, utilizing existing and sustainable resources for both care and training, and the development of a dedicated local infrastructure.

#### Knowledge gaps

- Which strategies of conducting sustainable emergency medical training programs in low-income countries are cost-effective?
- Which validated educational assessment tools can be tailored to low-income countries?
- What is the relative effectiveness of various training methods in low-income countries?
- Which educational interventions improve clinical outcomes in low-income countries?

*Performance measurement systems*<sup>EIT-023B</sup>

For resuscitation systems (out-of-hospital and in-hospital), does the use of a performance measurement system (e.g., Utstein template of outcome assessment) improve and/or allow for comparison of system outcomes (patient-level and system-level variables)?

#### Consensus on science

One LOE 3 before-and-after intervention study<sup>479</sup> found no statistically significant improvement in CPR quality or patient survival from providing information about CPR performance to the training teams of three different ambulance services. One LOE 4 case series<sup>480</sup> found a positive psychological effect on EMS personnel of reporting cardiac arrest outcomes back to them and presenting the results to the media.

#### Treatment recommendation

There is insufficient evidence to make recommendations supporting or refuting the effectiveness of specific performance

measurement interventions to improve processes of care and/or clinical outcomes in resuscitation systems.

#### Knowledge gaps

- The optimal system to monitor and improve the quality of care delivered within a resuscitation system.
- Does providing feedback to emergency medical personnel about their performance (individually and/or at a system level) improve patient outcomes?

#### Recognition and prevention

Patients who have cardiac arrest often have unrecognised or untreated warning signs. This section describes strategies to predict, recognise, and prevent cardiorespiratory arrest, including the role of education.

#### Sudden death in apparently healthy children and young adults<sup>EIT-007</sup>

In apparently healthy children and young adults, does the presence of any warning signs available to the layperson or HCP (e.g., syncope, family history), as opposed to their absence, predict an increased risk of sudden death? (Exclude screening in athletes and patients with known ischaemic heart disease.)

#### Consensus on science

*Specific symptoms in apparently healthy children and young adults.* There are no studies specifically examining the nature of syncope in apparently healthy children and young adults and their risk of sudden cardiac death (SCD). In one LOE P3 study<sup>481</sup> a family history of syncope or SCD, palpitations as a symptom, supine syncope, and syncope associated with exercise and emotional stress were more common in patients with than without Long QT Syndrome (LQTS). Two LOE P5 studies in older adults<sup>482,483</sup> identified the absence of nausea and vomiting before syncope and electrocardiogram (ECG) abnormalities as independent predictors of arrhythmic syncope. Less than 5 s of warning signs before syncope and less than two syncope episodes were predictors of syncope due to ventricular tachycardia (VT) or atrioventricular (AV) block.

A postmortem case study (LOE 5)<sup>484</sup> highlighted that inexplicable drowning and drowning in a strong swimmer may be due to LQTS or *Catecholaminergic Polymorphic Ventricular Tachycardia* (CPVT). Two LOE P5 studies<sup>485,486</sup> identified an association between LQTS and presentation with seizure phenotype.

*Screening for risk of SCD in apparently healthy young adults and children.* Evidence from two large prospective screening trials (LOE P1)<sup>487,488</sup> failed to identify any symptoms alone as a predictor of SCD in apparently healthy children and young adults. There was strong evidence in one of these trials<sup>487</sup> for use of 12-lead ECG when screening for cardiac disease.

*Prodromal symptoms in victims of sudden death and SCD.* Eight LOE P5 studies<sup>489–497</sup> examined the prodromal symptoms in victims of sudden death and SCD. Many patients complained of cardiac symptoms including syncope/presyncope, chest pain, and palpitations before death.

*Risk of SCD in patients with known cardiac disease.* In patients with a known diagnosis of cardiac disease, 11 studies (LOE P4<sup>498</sup>; LOE P5<sup>499–508</sup>) showed that syncope (with or without prodrome—particularly recent or recurrent) was invariably identified as an independent risk factor for increased risk of death. Chest pain on exertion only, and palpitations associated with syncope only, were associated with hypertrophic cardiomyopathy, coronary

abnormalities, Wolff-Parkinson-White, and arrhythmogenic right ventricular cardiomyopathy.

*Screening of family members.* Five LOE P4 studies<sup>498,509–512</sup> examining the systematic evaluation of family members of patients with cardiac diseases associated with SCD and victims of SCD demonstrated a high yield of families affected by syndromes associated with SCD.

#### Treatment recommendation

Children and young adults presenting with characteristic symptoms of arrhythmic syncope should have a specialist cardiology assessment, which should include an ECG and in most cases an echocardiogram and exercise test.

Characteristics of arrhythmic syncope include syncope in the supine position, occurring during or after exercise, with no or only brief prodromal symptoms, repetitive episodes, or in individuals with a family history of sudden death. In addition, nonpleuritic chest pain, palpitations associated with syncope, seizures (when resistant to treatment, occurring at night, or precipitated by exercise, syncope, or loud noise), and drowning in a competent swimmer should raise suspicion of increased risk. Systematic evaluation in a clinic specializing in the care of those at risk for SCD is recommended in family members of young victims of SCD or those with a known cardiac disorder resulting in an increased risk of SCD.

#### Knowledge gaps

- Efficacy, elements, and patient selection criteria for dedicated cardiac screening clinics for relatives of patients with inheritable cardiac disease or SCD victims.
- Outcomes in children and young people specifically investigated for cardiac symptoms potentially related to risk of SCD.
- Incidence of warning signs in those who have suffered sudden unexpected death in the young compared with those who died from other causes or a control population.
- Cardiac evaluation of children with seizure disorders without definite cerebral disease and recalcitrant to therapy.

#### Early recognition and response systems to prevent in-hospital cardiac arrests<sup>EIT-024</sup>

In adults admitted to hospital, does use of early warning systems/rapid response team (RRT) systems/MET systems, compared with no such responses, reduce cardiac and respiratory arrest?

#### Consensus on science

A single LOE 1 study involving 23 hospitals<sup>513</sup> did not show a reduction in cardiac arrest rate after introduction of an MET when analysed on an intention-to-treat basis. *Post hoc* analysis of that study<sup>514</sup> showed a significant inverse relationship between frequency of team activation and cardiac arrest and unexpected mortality rate. An LOE 2 multicentre study<sup>515</sup> did not show a reduction in cardiac arrest numbers after implementation of an MET. Seven additional LOE 3 studies<sup>516–522</sup> did not show a reduction in cardiac arrest rate associated with the introduction of an RRT/MET.

A meta-analysis<sup>523</sup> showed that RRT/MET systems were associated with a reduction in rate of cardiopulmonary arrest outside the ICU but not with a lower hospital mortality rate.

Seventeen LOE 3 single-centre studies<sup>524–540</sup> reported reduced numbers of cardiac arrests after the implementation of RRT/MET systems. None of these studies addressed the impact of confounding factors on study outcomes.

A single-centre LOE 3 study<sup>541</sup> was unable to demonstrate a reduction in cardiac arrest rates after the implementation of an early warning scoring system (EWSS). After implementing an EWSS, cardiac arrest rate increased among patients who had higher

early warning scores, compared to similarly scored patients before the intervention.

#### *Treatment recommendation*

In adult patients admitted to hospital, there is insufficient evidence to support or refute the use of early warning/RRT/MET systems, compared with no such systems, to reduce cardiac and respiratory arrests and hospital mortality. However, it is reasonable for hospitals to provide a system of care that includes (a) staff education about the signs of patient deterioration; (b) appropriate and regular vital signs monitoring of patients; (c) clear guidance (e.g., via calling criteria or early warning scores) to assist staff in the early detection of patient deterioration; (d) a clear, uniform system of calling for assistance; and (e) a clinical response to calls for assistance.

There is insufficient evidence to identify the best methods for the delivery of these components and, based on current evidence, this should be based on local circumstances.

#### *Prediction of cardiac arrest in adult patients in hospital*<sup>EIT-025</sup>

In hospital inpatients (adult), does the presence of any specific factors, compared with no such factors, predict occurrence of cardiac arrest (or other outcome)?

#### *Consensus on science*

**Outcome: cardiac arrest.** One LOE P3 multicentre cross-sectional survey,<sup>542</sup> one LOE P2 multicentre matched case-control study using pooled outcomes (cardiac arrest, unplanned ICU admission, and death),<sup>543</sup> and two single-hospital retrospective case-control studies (LOE P3<sup>544</sup> and LOE P4<sup>545</sup>) supported the ability of alterations in physiological variables, singly or in combination, to predict the occurrence of cardiac arrest. Single variables included heart rate, respiratory rate, systolic blood pressure, and decrease in level of consciousness. Combined elements included variably pooled and scored data (Modified Early Warning Score [MEWS]) with different cut-off points (MET criteria and MEWS). Sensitivity ranged from 49% to 89% and specificity from 77% to 99%.

An LOE P3 multicentre prospective observational study<sup>546</sup> measured the incidence of cardiac arrest, unplanned ICU admissions, and deaths, with or without antecedents recorded on charts: 60% of primary events had antecedents, the most frequent being decreases in systolic blood pressure and Glasgow Coma Scale (GCS) score.

Oposing evidence from one LOE P2 multicentre matched case-control study<sup>543</sup> and one LOE P2 single-hospital retrospective case-control study<sup>545</sup> reported that single variables and cut-offs did not correlate with the occurrence of cardiac arrest. Data were insufficient to define which variables and cut-offs were the best predictors of the occurrence of cardiac arrest.

**Outcome: unexpected ICU admission.** One LOE P3 multicentre cross-sectional survey,<sup>542</sup> one LOE P2 multicentre matched case-control study using pooled outcomes (cardiac arrest, unplanned ICU admission, and death),<sup>543</sup> one LOE P3 single-institution retrospective observational study,<sup>547</sup> and one LOE P2 single-centre prospective cohort study<sup>548</sup> suggested that for in-hospital patients, altered vital signs were associated with unplanned ICU admission. However, different criteria for ICU admission between studies make this a less useful end point.

**Outcome: mortality (predicted on admission to hospital).** Six studies (LOE P2<sup>549</sup>; LOE P3<sup>550,551</sup>; LOE P4<sup>552–554</sup>) supported the value of combinations of demographic, physiological, and/or laboratory variables recorded on admission in predicting death in specific patient populations.

Three studies (LOE P2<sup>555</sup> LOE P3<sup>556</sup> and LOE P4<sup>557</sup>) supported the value of combinations of demographic, physiological, and laboratory variables recorded on admission in predicting death in specific patient populations.

Eleven studies (LOE P1<sup>558–563</sup>; LOE P2<sup>548,564,565</sup> and LOE P3<sup>566,567</sup>) supported the value of different combinations of demographic, physiological, and/or laboratory value derangement recorded at admission to hospital in predicting death with a sensitivity and specificity in the range of 0.6–0.8, but the best combination of variables and cut-off levels is still to be identified.

**Prediction during hospital stay on ordinary wards.** Eleven studies (LOE P1 prospective multicentre observational<sup>568</sup>; LOE P1 prospective single-centre cohort<sup>569,570</sup>; LOE P3 multicentre cross-sectional survey<sup>542,571</sup>; LOE 2 multicentre matched case-control using pooled outcomes [cardiac arrest, unplanned ICU admission, and death]<sup>543</sup>; LOE P2 single-centre prospective observational<sup>572–574</sup>; LOE P3 multicentre prospective in a selected population of patients with greater illness severity<sup>575</sup>; LOE P3 single-centre retrospective observational<sup>576</sup>) supported the ability of physiological derangements measured in adult ward patients to predict death. The more abnormalities, the higher the risk of death, with a positive predictive value ranging from 11% to 70%. The best combination of variables and cut-off points is still to be identified.

**Best variables to predict outcome.** One LOE P2 cohort study on existing datasets<sup>577</sup> and 3 LOE P1 single-centre prospective studies<sup>561–563</sup> evaluating different variables showed a marked variation in their sensitivity and positive predictive value. For aggregate-weighted scoring systems, inclusion of heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), AVPU (alert, vocalizing, pain, unresponsive), temperature, age, and oxygen saturation achieved the best predictive value (area under Receiver Operating Characteristic curve 0.782, 95% CI 0.767–0.797). For single-parameter track and trigger systems, cut-off points of HR <35 and >140 min<sup>-1</sup>, RR <6 and >32 min<sup>-1</sup>, and SBP <80 mm Hg achieved the best positive predictive value. The inclusion of age improved the predictive value of both aggregate and single-parameter scoring systems.

#### *Treatment recommendation*

Hospitals should use a system validated for their specific patient population to identify individuals at increased risk of serious clinical deterioration, cardiac arrest, or death, both on admission and during hospital stay.

#### *Educational strategies to improve outcomes*<sup>EIT-026A</sup>

For hospital staff, does the use of any specific educational strategies, compared with no such strategies, improve outcomes (e.g., early recognition and rescue of the deteriorating patient at risk of cardiac/respiratory arrest)?

#### *Consensus on science*

There are no RCTs addressing the impact of a specific educational intervention on improvement of outcomes such as the earlier recognition or rescue of the deteriorating patient at risk of cardiac/respiratory arrest.

One LOE 3 multicentre before-and-after study<sup>578</sup> found that the number of cardiac arrest calls decreased while prearrest calls increased after implementing a standardised educational program in two hospitals; the intervention was associated with a decrease in true arrests as well as an increase in initial survival after cardiac arrest and survival to discharge. A prospective LOE 3 single-centre trial<sup>579</sup> of a simulation-based educational program failed to yield such benefits.

### Treatment recommendation

There is insufficient evidence to identify specific educational strategies that improve outcomes (e.g., early recognition and rescue of the deteriorating patient at risk of cardiac/respiratory arrest). Educational efforts have a positive impact on knowledge, skills, and attitudes/confidence, and increase the frequency of activation of a response, and should therefore be considered.

### Knowledge gaps

- Optimal risk stratification on admission and during hospital stay for clinical deterioration or death.
- Methods to identify patients most likely to benefit from early treatment escalation.
- Importance of various components of the rapid response system—including education, monitoring, calling criteria, mechanism of calling, and response.
- Elements of required education—including calling criteria, clinical skills, and simulation training.
- Optimal frequency of vital signs monitoring to detect deterioration.
- Cost-benefits of physician-led versus nonphysicians teams.
- Cost-benefits of rapid response team versus patient team responses.
- Do RRT/MET systems (or their individual components) improve outcomes other than cardiac arrest (e.g., reduced hospital mortality, reduced length of stay)?
- Impact of other variables (e.g., time of day, monitoring status) on risk.

### Ethics and outcomes

The decision to start, continue and terminate resuscitation efforts is based on the balance between the risks, benefits, and burdens these interventions place on patients, family members, and healthcare providers. There are circumstances where resuscitation is inappropriate and should not be provided. This includes when there is clear evidence that to start resuscitation would be futile or against the expressed wishes of the patient. Systems should be established to communicate these prospective decisions and simple algorithms should be developed to assist rescuers in limiting the burden of unnecessary, potentially painful treatments.

### Decisions before cardiac arrest<sup>EIT-016</sup>

In adults and children with cardiac arrest (prehospital [OHCA], in-hospital [IHCA]), does existence and use of advance directives (e.g., “living wills” and Do Not Attempt Resuscitation [DNAR] orders), compared with no such directives, improve outcomes (e.g., appropriate resuscitative efforts)?

### Consensus on science

In adults with out-of-hospital cardiac arrest, five studies (LOE 4<sup>580–582</sup>; LOE 5<sup>583,584</sup>) supported the use of DNAR orders and Physician Orders for Life Sustaining Treatment (POLST) forms compared with no such directives to improve outcomes (e.g., appropriate resuscitative efforts). One LOE 4 study<sup>585</sup> supported the use of advance directives in the context of a communitywide approach. Three LOE 4 studies<sup>586–588</sup> were neutral. Four studies (LOE 2<sup>589</sup>; LOE 4<sup>585,590,591</sup>) supported the use of advance directives. Two studies (LOE 1<sup>592</sup>; LOE 2<sup>593</sup>) suggested that the presence of advance directives reduced resuscitation rates in patients.

In adult patients with cardiac arrest, 18 additional studies (LOE 1<sup>594–597</sup>; LOE 2<sup>598–600</sup>; LOE 4<sup>601–606</sup>; LOE 5<sup>607–611</sup>) did not support the use of advance directives (e.g., living wills), compared with no such directives, to improve outcome defined as resuscitative efforts

based on patient preference. Evidence from one LOE 3 study<sup>612</sup> suggested that the presence of a DNAR order decreased CPR rates.

No study was found that specifically addressed these issues in children.

### Treatment recommendation

Standardised orders for limitations on life-sustaining treatments (e.g., DNAR, POLST) should be considered to decrease the incidence of futile resuscitation attempts and to ensure that adult patient wishes are honored. These orders should be specific, detailed, transferable across healthcare settings, and easily understood. Processes, protocols, and systems should be developed that fit within local cultural norms and legal limitations to allow providers to honor patient wishes about resuscitation efforts.

### Knowledge gaps

- Implementation of DNAR/POLST in patients who move among different healthcare settings (e.g., out-of-hospital and in-hospital).
- Relationship between DNAR/POLST decisions and patient preferences.
- Critical elements for prehospital DNAR.

### Termination of resuscitation rules<sup>EIT-003A</sup>

For adult patients in any setting, is there a clinical decision rule that enables reliable prediction of ROSC (or futile resuscitation efforts)?

### Consensus on science

One high-quality LOE P1 prospective study in adults<sup>613</sup> demonstrated that the “basic life support termination of resuscitation rule” (no shockable rhythm, unwitnessed by EMS, and no ROSC) is predictive of death when applied by defibrillation-only emergency medical technicians (EMTs). The survival rate with the application of this rule is 0.5% (95% CI 0.2–0.9). Subsequent studies including two LOE P1 studies<sup>614,615</sup> showed external generalizability of this rule.

Additional adult studies (LOE P1<sup>616</sup>; LOE P2<sup>617</sup>; LOE P5<sup>618</sup>) showed associations with futility of certain variables such as no ROSC at scene, nonshockable rhythm, unwitnessed arrest, no bystander CPR, call response time, and patient demographics.

Two in-hospital studies (LOE P1<sup>619</sup>; LOE P2<sup>620</sup>) and one emergency department (ED) study (LOE P2)<sup>621</sup> showed that the reliability of termination of resuscitation rules is limited in these settings.

### Treatment recommendation

Prospectively validated termination of resuscitation rules such as the “basic life support termination of resuscitation rule” are recommended to guide termination of prehospital CPR in adults.

Other rules for various provider levels, including in-hospital providers, may be helpful to reduce variability in decision-making; however, rules should be prospectively validated before implementation.

### Knowledge gaps

- When to start CPR in neonatal, paediatric, and adult patients.
- When to stop CPR in paediatric and neonatal patients.
- Prospectively validated termination of resuscitation rule for advanced life support providers.

### Quality of life

Part of the decision-making process in deciding for or against commencing resuscitation is the likelihood of success of the resus-



citation attempt and the quality of life that can be expected following discharge from hospital.

#### *Quality of life after resuscitation*<sup>EIT-006</sup>

In cardiac arrest patients (in-hospital and out-of-hospital), does resuscitation produce a good quality of life for survivors after discharge from hospital?

#### *Consensus on science*

Eight prospective cohort studies (LOE P1)<sup>622–629</sup>, two 'follow-up of untreated control group in an RCT' studies (LOE P2)<sup>630,631</sup>, eight retrospective cohort studies (LOE P3)<sup>632–639</sup>, and 28 case series (LOE P4)<sup>319,326,640–665</sup> showed that quality of life is good in cardiac arrest survivors.

One prospective cohort study (LOE P1)<sup>666</sup>, one 'follow-up of untreated control group in an RCT' study (LOE P2)<sup>667</sup>, three retrospective cohort studies (LOE P3)<sup>634,668,669</sup>, and 12 case series (LOE P4)<sup>417,670–680</sup> showed that cardiac arrest survivors experience problems in physical, cognitive, psychological, and social functioning that impact on quality of life to a varying degree.

Seven case series (LOE P4)<sup>681–687</sup> suggested that resuscitation led to high rate of cognitive impairment and poorer quality of life. Four of these seven studies evaluated populations in which cardiac arrest prognosis is considered poor: nursing home patients,<sup>681</sup> octogenarians,<sup>686</sup> out-of hospital paediatric cardiac arrests with on-going CPR on hospital arrival,<sup>683</sup> and patients who remain comatose after resuscitation from out-of-hospital cardiac arrest.<sup>687</sup>

#### *Treatment recommendation*

Resuscitation after cardiac arrest produces a good quality of life in most survivors. There is little evidence to suggest that resuscitation leads to a large pool of survivors with an unacceptable quality of life. Cardiac arrest survivors may experience problems including anxiety, depression, post-traumatic stress, and difficulties with cognitive function. Clinicians should be aware of these potential problems, screen for them, and if found, treat them. Interventional

resuscitation studies should be encouraged to include a follow-up evaluation (ideally at least 6 months post-event) that assesses general health-related quality of life with a validated instrument (e.g., Health Utility Index 3, EQ5D, SF36), affective disorder (anxiety and depression), post-traumatic stress disorder, and cognitive function.

#### *Knowledge gaps*

- The best approach for clinicians to use to measure quality of life for patients after resuscitation.
- Consensus on a recommended set of QoL dimensions and measures to facilitate comparison and integration of literature, and future research.
- Long-term QoL studies of resuscitated children.
- Impact on families of cardiac arrest survivors.

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## Appendix A. Evidence-based worksheets for Part 12: education, implementation, and teams: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations

Task Force	WS ID	PICO title	Short title	Authors	URL
ALS	ALS-SC-077	In adult cardiac arrest (prehospital) (P), does the performance of ALS procedures by experienced physicians (I) as opposed to standard care (without physicians) (C), improve outcome (O) (e.g., ROSC, survival)?	ALS procedures	Michael Bernhard, Bernd W. Böttiger, Clifton Callaway, Joseph P. Ornato	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc2.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc2.pdf</a>
BLS	BLS-002A	In rescuers (P), does performing CPR on adult and paediatric patients with cardiac arrest (out-of-hospital and in-hospital) (I) as opposed to not performing CPR (ventilations and compressions) (C), increase the likelihood of harm (O) (e.g., infection)?	Harm to rescuers from CPR	Sung Oh Hwang	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc3.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc3.pdf</a>
BLS	BLS-004B	In adult and paediatric patients with out-of-hospital cardiac arrest (including residential settings) (P), does implementation of a public access AED program (I) as opposed to traditional EMS response (C), improve successful outcomes (O) (e.g., ROSC, survival)?	Public access AED programs	E. Brooke Lerner	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc4.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc4.pdf</a>
BLS	BLS-005A	In rescuers performing CPR on adult or paediatric patients (P), does compression only CPR (I) when compared with traditional CPR (C) result in an increase in adverse outcomes (e.g., fatigue) (O)?	Rescuer fatigue in CC Only CPR	Michael Baubin, Anthony J. Handley	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc5.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc5.pdf</a>
BLS	BLS-012A	In rescuers performing CPR on adult or paediatric patients (out-of-hospital and in-hospital) (P), does the use of barrier devices (I) as opposed to no such use (C), improve outcome (O) (e.g., lower infection risk)?	Barrier devices	E. Brooke Lerner	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=BLS-012A.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=BLS-012A.pdf</a>
EIT	EIT-001A	For resuscitation teams (P), do briefings/debriefings (I), when compared to no briefings/debriefings (C), improve performance or outcomes (O)? (INTERVENTION)	Debriefing of CPR performance	Dana P. Edelson, Trevor Yuen	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc6.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc6.pdf</a>

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EIT	EIT-001B	For resuscitation teams (P), do briefings/debriefings (I), when compared to no briefings/debriefings (C), improve performance or outcomes (O)? (INTERVENTION)	Debriefing of CPR performance	Jasmeet Soar	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc7.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc7.pdf</a>
EIT	EIT-002A	For LAY PROVIDERS and HCPs (P), does the use of specific instructional methods (video/computer self-instructions) (I), when compared with traditional instructor-led courses (C) improve skill acquisition and retention (O)? (INTERVENTION)	CPR instruction methods (self-instruction vs traditional)	Anthony J. Handley	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc8.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc8.pdf</a>
EIT	EIT-002B	For LAY PROVIDERS and HCPs (P), does the use of specific instructional methods (video/computer self-instructions) (I), when compared with traditional instructor-led courses (C) improve skill acquisition and retention (O)? (INTERVENTION)	CPR instruction methods (self-instruction vs traditional)	Linda Denke, Mary Mancini	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc9.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc9.pdf</a>
EIT	EIT-003A	For adult (in any setting (P), is there a clinical decision rule (I) that enables reliable prediction of ROSC (or futile resuscitation efforts)? (DIAGNOSIS)	Futile resuscitation rules	Jennifer Dennett	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc10.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc10.pdf</a>
EIT	EIT-004	For students of advanced level resuscitation courses (such as ACLS and PALS) (P), does success in the written examination (I) when compared with lack of success (C), predict success in completing the practical skills testing associated with the course or in resuscitation management performance in actual or simulated resuscitation events (O)? (PROGNOSIS)	Written exam for advanced resuscitation courses	Farhan Bhanji, David L. Rodgers	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc11.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc11.pdf</a>
EIT	EIT-005A	In laypersons and HCPs performing CPR, does the use of CPR feedback devices when compared to no device improves CPR skill acquisition, retention, and real life performance? (INTERVENTION)	CPR feedback devices during training	Gavin D. Perkins, Joyce Yeung	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc12.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc12.pdf</a>
EIT	EIT-005B	In laypersons and HCPs performing CPR, does the use of CPR feedback devices when compared to no device improves CPR skill acquisition, retention, and real life performance? (INTERVENTION)	CPR feedback devices during training	Reylon A. Meeks	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc13.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc13.pdf</a>
EIT	EIT-006	In cardiac arrest patients (in-hospital and prehospital) [P] does resuscitation [I] produce a good Quality of Life (QoL) for survivors after discharge from the hospital. [O]? Prognosis	Quality of life after resuscitation	Stephen Brett, Vanessa Elliott, David L. Rodgers	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc14.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc14.pdf</a>
EIT	EIT-007	In apparently healthy children and young adults (P), does the presence of any warning signs available to the lay person or health care professional (e.g. syncope, family history) (I), as opposed to their absence (C), predict an increased risk of sudden death (O)? (Exclude screening in sportsmen and patients with known ischaemic heart disease)	Warning signs predict increased risk of sudden death	Rani Robson, Jonathan Skinner	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc15.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc15.pdf</a>

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EIT	EIT-008A	In bystanders (lay or HCP) (P), are there any specific factors (I) compared with standard interventions (C) that increase outcomes (e.g., willingness to provide or the actual performance of CPR (standard or chest compression only) on adult or paediatric patients with cardiac arrest (prehospital [OHCA]) (O)?	Willingness to provide CPR	Judy Young	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc16.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc16.pdf</a>
EIT	EIT-008B	In bystanders (lay or HCP) (P), are there any specific factors (I) compared with standard interventions (C) that increase outcomes (e.g., willingness to provide or the actual performance of CPR (standard or chest compression only) on adult or paediatric patients with cardiac arrest (prehospital [OHCA]) (O)?	Willingness to provide CPR	Tetsuo Hatanaka, Masami Ishikawa, Keiichi Tada	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc17.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc17.pdf</a>
EIT	EIT-009A	In ALS/PALS providers (P), are there any specific training interventions (e.g., duration of session, interactive computer programmes/e-learning, video self-instruction) (I) compared with traditional lecture/practice sessions (C) that increase outcomes (e.g., skill acquisition and retention) (O)?	Comparison of training methods	Alessandro Barelli, Farhan Bhanji	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc18.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc18.pdf</a>
EIT	EIT-010	In BLS providers (lay and HCP) (P), are any specific intervals for update/retraining (I) compared with standard practice (i.e., 12 or 24 monthly) (C) that increase outcomes (e.g., skill acquisition and retention) (O)?	Timing for BLS retraining	Maaret Castrén, Barbara Furry	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc19.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc19.pdf</a>
EIT	EIT-011A	In ALS and PALS providers (P), are any specific intervals for update/retraining (I) compared with standard practice (i.e., 12 or 24 monthly) (C) that increase outcomes (e.g., skill acquisition and retention) (O)?	Timing for advanced resuscitation retraining	Jane E. McGowan	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc20.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc20.pdf</a>
EIT	EIT-011B	In ALS and PALS providers (P), are any specific intervals for update/retraining (I) compared with standard practice (i.e., 12 or 24 monthly) (C) that increase outcomes (e.g., skill acquisition and retention) (O)?	Timing for advanced resuscitation retraining	Matthew Huei-Ming Ma, Chih-Wei Yang, Zuisen Yen	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc21.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc21.pdf</a>
EIT	EIT-012A	In lay providers requiring BLS training (P), does focusing training on high risk populations (I) compared with no such targeting (C) increase outcomes (e.g., bystander CPR, survival) (O)?	BLS training for high risk populations	Elaine Gilfoyle	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc22.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc22.pdf</a>
EIT	EIT-012B	In lay providers requiring BLS training (P), does focusing training on high risk populations (I) compared with no such targeting (C) increase outcomes (e.g., bystander CPR, survival) (O)?	BLS training for high risk populations	Cassandra L. Williams	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc23.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc23.pdf</a>
EIT	EIT-013A	In BLS providers (lay or HCP) requiring AED training (P), are there any specific training interventions (I) compared with traditional lecture/practice sessions (C) that increase outcomes (e.g., skill acquisition and retention, actual AED use) (O)?	AED training methods	Deems Okamoto	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc24.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc24.pdf</a>

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EIT	EIT-013B	In BLS providers (lay or HCP) requiring AED training (P), are there any specific training interventions (I) compared with traditional lecture/practice sessions (C) that increase outcomes (e.g., skill acquisition and retention, actual AED use) (O)?	AED training methods	Gavin D. Perkins, Joyce Yeung	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc25.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc25.pdf</a>
EIT	EIT-014A	In providers (lay or HCP)(P), does undertaking training/perform actual CPR or use of defibrillator (manual or AED) (I) compared with no such training/performance(C) increase harm (e.g., infection or other adverse events)(O)?—include electrical safety of defibrillation	CPR training and harm to rescuer	Franklin H.G. Bridgewater	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc26.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc26.pdf</a>
EIT	EIT-015	In AED programs (P), does the inclusion of any specific factors (e.g., linkage to 911 registries, location of program [including home]) (I) compared with not including those factors (C) improve the outcome of the program (O)?	AED training content	David C. Parish, Andrea Scapigliati, Antoine Trammell	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc27.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc27.pdf</a>
EIT	EIT-016	In adult and paediatric patients with cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does existence and use of advanced directives (e.g., “living wills” and “do not resuscitate” orders) (I) compared with no such directives (C), improve outcome (e.g., appropriate resuscitation efforts) (O)?	Advanced directives	Jennifer Dennett, Terri Schmidt	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc28.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc28.pdf</a>
EIT	EIT-017A	In ALS providers undergoing ALS courses (P), does the inclusion of specific leadership/team training (I), as opposed to no such specific training (C), improve outcomes (e.g., performance during cardiac arrests) (O)?	Team and leadership training	Robin P. Davies, Dana P. Edelson, Trevor Yuen	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc29.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc29.pdf</a>
EIT	EIT-018A	In ALS providers undergoing ALS courses (P), does the inclusion of specific precourse preparation (e.g., e-learning and pre-testing) (I), as opposed to no such preparation (C), improve outcomes (e.g., same skill assessment, but with less face to face (instructor) hands on training) (O)?	Precourse preparation for advanced courses	Andrew Lockey, David L. Rodgers	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc30.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc30.pdf</a>
EIT	EIT-019A	In participants undergoing BLS/ALS courses (P), does the inclusion of more realistic techniques (e.g., high fidelity manikins, in-situ training) (I), as opposed to standard training (e.g., low fidelity, education centre) (C), improve outcomes (e.g., skills performance on manikins, skills performance in real arrests, willingness to perform) (O)?	High fidelity training	Jordan Duval-Arnould, Elizabeth A. Hunt	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc31.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc31.pdf</a>
EIT	EIT-019B	In participants undergoing BLS/ALS courses (P), does the inclusion of more realistic techniques (e.g., high fidelity manikins, in-situ training) (I), as opposed to standard training (e.g., low fidelity, education centre) (C), improve outcomes (e.g., skills performance on manikins, skills performance in real arrests, willingness to perform) (O)?	High fidelity training	Judith Finn	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc32.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc32.pdf</a>

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EIT	EIT-020	In participants undergoing ALS courses (P), does the use of random scheduling (introducing station cases in a random manner) (I), as opposed to block scheduling (grouping the agenda around specific station activities such as VF or bradycardias) (C), improve outcomes (e.g., skills performance) (O)? Other outcomes may need to be determined after review of the literature, include use of modular courses	ALS scenarios: random vs block	Ian Bullock, David L. Rodgers	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc33.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc33.pdf</a>
EIT	EIT-021A	In participants undergoing BLS/ALS courses (P), does end of course testing (I), as opposed to continuous assessment and feedback (C), improve outcomes (e.g., improve learning/performance) (O)?	End of course testing vs continuous feedback	Farhan Bhanji, Gavin D. Perkins	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc34.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc34.pdf</a>
EIT	EIT-022	In communities where processes/guidelines are being implemented (P), does the use of any specific factors (I), compared with no such use (C), improve outcomes (e.g., success of implementation) (O)?	Implementation of community guidelines	John E. Billi, R. Van Harrison	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=EIT-022.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=EIT-022.pdf</a>
EIT	EIT-022B	In communities where processes/guidelines are being implemented (P), does the use of any specific factors (I), compared with no such use (C), improve outcomes (e.g., success of implementation) (O)?	Implementation of community guidelines	Patrick Chow-In Ko	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=EIT-022B.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=EIT-022B.pdf</a>
EIT	EIT-023B	For resuscitation systems (prehospital and in-hospital) (P), does the use of a performance measurement systems (e.g., Utstein) improve and/or allow for comparison of system outcomes (patient level and system level variables) (O)?	Measuring performance of resuscitation systems	Judith Finn, Satoshi Takeda	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc37.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc37.pdf</a>
EIT	EIT-024	In adult patients admitted to hospital (P), does use of EWSS/response teams/MET systems (I) compared with no such responses (C), improve outcome (e.g., reduce cardiac and respiratory arrests) (O)?	METs	Michael DeVita, Mary Beth Mancini, Nicola Poplett, Gary Smith, Jasmeet Soar	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc38.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc38.pdf</a>
EIT	EIT-025	In-hospital in-patients (adult) (P), does the presence of any specific factors (I) compared with no such factors (C), predict occurrence of cardiac arrest (or other outcome) (O)?	Predicting in-hospital cardiac arrest	Erga Cerchiari, Michael DeVita	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc39.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc39.pdf</a>
EIT	EIT-026A	In-hospital staff (P), does the use of any specific educational strategies (I) compare with no such strategies (C) improve outcomes (e.g., early recognition and rescue of the deteriorating patient (at risk of cardiac/respiratory arrest)) (O)?	Training strategies for hospital staff (to predict arrest?)	Geoffrey K. Lighthall, Anne Lippert	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc40.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc40.pdf</a>
EIT	EIT-027	In adult and paediatric patients with out-of-hospital cardiac arrests (P), does transport to a specialist cardiac arrest centre (I) compared with no such directed transport (C), improve outcome (e.g., survival) (O)?	Cardiac arrest centres	Graham Nichol, Jasmeet Soar	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc41.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc41.pdf</a>
EIT	EIT-028A	What resuscitation training interventions are practical, feasible and effective in low income countries?	Resuscitation training in low income countries	Martin Botha	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc42.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc42.pdf</a>
EIT	EIT-028B	What resuscitation training interventions are practical, feasible and effective in low income countries?	Resuscitation training in low income countries	Peter A. Meaney	<a href="http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc43.pdf">http://www.resuscitationjournal.com/article/PIIS0300957210004569/attachment?filename=mmc43.pdf</a>



Writing group member	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Farhan Bhanji	McGill University—Assistant Professor of Pediatrics	None	None	None	None	None	None
John E. Billi	University of Michigan Medical School Associate Dean	None	None	None	None	None	None
Jennifer Dennett	Central Gippsland Health Service-Deputy Director of Nursing	None	None	None	None	None	None
Judith Finn	University of Western Australia—Professor	<sup>b</sup> Multiple National Health and Medical Research Grants (NH&MRC), National Heart Foundation Australia and State Government grants of >\$10,000 since 1999. A—No money came to me—all came to my University to employ research staff and meet research expenses. No grants were directly related to any topic on which I am undertaking a Worksheet and none involved the trialing of a commercial product	None	<sup>a</sup> Less than \$1000 from the Japanese Resuscitation Council to speak at their JRC Conference in Osaka in 2009	None	None	None
Mary Fran Hazinski	Vanderbilt University School of Nursing—Professor; AHA ECC Product Development—Senior Science Editor <sup>a</sup> I receive significant compensation from the AHA precisely to provide protected time so I can co-edit the 2010 CoSTR and the 2010 AHA Guidelines for CPR and ECC. Thus, although I have a significant relationship, I think the purpose of the relationship is to help ensure the quality, consistency and timeliness of the both documents because I can devote the time to follow-through. One of the CoSTR sections that I will be helping to write and that I will be editing is the Education, Implementation and Teams section	None	None	None	None	None	None
Ian Jacobs	University of Western Australia: Discipline of Emergency Medicine Teaching/Research academic—Professor; American Heart Association: Evaluation of evidence worksheets for C2010—Work Sheet Expert	<sup>b</sup> Chief investigator on numerous grants awarded by:	<sup>b</sup> Funds are received into the Discipline of Emergency Medicine —University of Western Australia from the Ambulance Service—Western Australia and Laerdal (Australia) to maintain the Cardiac Arrest Registry for Western Australia. Our role is to independently maintain, analyse and report outcomes of cardiac arrest in Western Australia. I oversee the operation of the registry and reporting of outcomes. These funds are not used in any way to provide any direct or indirect salary or other financial support	None	None	None	None



Writing group member	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
		(a) National Health and Medical Research Council (b) The Department of Health—Western Australia (c) The National Heart Foundation of Australia These funds are awarded to the University of Western Australia and none are used to provide any direct or indirect salary or other financial support					
Matthew Huei-Ming Ma	National Taiwan University Hospital: Patient care, education and research—Associate professor of emergency medicine	None	None	None	None	None	None
Peter T. Morley	Royal Melbourne Hosp; Univ of Melbourne; Dir of Medical Education; AHA EEE	None	None	None	None	None	None
Gavin D. Perkins	University of Warwick—Associate Professor	<sup>b</sup> Department of Health National Institute of Health (NIH) Research—Research for patient benefit grant to investigate strategies to improve quality of CPR in clinical practice. Grant awarded to institution—I am the PI;	None	None	None	None	None
	Editor for Resuscitation Journal	<sup>b</sup> Resuscitation Council (UK)—Research Grant to support randomised controlled trial of e-learning versus standard advanced life support training. Grant awarded to my institution. I am the PI					
David Rodgers	Healthcare Simulation Strategies—President and Owner	None	None	<sup>a</sup> Received \$750 for presenting at Laerdal Medical Midwest Simulation User Network meeting in 2008	None	<sup>b</sup> Provide consultation services to Laerdal Medical in patient simulation education program development	<sup>b</sup> Spouse (Robin R. Roberts) is an employee of the American Heart Association

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be “significant” if (a) the person receives \$10,000 or more during any 12-month period, or 5% or more of the person’s gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10,000 or more of the fair market value of the entity. A relationship is considered to be “modest” if it is less than “significant” under the preceding definition.

<sup>a</sup> Modest.

<sup>b</sup> Significant.





Worksheet collaborator	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Linda Denke	Collin College Education of senior nursing students	None	None	None	None	None	None
Michael DeVita	Professor of Nursing UPMC Health System healthcare organisation physician, associate medical director	None	None	None	None	None	None
Jordan Duval-Arnould	Johns Hopkins University—Senior Clinical Research Coordinator	None	None	None	None	None	None
Dana P. Edelson	University of Chicago—Assistant Professor	<sup>b</sup> Research Grants  Pending NHLBI Career Development Award Strategies to Predict and Prevent In-Hospital Cardiac Arrest (IHCA) (1K23HL097157-01) To validate a clinical judgment based tool for predicting impending clinical deterioration of hospitalised floor patients and compare it to previously described physiology-based tools Role: PI (funds delivered to university) <sup>b</sup> 2009—present Philips Healthcare Research Grant Advancements in Cardiopulmonary Resuscitation and Emergency Care during Haemodynamic Crisis To measure capnography and pulse pressure, using a novel plethysmographic sensor, in critically ill patients and correlate quality of CPR with these measures during CA Role: PI (funds delivered to university) <sup>b</sup> 2008—present Philips Healthcare Research Grant Q-CPR Users and Development Research Alliance The purpose of this project is to establish a multi-centre registry of in-hospital resuscitation quality data and a network for clinical trials of resuscitation	<sup>a</sup> Philips Healthcare, Andover, MA	<sup>a</sup> Philips Healthcare, Andover, MA	None	<sup>a</sup> Triage Wireless, San Diego, CA	<sup>a</sup> Expert Witness—Hanna Campbell & Powell LLP, Akron, OH—Hankton v Beeson



Worksheet collaborator	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Tetsuo Hatanaka	Emergency Life-Saving Technique Academy—Professor	<sup>b</sup> Research grant for “Cardiovascular Disease H18-Heart-01: A Study on Automated External Defibrillator Program and System Development for Improved Survival from Emergency Cardiovascular Disease” from the Ministry of Health, Labor and Welfare, Japan. The grant money comes directly to me	None	<sup>a</sup> Several kinds of honoraria for scientific meetings	None	None	None
Elizabeth A. Hunt	Johns Hopkins University School Med. Pediatric intensivist, researcher & Dir of Johns Hopkins Med Simulation Center—Director, Assist. Prof.	<sup>a</sup> Co PI on AHA grant to study relationship between scripted debriefing & high fidelity simulation on learning during PALS course	None	None	None	None	None
Sung Oh Hwang	Yonsei University, Republic of Korea Professor	None	None	None	<sup>b</sup> Patent owner (Sung Oh Hwang)—US patent (US7214203), Cardiopulmonary resuscitation apparatus <sup>b</sup> Stock holder (Sung Oh Hwnag)—Humed Co, Republic of Korea	None	None
Masami Ishikawa Patrick Chow-In Ko	Kure Kyosai Hosp; MD National Taiwan University Hospital healthcare provider Attending Physician/Assistant Professor	None None	None None	None None	None None	None None	None None
Yasuhiro Kuroda	Kagawa University, Japan: Department of Emergency, Disaster, and Critical Care Medicine—Professor	None	None	None	None	None	None
E. Brooke Lerner	Medical College of Wisconsin—Associate Professor	<sup>b</sup> Grant funding All monies are given to my institution. I receive no funding directly 1. Injury Research Center, Medical College of Wisconsin 2009–2011 Development of a Study of EMS Findings Predictive of Ped. Trauma Center—understand the epidemiology of injured ped.pts transported by EMS. To develop a strong multi-center study proposal to determine which Field Triage Criteria are most predictive of trauma center need for ped. patients	None	None	None	None	None

Worksheet collaborator	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
		<p>Role: Principal-Investigator 5% support 2.HRSA/MCHB Project #U03MC00007 2008-20011 EMS for Children Network Development Demonstration Project To form collaborative research partnerships among various EMS agencies and academic and hospital-based entities Role: Co-Investigator 10% support 3. CDC, Project #1R49CE001175-01 2008-2012 Injury Research Center at the Medical College of Wisconsin Grant addresses the burden of injury in the Great Lakes Region of the Midwest (Wisconsin, Minnesota, Illinois, Indiana, Michigan &amp; Ohio). Role: Epidemiologist 5% support 4. CDC, Project #U17/CE001232-01 2007-2010 Identifying &amp; Disseminating Best Practices by Collaboration of Public Health &amp; the EMS-This cooperative agreement is to bring together national organisations to work on projects to gather &amp; disseminate information on the response to terrorism related injuries. Main activities include developing a national guideline for mass casualty triage and identify communities that are models for integration of public health and emergency care. Role: Principal-Investigator 9% support 5. Zoll Medical Corporation, Project # N/A 2006-2010 Circulation Improving Resus. Care This project will determine if Auto-Pulse integrated CPR is superior or equivalent to manual CPR, in terms of the number of pts who survive to hospital discharge after OHCA. Role: Consultant 20% support</p>					

Worksheet collaborator	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Geoffrey K. Lighthall	US Department of Veterans Affairs Physician	None	None	None	None	None	None
Anne Lippert	Danish Institute for Medical Simulation: Regional Institute for Medical education, development and research—Consultant	None	None	None	None	None	None
Andrew Lockey	Calderdale & Huddersfield NHS Foundation Trust—EM Consultant	None	None	None	None	None	None
Jane E. McGowan	SCPA/Tenet healthcare: Pediatric Practice Group—Attending Neonatologist	None	None	None	None	None	None
Peter A. Meaney	University of Pennsylvania, Children's Hospital of Philadelphia: Anaesthesia, Critical Care and Pediatrics—Assistant Professor	<sup>a</sup> Laerdal Foundation, Research grant "Development and Validation of a Quantitative Measurement Device to Assess Technical Basic Life Support Skills in Resource Limited Settings." No direct support to investigator	<sup>a</sup> Laerdal Corporation, Research equipment (study manikins) for "Development and Validation of a Quantitative Measurement Device to Assess Technical Basic Life Support Skills in Resource Limited Settings." No direct support to investigator	<sup>a</sup> Received \$400 to give lecture on "Pediatric Rhythms and Outcomes for In-Hospital Cardiac Arrest" at San Antonio Trauma Symposium, August 2008	<sup>a</sup> I have multiple mutual funds as part of my retirement and college savings portfolios. Am unsure as to how much is allocated to any conflicted companies	None	None
Reylon A. Meeks	Blank Children's Hosp/Pleasant Hill FD; Clinical Nurse Specialist/Fire Chief	<sup>a</sup> Operation Smile, Educational development grant, "Pilot Training Proposal: Acute Care Training for the Peri-Operative Pediatrician." No direct support to investigator	None	None	None	None	None
Graham Nichol	University of Washington State-Professor	<sup>b</sup> NHLBI, Bethesda, MD. Co-PI, Resuscitation Outcomes Consortium Data Coordinating Center <sup>b</sup> NHLBI, Bethesda, MD. PI, Randomised Trial of Haemofiltration After Resuscitation from Cardiac Arrest <sup>b</sup> NHLBI, Bethesda, MD. Co-I, Randomised Field Trial of Cold Saline IV After Resuscitation from Cardiac Arrest. <sup>a</sup> Asmund S Laerdal Foundation for Acute Medicine Stavanger, NO PI, Randomised Trial of CPR Training Aid in Community	None	None	None	None	None



Worksheet collaborator	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Deems Okamoto	Ballard Emergency Physicians—Independent contractor providing emergency medical evaluation and treatment as a physician	None	None	None	None	None	None
Joseph Ornato	Virginia Commonwealth University Health System academic health center Prof & Chmn, Emergency Medicine	<sup>b</sup> NIH Neurological Emergency Treatment Trials, Principal Investigator, VCU study site	None	<sup>a</sup> ZOLL Circulation (approximately 1 lecture a year at most for last 5 years)	None	<sup>b</sup> Significant Consultant Advisory Board:  NIH sponsored Resuscitation Outcomes Consortium, Cardiac Co-Chair/Consultant <sup>a</sup> Advisory Board: ZOLL Circulation (unpaid, receive only travel reimbursement for approximately 1 advisory board meeting per year, usually on East Coast close to home)	<sup>b</sup> American Editor, Resuscitation
David Parish	Mercer University School of Medicine Education of medical students and residents, medical research, patient care and community service. Professor, Interim Chair, Internal Medicine	None	None	None	None	None	None
Nicola Polett	Portsmouth Hospitals NHS Trust Healthcare—NHS Resuscitation Manager	None	None	None	None	None	None
Rani Robson	North Bristol NHS Trust—Cardiology Registrar	None	None	None	None	None	None
Andrea Scapigliati	Catholic University School of Medicine, Rome, Italy—Assistant Professor	None	None	None	None	None	None
Terri Schmidt	Clackamas County Health Department—EMS Medical Director	None	None	None	None	None	<sup>a</sup> Investigator in the Resuscitations Outcomes Consortium which is funded by the NIH and AHA among others. Funding is to the institution and I have no salary support on the grant



Worksheet collaborator	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Judy Young	Anne Arundel Medical Center: Direct patient care nurse in the CCU (Critical Care Unit). Work part time for this facility—Staff Nurse, CCU; Brevard Community College—Adjunct Clinical Faculty, Department of Nursing.; Sebastian River Medical Center: Direct patient care to critical care patients in the ICU. Work part time for this facility—RN, ICU; Florida Legal Nurse Experts, LLC—Owner, Florida Legal Nurse Experts, LLC	None	None	None	None	None	None
Trevor Yuen	University of Chicago Med Center; Clinical Research Data Assistant	None	None	None	None	None	None

This table represents the relationships of worksheet collaborators that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all worksheet collaborators are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10,000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10,000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

<sup>a</sup> Modest.

<sup>b</sup> Significant.

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