Circulation

AHA SCIENTIFIC STATEMENT

Resuscitation Education Science: Educational Strategies to Improve Outcomes From Cardiac Arrest

A Scientific Statement From the American Heart Association

ABSTRACT: The formula for survival in resuscitation describes educational efficiency and local implementation as key determinants in survival after cardiac arrest. Current educational offerings in the form of standardized online and face-to-face courses are falling short, with providers demonstrating a decay of skills over time. This translates to suboptimal clinical care and poor survival outcomes from cardiac arrest. In many institutions, guidelines taught in courses are not thoughtfully implemented in the clinical environment. A current synthesis of the evidence supporting best educational and knowledge translation strategies in resuscitation is lacking. In this American Heart Association scientific statement, we provide a review of the literature describing key elements of educational efficiency and local implementation, including mastery learning and deliberate practice, spaced practice, contextual learning, feedback and debriefing, assessment, innovative educational strategies, faculty development, and knowledge translation and implementation. For each topic, we provide suggestions for improving provider performance that may ultimately optimize patient outcomes from cardiac arrest.

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Despite ongoing advances in resuscitation science, cardiac arrest survival rates remain suboptimal for both in-hospital and out-of-hospital settings. High-quality cardiopulmonary resuscitation (CPR) in compliance with American Heart Association (AHA) guidelines is associated with improved survival outcomes from cardiac arrest.[1] Although millions of lay providers and healthcare providers are trained in resuscitation every year, major gaps exist in the delivery of optimal clinical care (eg, poor-quality CPR or no CPR in the out-of-hospital setting) for individuals with cardiac arrest. Educational activities are not consistently achieving their intended outcomes, with a significant decay in skills within months after the learning activity.[2,3] The design and delivery of resuscitation education must be optimized by leveraging proven educational methods that promote learning and retention to ensure that individuals with cardiac arrest receive excellent resuscitative care. Similarly, knowledge translation and implementation science is inadequately considered in efforts to implement principles taught during resuscitation education despite their critical impact on patient outcomes. Poor CPR quality is a preventable harm.

Dramatic variation in cardiac arrest survival across comparable geographic and institutional populations[4,5] suggests that there are modifiable risk factors that may improve survival, including quality of resuscitative care delivered. For example, the

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implementation of rapid response teams comprising healthcare providers with advanced resuscitation skills is associated with a reduction in the incidence of cardiopulmonary arrests and improved survival rates.[6–8] It is critical to focus efforts on training and implementation issues to optimize outcomes and to evaluate the effectiveness of proposed strategies. Given the >500 000 cardiac arrests per year in the United States,[1] enhanced training and knowledge translation could save more lives than any new scientific breakthrough in the clinical management of cardiac arrest. Deliberate consideration of the scientific evidence for effective design and delivery of resuscitation education and knowledge translation is required to improve cardiac arrest outcomes. In this AHA scientific statement, we describe the existing literature supporting the various elements of resuscitation education and knowledge translation, provide suggestions to improve cardiac arrest outcomes, and highlight opportunities for future research in the field.

THE FORMULA FOR SURVIVAL IN RESUSCITATION

The formula for survival in resuscitation was introduced in an International Liaison Committee on Resuscitation (ILCOR) advisory statement on education and resuscitation in 2003 and adopted during a 2006 Utstein Symposium meeting attended by international resuscitation experts.[9,10] The formula describes 3 interactive factors—guideline quality (medical science), efficient education of patient caregivers (education efficiency), and a functional chain of survival at the local level (local implementation)—as key determinants of survival after cardiac arrest. Medical science includes ILCOR's coordinated review of resuscitation science, the development of consensus treatment recommendations,[3,11–13] and the subsequent dissemination of resuscitation guidelines by various councils and resuscitation organizations worldwide.[10]

Here, we discuss the education and local implementation components of the formula for survival, drawing attention to key elements that may improve overall survival after cardiac arrest. We expand on the original formula for survival in resuscitation by highlighting elements that serve to optimize educational efficiency and local implementation (Figure). Educational efficiency is influenced by the instructional design of educational offerings, including but not limited to mastery learning and deliberate practice, spaced learning, contextual learning, feedback and debriefing, assessment, and other innovative educational strategies. Educational offerings include resuscitation training events and courses, learning that is structured around clinical resuscitation events (eg, postevent debriefing), and education facilitated through technology. As the Figure shows, education science informs how we integrate instructional design features into educational offerings in these different contexts. Enhancing instructional design in these contexts can improve educational outcomes (ie, provider knowledge, skills, and attitudes), which will ultimately translate to improved patient outcomes and survival after cardiac arrest. Principles from knowledge translation and implementation science should inform implementation efforts at the local level. Faculty development is the process by which resuscitation instructors (ie, teaching faculty) and implementers (ie, individuals supporting knowledge translation efforts) work to improve the skills necessary to achieve the outcomes relevant to their specific role. The design of faculty development

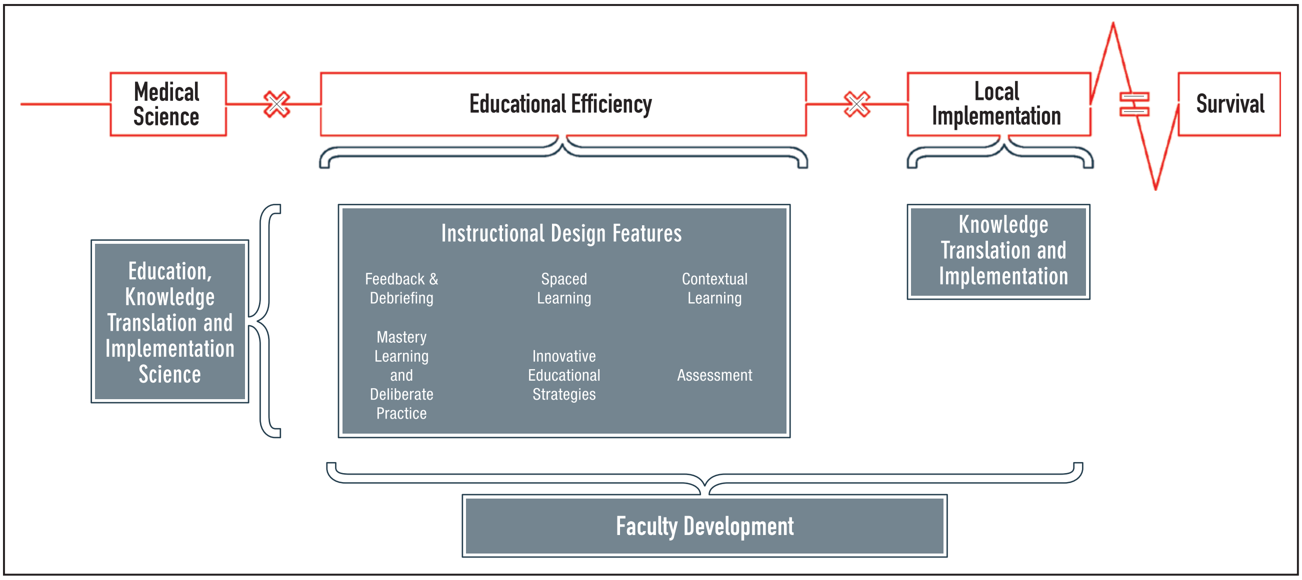

Figure. Modified formula for survival.

efforts should be informed by education science and structured to provide the skills necessary for instructors and implementers to achieve success.

RATIONALE FOR THE AHA SCIENTIFIC STATEMENT ON RESUSCITATION EDUCATION

ILCOR remains the major international forum for the systematic review of resuscitation science with the intermittent publication of the International Consensus on CPR and Emergency Cardiovascular Care (ECC) Science With Treatment Recommendations. ILCOR has conducted systematic reviews based on PICO (population, intervention, comparator, outcome) questions and focused on randomized controlled trials. This approach is designed to look at clinical questions with direct evidence and may not be as relevant for education or implementation topics, which often involve complex interventions such as different modes of debriefing; multifaceted outcomes like learning, retention, and patient outcomes; or topics that do not conform to the randomized controlled trial research design and are informed by reviews of literature from nonmedical fields such as educational psychology. From the perspective of the AHA ECC Committee, there was an opportunity to build on the ILCOR process to better inform resuscitation instructors and implementers to close the gap between desired and actual performance in resuscitation events for both lay providers and healthcare professionals.

METHODS

This scientific statement was produced through a multistep process, involving (1) developing a steering committee; (2) defining the scope of the scientific statement; (3) selecting topics, working group leads, and writing group members; (4) selecting working group members; (5) reviewing the literature; (6) holding an AHA Education Summit; and (7) drafting and revising a scientific statement. A steering committee of 5 individuals was formed. Steering committee members had expertise in resuscitation science and resuscitation education and prior involvement with ILCOR evidence reviews, AHA guideline development, and AHA resuscitation product development (A.C., F.B., V.M.M., M.B.M., E.A.H.). These individuals met in person and via several conference calls to define the scope of the scientific statement. Decisions were based on knowledge of the existing literature, including existing scientific statements, and group consensus on which topics would most likely lead to improvements in educational and patient outcomes. The steering committee decided to focus the scientific statement and AHA Education Summit on 8 key topic areas: 6 topics relate to instructional design features (ie, mastery learning and deliberate practice, spaced learning, contextual learning, feedback and debriefing, innovative educational strategies, and assessment), with the other 2 topics being faculty development and knowledge translation and implementation.

Individuals with expertise in a key topic area were identified by the steering committee and invited to participate in a working group tasked with conducting an evidence review for 1 topic area. Each working group was composed of 5 to 9 members who were selected on the basis of expertise. Various professions (eg, nursing, medicine, paramedicine, respiratory therapy, psychology, research, education, hospital administration) and clinical specialties (eg, critical care, pediatrics, neonatology, emergency medicine, anesthesia, internal medicine, cardiology) were appropriately represented in each working group. Working groups conducted scoping reviews of the literature by using an existing methodological framework[14] or building on existing published reviews from 1 of the 8 key topic areas. Working group leads were assigned by the steering committee and invited to be part of the writing group, with the writing group approved in accordance with the AHA's conflict of interest management policy.

A summary of each review was presented at the AHA Education Summit, held February 27 and 28, 2017, in Chicago, IL. Steering committee members, working group leads, working group members, and AHA staff made up the participants. Small group sessions during the summit allowed discussion of the evidence for each topic area, identification of suggestions, and considerations for implementation and research gaps. Each working group also received input from participants from outside their group in a roundtable format. Input and edits for each key topic area were received, integrated with the results of the literature review, and presented to all participants at the end of the AHA Education Summit. Modifications were then integrated into drafts of each section prepared by the working group lead, which were subsequently reviewed and incorporated into a single document. A draft of the scientific statement was prepared and circulated among writing group members for comments and editing until consensus was reached.

MASTERY LEARNING AND DELIBERATE PRACTICE

Background

Despite the common phrase "practice makes perfect," not all practice is equal. It is possible for a learner to practice multiple times with no observable improvement in performance. One unifying theme for resuscitation courses is that all are trying to increase the likelihood that the learner will be able to save a life during a cardiac arrest event when seconds matter. Educators should deliver resuscitation education experiences that allow learners to practice key skills, receive directed feedback, and improve until they attain mastery. Incorporation of these instructional design elements for key competencies has the potential to improve translation of skills acquired in the classroom to the real clinical environment.

The term *mastery* implies that a learner can consistently demonstrate a predefined level of competence for a specific skill or task. For example, learners in a basic life support (BLS) course would be expected to demonstrate in a simulated cardiac arrest that they can provide guideline-compliant chest compressions, place an automated external defibrillator (AED) and deliver a shock within 180 seconds, and achieve a chest compression fraction of >80%. To optimize the likelihood that a learner will be able to master key resuscitation skills, an instructor may ask a learner to practice multiple times to increase the likelihood of achieving identified learning objectives. Mastery learning and deliberate practice have been identified as "features…of simulation-based medical education that teachers should know in order to…maximize educational benefit."[15] In this section, we define mastery learning and deliberate practice, explore the evidence supporting the use of these instructional design features in resuscitation education, provide suggestions, and describe implementation issues related to integrating these concepts into resuscitation education.

Definitions

McGaghie[16] has synthesized the literature on mastery learning and describes 7 complementary features:

1. *Baseline, or diagnostic testing;*
2. *Clear learning objectives, sequenced as units usually in increasing difficulty;*
3. *Engagement in educational activities (eg, deliberate skills practice, calculations, data interpretation, reading) focused on reaching the objectives;*
4. *A set minimum passing standard (eg, test score) for each educational unit;*
5. *Formative testing to gauge unit completion at a preset minimum passing standard for mastery;*
6. *Advancement to the next educational unit given measured achievement at or above the mastery standard; and*
7. *Continued practice or study on an educational unit until the mastery standard is reached.*

For resuscitation courses that use mastery learning, course design must include frequent assessments of learning and an element of flexibility. For example, a plan should exist for learners to be given more time (or a new teaching method) if the standard approach is not working for them to attain the minimum passing standard for a specific skill.

First described by Ericsson et al[17] in 1993, deliberate practice "includes activities that have been specially designed to improve the current level of performance" in which weaknesses are systematically identified and addressed to move to the next level. They highlight that repetition is not sufficient; rather, repetition should be paired with feedback directed at weaknesses and coupled with the assignment of specific exercises for the individual to address between sessions with the coach. The resuscitation community can apply the key principles from this framework to create the most effective and efficient training programs possible, given the limited time available and high-stakes nature of our curricula.

Summary of Evidence

Mastery Learning and Deliberate Practice in Health Care (Not Resuscitation)

Studies demonstrate exposure to a mastery learning curriculum that uses deliberate practice is associated with improvement in a variety of procedural skills. For example, McGaghie et al[18] summarized a series of studies describing the impact of their mastery learning course for central venous line insertion by internal medicine residents who demonstrated measurably improved skills and decreased arterial punctures, line adjustments, and insertion failures. In addition, they reported a 7:1 rate of financial return for the resources invested in the simulation-based training secondary to decreased costs from central line–associated bloodstream infections. These data were supported by a systematic review that measured a strong association between the use of simulation-based education with deliberate practice and improved educational outcomes relative to standard educational approaches across different skill domains (surgical/technical skills, resuscitation skills, cardiac auscultation skills), with an overall effect size correlation of 0.71 (large effect size).[19,20]

Mastery Learning and Deliberate Practice in Health Care: Resuscitation

In resuscitation training, the use of a mastery learning and deliberate practice model to teach advanced cardiovascular life support (ACLS) to internal medicine residents as four 2-hour blocks with peer feedback showed that 80% (33 of 41) of participants passed the assessment after the scheduled 8-hour course, whereas 20% (8 of 41) required an additional 15 minutes to 1 hour to achieve the minimal passing score on all 6 ACLS cases.[21] Their results demonstrate the feasibility of using this model for resuscitation courses, including setting minimum passing scores while navigating varying amounts of time for learners to achieve their predefined level of mastery. Although most studies of retention demonstrate a significant decay in resuscitation skills within weeks to months after completion,[3] remarkably, they did not see a measurable decay in skill when assessing the learners 14 months after their course.[22]

Reed et al[23] describe excellent success in teaching fourth-year medical students partial task skills related to resuscitation (chest compressions, defibrillation, bag-mask ventilation, etc) using a hybrid model of asynchronous online didactic modules combined with subsequent hands-on deliberate practice with a mastery learning model. This study was unique in the use of the asynchronous online module and demonstrated excellent retention of skills on surprise retesting at 1 to 9 months after the course. A study of pediatric residents demonstrated that a short, deliberate practice-based training session (1–2 hours) was effective in allowing learners to achieve mastery, which was maintained in 90% of learners 2 months after training.[24] In 2 different studies assessing the impact of simulation-based deliberate practice interventions in neonatal resuscitation scenarios, Sawyer et al[25] found deliberate practice to be associated with improved skills and global performance scores in simulated scenarios, and Cordero et al[26] found improved procedural skills (eg, intubation, umbilical lines) and teamwork scores.

Hunt et al introduced a variant of deliberate practice called rapid-cycle deliberate practice that explicitly acknowledges the need to rapidly achieve a set level of mastery and expertise in any given session because of the high-stakes nature of certain clinical skills related to time-sensitive emergencies such as cardiac arrest or difficult airway.[27] Key instructional design features include a baseline formative assessment simulation, followed by interruptions when errors are observed, objective data-driven feedback, multiple opportunities to rewind and repeat until mastery of that concept is achieved, and then escalation of the difficulty or number of objectives. Through the addition of more complex concepts or skills, learners are kept in what Vygotsky[28] referred to as the zone of proximal development to keep stretching and building on what they have mastered. The facilitator provides specific prescriptions on how to improve performance such as the evidence-based use of "action-linked phrases" (eg, link the discovery of loss of pulse to the initiation of chest compressions by using the script, "There's no pulse. I'm starting compressions") or specific choreography to minimize pauses in chest compressions.[29] Rapid-cycle deliberate practice has been associated with improved performance with shorter training times, along with a decrease in decay compared with standard simulation approaches.[27,30–33] Although learners rate rapid-cycle deliberate practice sessions highly, they report fatigue resulting from the constant high energy required with this model of effortful practice.[27,30,31] In summary, emerging evidence suggests that using mastery learning and deliberate practice for resuscitation courses is associated with improved performance compared with traditional courses, as well as translation to improved patient care.

Standard Setting/Cut Scores

Yudkowsky et al[34,35] present a thoughtful summary of issues to consider when attempting to define the minimum passing standard or cut scores for educational exercises by framing these discussions in the context of patient safety. Standard setting in mastery learning is contrasted with the process of setting cutoffs for examination scores. That is, "rather than predicting the behavior of a minimally competent student who is just at the edge of acceptable performance, judges will be modeling the performance of a student who is well prepared to succeed at the next stage of instruction or practice."[35] Overlearning and automaticity should be considered,[35] with the learner spending extra time practicing a skill even after performing it correctly once, with a goal of performing it correctly a specified number of times or more quickly and within a certain time frame to attenuate the natural decay of skill.[35,36] For example, a randomized controlled educational trial of surgical novices revealed improved transfer of surgical skills from the simulated environment (skills trainer) to the operating room (animal model) when the intervention group was exposed to the deliberate practice model and trained past proficiency. Cognitive load is the amount of mental effort and memory in use during an educational experience.[37] Training to overlearning and automaticity was associated with increased ability to free up cognitive space (ie, reduce cognitive load) to be able to attend to other clinical issues because not all mental energy is going into doing the basic procedure.[38] Delineating key outcome measures for resuscitation courses and setting minimum passing scores are important concepts for mastery learning and deliberate practice, particularly in resuscitation courses where lives are at stake and failure is not an option.

Suggestions

- Incorporate a mastery learning model for performance behaviors in which a minimum passing standard is required. Prioritization should be given to those behaviors that have a clear link to patient safety or clinical outcomes.
- Use deliberate practice as the training model for behaviors that have any of the following:
  - Are difficult to master without feedback
  - Can benefit from automaticity
  - Optimize retention and shorten learning curves
- Establish a performance goal for both mastery learning and deliberate practice. Standard

performance should be an observable behavior and set on the basis of the following:
  - Patient outcomes
  - Process measures (time, accuracy, best practice, protocol, or checklist standard of performance)
- Use overlearning for behaviors that are likely to decay and require effort to retrain to mastery or that require significant cognitive load to free up space to be able to manage other aspects of a resuscitation event simultaneously.
- Whenever possible, provide model/exemplar performance for learners (model/exemplar videos).

Implementation Issues

- Develop a reliable approach to dealing with the variable time aspect of mastery learning within the context of resuscitation educational offerings.
- Identify or develop key metrics and assessment tools to be used in mastery learning (ie, in terms of minimum passing scores relevant to resuscitation events).
- Because deliberate practice is instructor intensive, issues need to be considered to be able to scale up. Therefore,
  - Take advantage of face-to-face time after completion of cognitive testing (finish the knowledge examination and close knowledge gaps as necessary).
  - Take advantage of time when the learner can practice with other feedback sources (eg, automated feedback from device).
  - Clearly delineate any skills for which mastery is not necessary within a resuscitation course (eg, mastery for intraosseous line placement but not for central venous line placement).
  - Explore approaches to addressing aspects of teamwork in this model.

SPACED PRACTICE

Background

Resuscitation training involves the acquisition of specific knowledge, skills (psychomotor, teamwork, communication), and attitudes with the goal of maximizing performance during patient care. The schedule of training for many current resuscitation courses, such as ACLS or pediatric advanced life support (PALS), involves learners participating in a 1- or 2-day training course and passing a test to obtain a course completion card. Depending on the course, renewal is typically required every 1 to 2 years. This schedule of course work is effective for short-term learning because most providers will pass their test at the end of the course. However, evidence demonstrates that after resuscitation training courses, skills and knowledge deteriorate after 1 to 6 months without ongoing practice.[39–41] When providers are called on to resuscitate a patient during this interval, their performance may be suboptimal. Increasing the frequency of training may improve the efficacy of training, protect against skill deterioration, enhance performance during patient care, and improve patient outcomes.

Definitions

Spaced or distributed practice involves the separation of training into several discrete sessions over a prolonged period with measurable intervals between training sessions (typically weeks to months), whereas massed practice involves a single period of training without rest over hours or days. In spaced practice, the content is distributed across different sessions or repeated at each session. The number of repetitions and time intervals between repetitions can vary. The term *booster training* has been used to describe spaced practice after initial completion of training and is generally related to low-frequency tasks such as the provision of CPR.[42] The terms *just-in-time training*, *just-in-place training*, and *refreshers* describe training that is conducted in temporal or spatial proximity to performance.[43,44]

The spacing effect, the finding that practice distributed over time yields better learning than practice massed more closely together, was first described in cognitive psychology.[45] Extensive research has reported the benefits of spacing in controlled learning laboratories. Although the exact mechanism behind the spacing effect is not yet clear, the theoretical basis underlying study-phase retrieval and elaboration is particularly compelling. Study-phase retrieval theory describes that after the initial learning of information, repetition after a period of rest requires retrieval of that information from another part of the brain. This leads to elaboration of learning and a deeper processing of the information into memory.[46] In contrast, a massed approach involves repetition within a very short period when the first episode of learning is still active when the second presentation occurs (ie, does not require retrieval from another location, thus resulting in limited processing into memory).

Most research on spaced learning involves memory or the retrieval of discrete information. Working memory organizes the information so that it may be efficiently stored as packages in long-term memory. Although the capacity of long-term memory is limitless in duration and volume, the working memory capacity is limited to 7±2 units.[37,47,48] Because learning requires the processing of information in working memory, it suffers when the cognitive load of the task exceeds the working memory capacity of the learner. Teaching a complex procedure in small portions over a dispersed period decreases the intrinsic load of the learner and prevents cognitive fatigue, which might alter the cognitive load of learners.[49]

Summary of Evidence

In this section, we highlight some of the research supporting the use of spaced practice for resuscitation training by provider type (lay or healthcare provider) and course type (BLS, ACLS, or PALS). For healthcare and lay providers, the studies of spacing are heterogeneous in instructional design, learners, and outcomes. A systematic review of best practices to teach CPR to school children reported that implementation of spaced practice improves BLS performance.[50] Training every 6 or 12 months was superior to biannual training,[51,52] and a brief 15-minute refresher at 6 months improved retention of chest compression skills in adult lay providers.[53]

Healthcare Providers: BLS Training

The benefits of using brief, frequent, and repeated practice episodes have been described as they relate to resuscitation skills.[54] Nurses participating in spaced in situ training for 15 minutes every 2, 3, or 6 months demonstrated improvements in the 2- and 3-month groups compared with the 6-month and control groups (for initiation of compressions and performing defibrillation).[32] Using a voice-activated manikin for 6 minutes of practice each month improved confidence and skills over a 1-year period.[55–57] Nurses and residents who completed booster training at 1, 3, and 6 months for 120 seconds in a pediatric intensive care unit improved their skills.[42] The placement of a portable training system in a pediatric intensive care unit for 15 weeks improved skills of participants practicing >2 times per month compared with those practicing less frequently.[44] Nurses practicing CPR for as little as 2 minutes at repeated intervals improved retention in some studies,[58–60] although another study demonstrated no significant impact.[61] The Resuscitation Quality Improvement program is a BLS training program offered by the AHA that requires learning, practice, and testing every 3 months at a workplace-based training station.[62] Participants perform self-directed CPR skills practice with automated feedback. This approach may also be cost-effective compared with the current paradigm because it involves short training sessions in the workplace that do not require providers to take time off from their clinical duties.

Healthcare Providers: Advanced Life Support Training

Spaced practice has demonstrated positive outcomes compared with massed training. Students who participated in 4 weekly 1.25-hour PALS sessions over 4 weeks demonstrated a modest improvement in completion of critical skills compared with participants in a single 5-hour PALS course.[63] Another study of a spaced PALS program involving six 30-minute in situ simulations over 6 months noted improvements in guideline adherence related to ventilations and chest compressions but no improvement in teamwork behaviors compared with a single traditional 7.5-hour course.[64] A systematic review related to neonatal resuscitation noted that spaced practice improves performance.[65] A booster session 9 months after an initial neonatal resuscitation training course resulted in improved procedural and teamwork skills of residents.[66] A separate study reported that fewer errors were made by individuals participating in neonatal resuscitation booster training every 3 months compared with a standard training group.[67]

In summary, the evidence demonstrates improvements in both BLS and advanced life support performance with spaced practice for all types of providers. However, the optimal duration and frequency of training are undetermined, and a one-size-fits-all approach to spaced practice is likely not appropriate. The goal should be to achieve and maintain mastery. The optimal duration of each resuscitation training session, the interval between sessions, and the number of repetitions are likely dependent on the content area, learner, instructor, and prior experience.

Suggestions

- The current massed approach to resuscitation training should be replaced or supplemented with a spaced practice.
- The duration and design of each training session, the interval between sessions, and the number of repetitions should be tailored to context, learner type, objectives, and prior experiences.
- Techniques such as debriefing after real resuscitation events and in situ simulation can be used to provide spaced training experiences.
- Technology-enhanced simulators and learning management systems should be used to collect individual learner data during training to determine the interval of training.

Implementation Issues

- Implementing spaced practice will increase the number of learning, practice, and testing sessions, likely leading to increased costs.
- Organizing spaced practice will require more complex logistics for faculty and trainees.
- Participation in spaced learning requires ongoing motivation. It may be challenging to engage providers in repeated, effortful practice.
- The optimal interval of training is unknown for most skills, so learning management systems will

have to be used to inform the interval for individual providers.

- Although in situ simulation and debriefing after real events offer workplace-based opportunities for spaced practice, these techniques are limited to providers working in institutions where resources and personnel are available to support these activities.

CONTEXTUAL LEARNING

Background

A core educational concept for instructional design of resuscitation training is the applicability of training experiences to each learner's real-world scope of practice. In broad terms, factors influencing relevance can be ascribed to the learner (eg, age, background, clinical experience, expectations, emotion, stress level) or to the environment (eg, training location, devices and media used, local institutional and societal considerations). These factors all represent potential targets for instructional design and content delivery with a goal of optimizing a given learner's real-world performance. Failure to optimize the context of training may have negative effects on learning outcomes. This section describes the evidence supporting the contextualization of resuscitation training about both learner factors (eg, alignment of learning objectives, team training, CPR training for lay providers, stress, and cognitive load) and environmental factors (eg, manikin/simulator features, training setting, training in limited-resource medical settings).

Definitions

Team training refers to elements of resuscitation education focusing on facets of crisis resource management relevant to the function of a group of ≥2 providers working together simultaneously such as leadership and followership, communication, situational awareness, and resource use.[68] Layperson training refers to resuscitation training for nonclinicians, focusing on training in bystander CPR, AED use, and emergency response system activation. Manikin fidelity refers to the presence of simulated physical features that can be observed, palpated, heard, or auscultated to more closely resemble an actual patient.[69] In situ learning describes teaching experiences conducted within the physical space where an analogous clinical event would occur rather than in a classroom or a simulation center. Limited-resource settings are areas limited by economic, social, or governmental factors (eg, developing nations). Two broad categories of context are reviewed: the learner context and the environmental context.

Summary of Evidence

Learner Context: Maximizing Relevance to Practice

The needs of specific learners should be well aligned with learning objectives and content delivery whenever possible; variation in learner needs, backgrounds, and expectations can make this challenging to achieve (eg, the ability and willingness to perform chest compressions is an appropriate objective for laypeople, whereas the quality of CPR would be the key focus for healthcare providers). Published studies that examined the impact of variations in learner group size, course duration, instructor background (eg, clinician versus nonclinician), and modular content delivery[64,70–75] have yielded variable results, with some studies demonstrating no clear advantages of 1 approach over another and others showing some potential impact. One study found that learners preferred smaller group size, although educational outcomes were not different.[71] Another recent study comparing BLS taught with and without targeted content found that hospital-based providers achieved critical clinical tasks at a significantly higher rate during simulated cardiac arrest after training with learning objectives specific to in-hospital cardiac arrest management.[33] These data suggest that courses with content targeted to the learner warrant further exploration.

Learner Context: Team Training

Team training has been a component of the AHA's resuscitation education since 2005 and is directed toward optimizing teamwork, communication, leadership, and other aspects of crisis resource management. Multiple studies have demonstrated that standardized team training as a supplement to BLS or ACLS courses can enhance team dynamics and communication and may contribute to improvement in technical skills.[76–79] Team training in these studies ranged from 90 additional minutes to half-day workshops dedicated to team principles. One study demonstrated improved adherence to guidelines during actual in-hospital cardiac arrests and resulted in a 2-fold increase in the odds of patient survival after the intervention.[80] Another study demonstrated a positive association between higher scores on an instrument quantifying leadership skills and improved CPR quality during simulated cardiac arrests.[77]

The context and perspective of a given learner affect the usefulness of teamwork training.[81] Leadership training may not be applicable to a learner whose responsibilities do not involve leading a team of providers during a resuscitation event. Team function during management of out-of-hospital cardiac arrest may be pertinent to prehospital, emergency department, and intensive care providers but less so to laypeople or providers in the outpatient setting where the response to an individual with cardiac arrest will not consist of a full team of providers.

Learner Context: Layperson Training

Laypeople represent a distinct group with varying perspectives and learning objectives because the primary focus is to overcome their barriers to initiating CPR, with less emphasis on optimizing the way it is performed. Studies examining layperson training in CPR vary in design, with limited results that demonstrate clear advantages of any specific instructional design element. The training is focused on psychomotor skill acquisition for chest compressions and AED use in adults and children.[50] Notably, multiple studies have demonstrated that video or image-based self-instruction was noninferior to instructor-led courses[82–84] and that instruction by peers was as effective as instruction by trained healthcare providers.[85,86]

Learner Context: Stress and Cognitive Load

Experiential learning, as distinct from didactic learning, depends on realistic emotional investment from learners. Cognitive load and stress levels for learners should be factored into the instructional design of the educational experience.[87,88] Published studies examining elements of stress and cognitive load during resuscitation education are largely qualitative. One study examined the use of cognitive aids during simulated resuscitation events in which 85% of subjects used aids but still performed incorrect management in 25% of cases.[89] Another study described how the addition of a cognitive task while performing bag-mask ventilation did not significantly affect psychomotor performance of bag-mask ventilation by pediatric residents.[90] Although stressful training experiences may, in theory, prepare learners for the high-stress clinical environment, excessively stressful training scenarios may overwhelm them both emotionally and cognitively, potentially having a negative impact on learning.[91] Several studies have used scalable instruments designed to measure situational awareness (eg, situation awareness global assessment technique)[92] and cognitive load (eg, Paas scale)[93] during resuscitation educational exercises involving simulations or question-and-answer sessions. Each of these studies showed a significant correlation between subject experience level and scores showing lower cognitive load or higher situational awareness.[94–96] Preliminary data describe measurable biological responses in learners: Increased salivary cortisol levels have been found in subjects performing simulations in which resources were judged to be outweighed by demands, and increasing pupillary dilation as an index of autonomic central nervous system activity has been noted to correlate with cognitive load as measured by the Paas scale.[97,98] More work is necessary to determine how levels of stress and cognitive load in training affect learning and eventual performance in the real-world environment.

Environmental Context: Manikin Fidelity

Simulators with advanced physical features have been developed to allow simulation of patients with multiple ages (eg, newborn, infant, child, adult) and physiological states (eg, traumatic injury, pregnancy). These devices can theoretically lead to greater learner engagement while allowing cues and state changes to occur in an automated fashion to improve the consistency of learning experiences. Disadvantages of the use of these devices include higher cost, the need for trained personnel to operate them, and imperfect technology to simulate certain key clinical findings (eg, altered mental status, delayed capillary refill time).

Studies examining the impact of higher-fidelity physical features in simulators during resuscitation education have yielded varied results. A recent systematic review found that using a higher-fidelity manikin led to improved skill acquisition after course completion without a significant impact on longer-term skill outcomes or knowledge[69]; 3 subsequent studies also have not demonstrated significant differences in learning outcomes.[99–101] The physical features of manikins and simulators to which the term *fidelity* is applied are insufficient by themselves in positively influencing learning outcomes. Rather, the use of these devices should be accompanied by appropriate instructional design to ensure knowledge transfer and learner engagement. The term *functional task alignment* has been recommended to represent this more complete approach to training scenario design, which can take advantage of physical cues from a manikin without exclusively relying on it for helping learners suspend disbelief.[102]

Environmental Context: In Situ Education

In situ resuscitation education may theoretically improve realism for learners but must be balanced with the logistical challenges of conducting educational sessions in real clinical spaces. Ten studies have examined differences in learning outcomes between resuscitation education conducted in situ compared with a standard classroom/laboratory setting and have not revealed advantages with in situ resuscitation training.[32,64,103–110] Nonetheless, learners view in situ settings as more authentic, and 1 study found that learners believed in situ training held greater potential for affecting organizational change.[103,107]

Environmental Context: Limited-Resource Settings

Appropriate use of human and material resources and technologies in low-resource environments is essential. Consideration should be given to matching training environments with real clinical environments to optimize the contextual nature of learning. Most studies of resuscitation training in developing nations have shown immediate improvement in knowledge, skill, and attitudes among healthcare providers. Programs in neonatal resuscitation have shown that clinical outcomes for at-risk neonates are improved.[65,111] One study also reported sustaining ongoing instruction through train-the-trainer methodology, resulting in decreased stillbirths and neonatal mortality.[112] These programs have in common the use of inexpensive task trainer–based psychomotor skill instruction for airway opening, suctioning, stimulation, assisted ventilation, and chest compressions for depressed newborns. Studies of courses combining didactic and psychomotor skill training in trauma and medical resuscitation outside of neonates have also demonstrated improved knowledge and reported self-efficacy.[108,113–116]

Suggestions

Maximizing Relevance to Practice

- Instructors should consider optimizing learning context for healthcare providers by considering multiple factors specific to their native setting, including training background, team composition during resuscitative care, resource availability, and relevance to normal clinical practice.

Team Training

- Team training should be conducted in a contextualized manner with regard to learning objectives (eg, types of scenario such as cardiac arrest) and team composition (eg, numbers and background of providers), which may require the ability to vary the delivery of a teaching scenario to address differences in these phenomena.

Layperson Training

- Life support training for laypeople should be conducted with a goal of increasing bystander CPR rates, AED use, and activation of emergency medical services.
- Layperson training should account for individual learner factors such as age (eg, children too young to perform effective CPR should be trained to call for help or to call 9-1-1), physical characteristics (eg, body habitus, physical limitations), access to learning resources, and exposure to specific at-risk populations (family members of cardiac arrest survivors, etc).

Stress and Cognitive Load

- Instructors should consider incorporating stress into training to an appropriate degree for learners to maximize engagement (ie, not too easy) but to avoid interference with knowledge and skill acquisition resulting from excessive stress (ie, not too hard).
- Instructors should tailor content delivery to an appropriate degree of cognitive load with respect to a given learner. This includes aspects of instructional design (eg, including or excluding content elements to increase cognitive load based on objectives and intended learners) and delivery (eg, recognition of cognitive overload and adjustment of scenario delivery in real time).

Manikin Fidelity

- Manikins or task trainers should be selected on the basis of the availability of physical features that align with relevant learning objectives (eg, manikins selected for CPR training should allow compression to AHA targets for compression depth [5–6 cm]).

In Situ Education

- In situ education can be considered as a replacement for classroom- or laboratory-based resuscitation training, particularly when classroom or laboratory space is not available.

Limited-Resource Settings

- Resuscitation education should be configured to account for local resource availability in terms of both appropriateness of learning objectives and selection of equipment and adjuncts with which to conduct teaching.

Implementation Issues

Maximizing Relevance to Practice

- Heterogeneity among learner groups may require educators to adjust instructional design and scenario development because various professions may have different learning objectives.
- Faculty development should include specific training elements geared toward conveying and maintaining techniques for assessing the needs of learners and alignment of learning objectives (eg, prebriefing, scenario variability, modularization).

Team Training

- Instructor training in resuscitation education must include methods for teaching and assessing teamwork concepts.

Layperson Training

- CPR training for laypeople should involve engagement of community leadership, school district leadership, and local legislation to maximize dissemination of training.
- Instructors should be familiar with local and community resources (eg, dispatch instructions, first responder team compositions and response times) to optimize relevance of training for members of that community.

Stress and Cognitive Load

- Instructors should have the skills to induce stress as an element of emotional context while balancing the need for experiential learning to be safe and for appropriate support and coaching to be available always.

Manikin Fidelity

- Instructors in centers that use high-fidelity manikins and simulators must have complete knowledge and familiarity with the specific physical capabilities of their training devices.
- The resuscitation educational community should work with and advocate to companies who design and manufacture manikins and task trainers to inform ongoing optimization of manikin design features.

In Situ Education

- Resuscitation education conducted in situ should consider safety and privacy issues such as ensuring teaching medication is not left in clinical spaces and that real patients are not exposed to resuscitation training events.

Low-Resource Medical Settings

- Life support training implementation should aim for dissemination and sustainability (eg, train the trainer), particularly when being deployed in lower-resource areas. This may include involvement of and ongoing collaboration with local stakeholders (eg, medical, regulatory, governmental agencies).

FEEDBACK AND DEBRIEFING

Background

As a fundamental element of resuscitation education, data on the performance (feedback) and conversations about the performance (debriefing) drive performance improvement. Optimal feedback and debriefing practices go hand in hand with faculty development efforts that translate them into educational practice. However, because few educators receive contextualized training for this specialized work, current feedback and debriefing practices may not align with the unique goals of resuscitation. A better understanding of how to structure feedback and debriefing practices for resuscitation education may enhance the effectiveness of this intervention. This section identifies several opportunities to augment feedback and debriefing practices for resuscitation education: (1) The creation of supportive learning environments is essential to promote psychological safety, to clarify expectations, to set performance goals, and to prepare learners for feedback and debriefing; (2) debriefing processes and content need to be adapted for simulation and clinical contexts; (3) feedback and debriefing sessions should integrate key performance data; and (4) feedback and debriefing must align with important elements of the instructional design. When viewed as elements of a comprehensive resuscitation curriculum, optimized feedback and debriefing practices promote attainment and retention of key skills and affect patient outcomes.

Definitions

Most literature blurs the line between feedback and debriefing.[117] Although this line remains indistinct, available definitions differentiate them. Here, we view data as a form of objective unprocessed information that makes up feedback. Thus, feedback is defined as information about the performance compared with a standard[118] (eg, automatically generated data from simulators or devices that capture the quality of CPR). Debriefing is a reflective conversation about performance and may include processed select performance data (ie, feedback).[119,120] Finally, performance refers to both taskwork and teamwork.[121] Taskwork represents what the team does, such as adhering to a resuscitation algorithm, but also includes psychomotor skills, such as performing CPR or defibrillation; teamwork reflects how team members perform taskwork with each other.[121]

Summary of the Evidence

Clinicians have a poor ability to self-assess,[122,123] and even experienced clinicians need external feedback to maintain and advance clinical skills. Although feedback and debriefing are effective educational interventions,[120,124–130] one third of studies in a meta-analysis of feedback demonstrated negative impacts on learning.[125] Learners have a difficult time using feedback if it threatens their self-esteem or conflicts with their perceptions of self,[125] even if educators give feedback according to established guidelines.[131] In general, effective feedback should be specific, timely, actionable, and tailored to learners, and it should identify aspects done well and those needing improvement.[132]

Feedback has been identified as an essential ingredient in simulation-based education,[15,133] highlighting discrepancies between current understanding or performance and the desired goal, with the aim of closing performance gaps.[134–136] In this vein, Hattie and Timperley[134] outlined 3 key issues for feedback, all with great relevance for resuscitation education:

1. Feed up: What are the goals? Make sure learners clearly understand performance goals.
2. Feedback: What is the progress toward the goals? Maximize opportunities to provide learners with critical performance feedback.
3. Feed forward: How do we make better progress toward the goals? Coach learners on how to practice with a focus on improvement.

A critical success factor for learning relates to establishing a challenging yet supportive learning environment. Educators can build a sense of psychological safety with a prebriefing to let learners know that mistakes are expected and serve as sources of learning and that interpersonal risk taking is encouraged.[137–139] An effective prebriefing builds rapport between learners and educators and encourages feedback receptivity by clarifying performance targets and explicitly outlining aspects of performance feedback relevant for the session so that learners know what to expect: timing, sources, purpose (training or assessment), etc.

Traditional approaches focus on the quality of feedback that educators provide. However, shifting conceptions of feedback have moved away from notions of "giving feedback" to the idea that learners actively seek, receive, and process feedback.[131,140–145] A recent meta-analysis explored feedback receptivity and highlighted key recipient processes, including self-appraisal, assessment literacy, goal setting, self-regulation, and engagement/motivation.[146] This work also viewed behaviors of givers and receivers, considered the characteristics of the feedback message related to task specificity and process, and incorporated contextual elements. In summary, this line of inquiry emphasizes a proactive willingness to receive feedback, a notion with relevance for resuscitation education.

Among several factors that mediate feedback responsiveness, credibility judgments and achievement goal orientation have emerged. Watling et al[147] demonstrated that learners weigh learning cues from their clinical practice and judge whether they are credible, and learning cues or feedback from highly regarded, excellent clinicians appear highly credible. As another influence of perceived credibility, learners consider the quality of relationships and commitment to learning in education alliances in judging credibility.[148,149] In addition, work has shown that achievement goal orientation influences both feedback seeking and feedback practices.[150,151] Here, the literature differentiates between 2 achievement goal orientations[152,153]: a learning goal orientation that encourages a growth mindset of improvement through effort and a performance goal orientation that emphasizes talent and a desire for positive reinforcement, thus viewing critical feedback as a threat. A learning goal orientation enhances feedback-seeking behaviors; educators may also assume a learning goal orientation by focusing on improvement rather than conveying a sense that they are "grading" learners' performance. Thus, resuscitation education events should be viewed as opportunities for improvement that demand feedback.

Debriefing conversations play a key role in resuscitation training. Several key issues guide debriefing practice, namely timing, process, content, and assessment.

- Timing: Debriefing conversations traditionally occur after simulation or real clinical events,[154–158] although they also may occur within simulation scenarios.[120,126] The timing and frequency of feedback may be synchronous, immediate or concurrent, or delayed or terminal. Recent systematic reviews highlight the benefit of terminal feedback,[120,126] although these findings are challenged by the success of the concurrent feedback within rapid-cycle deliberate practice.[27,159]
- Process: Despite some differences, most debriefing models share key similarities related to the overarching structure and process that attend to emotional reactions, clarification of the medical issues, ensuring a shared mental model, and analysis of events with generalizing of lessons for future practice. Sawyer et al[157] provide a critical realistic synthesis of debriefing that describes various approaches and methods. Debriefing scripts, especially for novice educators, have been shown to enhance debriefing effectiveness because they serve as a cognitive aid that helps the educators' debriefing process.[160,161] Blended approaches to debriefing are emerging that provide flexibility to adapt debriefing based on context.[158,162] Depending on the aspect of performance, educators should seek learners' perspectives as needed.[158] Educators should promote informed self-assessment[163] by providing learners with specific performance data and encouraging them to reflect on their performance.
- Content: Debriefing for resuscitation education must address specific content issues related to the performance domain, for example, taskwork (the work that must be accomplished) versus teamwork (how the team works together to achieve the taskwork).[121] Taskwork and teamwork should be viewed as interrelated entities. The focus of resuscitation education should be on high-quality BLS and advanced life support skills and the teamwork that helps or hinders the attainment of taskwork. The use of objective performance data whenever possible supports this aim. Mounting evidence has led to calls for the incorporation of real-time CPR feedback into BLS and ACLS training.[164] Key sources of feedback include verbal feedback (from peers, educators, resuscitation experts),[21,27,159] CPR feedback devices[47,165–168] (including defibrillator-generated data, stand-alone feedback devices, or manikin-generated data), data from simulators (defibrillation, medication administration times), and performance checklists.[169]
- Assessment: Several instruments can be used to assess debriefing quality, including the Debriefing Assessment for Simulation in Healthcare and the Objective Structured Assessment of Debriefing.[170–172] Although useful instruments can support research and faculty development

activities, these instruments address debriefing process and objectives at a high level only and lack contextualization for various educational settings, including resuscitation training. Initial reports highlight the role of self-debriefing or within-team debriefings (including learner self-assessment) focusing on nontechnical skills such as teamwork and communication,[173–175] although the generalizability to specific resuscitation and associated BLS and advanced life support remains unclear.[161,176]

Additional Considerations

Although cognitive load theory informs all aspects of instructional design in simulation, it also has specific relevance for feedback and debriefing.[177] When exploring performance gaps and diagnosing learning needs,[136] educators should consider the cognitive load of learners; during debriefings, they should attend to emotional reactions and provide their feedback in manageable chunks so that learners can process and act on it. Recent work shows that feedback/debriefing helps teams manage their cognitive load in subsequent scenarios.[178] These principles apply to postevent debriefings, within scenario feedback/debriefing, and in rapid-cycle deliberate practice educational models.[27] Although the use of video-assisted debriefing is common, evidence to support its use is lacking.[120,179–182]

Suggestions

- Prebriefings should establish a supportive learning environment. This includes highlighting key performance goals and performance expectations, emphasizing the importance of ongoing practice, actively preparing learners for the feedback they will receive, and describing when and how the debriefing will occur.
- Effective debriefings must be fit for the purpose and focus on how to achieve performance standards. Specifically, instructors should attend to the established debriefing processes, tailor debriefings to context, use debriefing scripts to promote debriefing effectiveness, and view training as an opportunity to model debriefing practice and to prepare learners for the process of a debriefing after actual clinical events.[183]
- Learners need performance data to improve; these data should be included in debriefings whenever possible. Quantitative data provided during resuscitation education should come from several sources, including instructors, CPR devices, and data from simulators. Some data may be available in real time; other data, during debriefings.
- Feedback and debriefing should be part of a larger curriculum design and should not occur in isolation. These powerful education interventions are integral elements to overarching curriculum design considerations.

Implementation Issues

- Faculty development is required for effective prebriefing and debriefing.
- Resuscitation courses need to be structured to allow optimal feedback and debriefing practices (ie, sufficient and appropriate time allocation relative to other activities).
- Collection of critical performance data (eg, CPR quality during a simulated cardiac arrest case) will require appropriate technology and timely processing and display of data for use during feedback and debriefing.

INNOVATIVE EDUCATIONAL STRATEGIES

Background

There is increasing focus on the use of new platforms and strategies for healthcare provider education. This section focuses on several emerging innovations in this area that have been applied to resuscitation education. The areas of focus are not meant to be exhaustive but rather to address several approaches that offer potential for improving laypeople's willingness to act, provider performance, and ultimately survival after cardiac arrest. Each of these innovative strategies can serve as a supplement to existing resuscitation education. Key lessons learned from these areas can contribute to the development of a comprehensive knowledge translation strategy that would specifically include novel methodologies and digital platforms. The select areas of focus in this section include both approaches and platforms: gamified learning, social media, blogs and podcasts, and crowdsourcing.

Definitions

Gamified learning, or gamification, is the use of game attributes with the purpose of affecting behaviors or attitudes of a learning-related task.[184,185] Blogs are a serialized, self-published platform for disseminating information,[186] and podcasts are a distribution platform for audio-based content.[187] Social media (eg, Facebook, Twitter) is "user-generated content that enables collaboration, dissemination, and interaction on various online platforms, including audiovisual components such as videos, photos, audio tracks, written word, and more."[188] Crowdsourcing is defined as an approach of reaching out to groups of individuals to perform a task that is usually performed by individuals or organizations.[189]

Summary of Evidence

Gamified Learning

Prior work in gamified learning and resuscitation has focused primarily on the application of games for CPR skill training, retention, teamwork, and situational awareness.[190–194] In some of these games, players find themselves in a situation in which they are required to initiate CPR to help another individual such as in the home or a public stadium. For example, 1 game includes a tournament and story mode and focuses on increasing awareness and course preparation for young adults.[195] Other gaming features include the use of avatars and evaluation of critical steps in CPR (eg, recognition, assessment, action).[190,192] Some gaming environments facilitate testing of psychomotor skills and pretraining scenarios; others use computer-based tools that allow users to respond by using a computer mouse or other interactive platform tools.[190,192]

Other work has blended games with web-based learning and similarly demonstrated the potential for games to supplement resuscitation training and skill acquisition.[196] Advantages of screen-based delivery include consistency, the lack of a need for an instructor, flexibility with regard to time and space for content delivery, and lower cost.[197,198] In this context, web-based patient simulations have been combined with standard simulation-based training to evaluate procedural knowledge, performance, and clinical decision-making skills.[196] Virtual training for AED use and training has also been shown to be feasible and favorable for knowledge and skills acquisition.[199] Nonetheless, no data exist to suggest that the use of gamified learning improves provider response and performance (eg, willingness to act, CPR performance, AED use) in real cardiac arrest scenarios outside the training environment. Gamified learning, however, offers the potential for reaching larger populations of resuscitation trainees while enhancing the teaching environment for various types of learners and improving skill retention.

Social Media

Social media is increasingly used to allow users to share content with large, global audiences. Potential advantages of incorporating social media into educational frameworks include opportunities for connectedness across individuals, engagement of learners in knowledge creation and dissemination, and reaching learners with varying learning styles through different modalities (eg, images, videos).[188,200,201] Physicians and medical trainees are increasing their social media presence.[202–205] As with blogs, there is also a growing literature about professionalism and rules of engagement for maximizing benefit on social media.[202,206,207] Some tips on the use of social media include maintaining professionalism at all times, being authentic, focusing on the task, grabbing attention when appropriate, and engaging with others. Journals and residency programs are also finding a role for using these platforms for knowledge dissemination and education.[208,209]

For resuscitation education, prior work has evaluated the use of video platforms such as YouTube for CPR instruction with mixed findings; accurate current information can be helpful, but many videos had incomplete information, low-quality compression delivery, and inaccurate instruction.[210–212] Prior work on Twitter suggests potential for this platform as an effective knowledge translation tool because many resuscitation-related tweets were identified as information seeking and education related.[213,214] In addition, several prior studies[214] and a scientific statement[215] have evaluated the potential of social media for resuscitation research. In summary, by using best practices for engagement, accuracy, and timeliness, social media can support communication and knowledge exchange for lay providers, instructors, and communities of trainees and instructors.

Blogs and Podcasts

Many studies have focused on the potential for blogs and podcasts to improve the dissemination of research. Outside of resuscitation, blogs and podcasts have been shown to improve readership and the promotion of scholarly publications, to enhance medical trainees' knowledge of various topics, and to improve education communication and dissemination.[187,216–221] Citations of blogs have been associated with the impact of scholarly work.[222,223] The Altmetric score has been developed as a measure of the broader impact of a publication. This widely used measurement includes blogs and podcasts associated with the work.[224] In the radiology literature, blogs about publications have been associated with broader dissemination and reported readership of the articles.[220] Podcasts as supplementary learning tools have also been noted to increase the reported knowledge of medical and dental students and trainees (eg, internal medicine).[218,225] As blogs and podcasts are becoming more commonplace, there is a significant opportunity to enhance their impact by focusing on measuring and tracking impact, standardizing and enhancing content development, and establishing and testing associated quality metrics.

Blogs and podcasts are evolving as valuable communication tools for information dissemination. They have appeal because they can include not only text but also embedded links, visuals, and interactive components through discussion forums. Prior literature has focused on best practices for generating blogs and podcasts to optimize reach, engagement, and dissemination.[226–230] Some of the features that can enhance use and uptake include credibility (transparency, trustworthiness), content (professionalism, academic robustness), and design (aesthetics, functionality).[226,228] With the launch of the 2015 AHA guidelines update for CPR and ECC, researchers used new short descriptions accompanied by infographics to facilitate translation of the information for broad audiences. These simple, easy-to-follow guides were useful for converting text to digestible formats for consumers that were shared thousands of times on Twitter, Facebook, and other social media platforms.

Crowdsourcing

As with other novel emerging areas, the literature in this area is growing slowly, with few comparative studies to date.[231] Using crowdsourcing platforms, nonmedical crowds could accurately evaluate medical skills (eg, cricothyrotomy) compared with experts.[232] Others have also shown that information generated by online crowdsourcing and collaboration for the intent of educational materials is feasible, although quality may be variable.[233–237] In resuscitation, crowdsourcing has been applied for improving education on resuscitation skills, cardiac arrest recognition, and AED awareness. Outside of the training environment, prior work has focused on calling on the public to locate an AED such as the MyHeartMap Challenge to engage the public to find AEDs in an urban city over 8 weeks.[238] Through a series of approaches, this team was able to validate entries from >99% of submissions, suggesting the ability to evaluate the trustworthiness of crowds for lifesaving information in this context. Prior work evaluating the ability of the public to submit crowdsourced designs for AEDs demonstrated the ability to harness large groups for contribution and self-reported willingness to respond in a resuscitation-related emergency.[238,239]

Suggestions

Gamified Learning

- Studied and applied game attributes (eg, narrative, competition, leader boards, incremental difficulty, socialization) that are refreshed and changed regularly for the purposes of improving learning engagement and skill/knowledge retention should be used.
- Content in these platforms should be developed by content experts and potentially vetted by trusted organizations.

Social Media

- Social media platforms should be used for knowledge dissemination, engagement, and tracking of attitudes and perceptions in real time and over time of resuscitation-related guidelines and information.

Blogs and Podcasts

- Leading organizations should support the timely and accurate development of blogs and podcasts on resuscitation education training and instruction that can be used in a longitudinal fashion to supplement provider training in courses.

Crowdsourcing

- Approaches for using crowdsourcing for development, vetting, voting, and dissemination of resuscitation-related educational materials should be tested and iterated with careful attention to issues related to quality control and conflicts of interest.
- The applicability of using crowdsourcing for evaluating simulated performance (eg, CPR, AED use) should be determined.

Implementation Issues

Gamified Learning

- The costs associated with initial design and development of games can be significant.
- Self-directed screen-based training should be focused primarily on knowledge and decision making. When skills are included, feedback and assessment should be informed by quantitative data that are reliable and accurate.

Social Media

- A standardized means to review information posted on social media is required to ensure the accuracy of shared knowledge.

Blogs and Podcasts

- Materials that translate educational content need to be created for both lay audiences and health-care providers.
- Challenges and opportunities related to ownership and standardization require further study.

Crowdsourcing

- Given the paucity of research in this area, any efforts to use crowdsourcing for formal education should be accompanied by efforts to collect data to understand the true impact of this strategy.

ASSESSMENT

Background

Assessment of competence is critical in the development of high-quality resuscitation teams. The assessment of resuscitation providers can be complex and should focus on the domains of clinical knowledge, technical skills, and teamwork. There are many assessment tools in the literature to assess these domains. Consideration of available tools and which domains are most important should be part of the development of an effective assessment strategy for resuscitation education. Educators are constantly making assessment decisions during resuscitation training. These include low-stakes decisions (eg, assessment to provide specific feedback and allow assessment for learning) and high-stakes (pass or fail) decisions (ie, determining assessment of learning). Assessment can no longer be thought of as an add-on at the end of a course; rather, the assessment strategy forms a key component of the instructional design of an educational program.

The quality of assessment decisions is critical to successful resuscitation training but is often unknown in resuscitation courses. Poor-quality assessments can prevent educators from identifying learners who are struggling, which influences the quality of feedback. Worse, it can lead to course completion cards for learners who are not competent. In addition, assessment data are important in resuscitation education research because low-quality assessments result in unreliable findings. Accurate assessments are also important in program evaluations of resuscitation education systems. For these reasons, there has been increased focus on a more contemporary approach to assessment in medical education,[240] which is relevant to resuscitation education. In this section, we introduce assessment concepts such as validity and how they are important in improving resuscitation education.

Definitions

Assessment is defined by the Standards for Educational and Psychological Testing as "any systematic method of obtaining information from tests and other sources, used to draw inferences about characteristics of people, objects, or programs."[241] In resuscitation education, the characteristics being assessed typically represent competence in one of several domains, including resuscitation knowledge and performance of certain technical skills (ie, CPR) and nontechnical skills (eg, leadership or communication). These constructs are complex and often are not directly observable. Therefore, decisions about a learner's abilities in these constructs must be made through inferences based on available assessment evidence. It is important to be clear on what construct is being measured in the assessment to ensure that the assessment measures all critical aspects of the construct (avoiding construct underrepresentation) and is not affected by variables other than the construct being measured (construct irrelevant variance).

Resuscitation education assessments can take several forms, including written (eg, multiple-choice questions) and performance (eg, a simulated resuscitation scenario or demonstration of a technical skill) assessments. Data to inform assessments can come from direct observation, retrospective video review, or devices (eg, task trainer measuring CPR compression quality). Assessment of performance in the clinical environment has not traditionally been used in resuscitation education but could provide robust data about a learner's abilities.

Assessment is typically thought of as occurring at the end of an educational intervention (ie, assessment of learning) to ensure the effectiveness of the intervention and, in the case of resuscitation courses, to decide about certification. Assessment can and should occur during the learning process (ie, assessment for learning) to aid facilitators in diagnosing learning to allow delivery of specific feedback and coaching.

Validity

The most important characteristic of any assessment strategy is its validity. Validation refers to the "process of collecting validity evidence to evaluate the appropriateness of interpretations, uses, and decisions based on assessment results."[242] If an instructor is provided with a range of assessment scores on a group of students, he or she cannot make decisions about the learners' competence without asking a number of questions. What was the content of the assessment, and was it a reasonable representation of the curriculum? How reproducible are the results? In what context was the assessment done? Answering questions like these provides meaning to the results of an assessment and allows interpretation of the results.

Validation is a journey, not a destination. It is a process requiring the collection of data to justify assessment decisions that are made. A tool cannot be labeled as validated because the assessment data it provides depend on population, context, and other variables. A checklist designed to measure performance in endotracheal intubation may function well for junior learners in the controlled environment of a simulated operating room but not in the assessment of more senior providers managing an unstable patient in an emergency department. Validity is not present or absent; rather, evidence is gathered to support or refute the interpretations being made with the assessment data available (similar to making a clinical decision about a patient based on available examination findings and laboratory tests).

Historically, validity has been divided into multiple types of validity (ie, content, criterion, and construct). However, contemporary validity frameworks consider validity to be a unitary concept, with construct validity representing the whole of validity. These frameworks present validity as a hypothesis, and like any hypothesis, it cannot be proven or disproven; instead, it can be supported (or refuted) by available evidence.[242]

The first step when developing an assessment strategy is to consider the purpose of the assessment and the decision made at the end of the assessment. This will inform the strength of validity evidence required. If the assessment is low stakes (eg, to provide specific feedback after a simulated resuscitation scenario), it is less critical to ensure that there is strong validity evidence for the assessment. However, if the decision is whether

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a learner passes or fails a course or is employable as a critical care provider, a stronger foundation of evidence must exist.

A validity framework can be used to guide the collection of validity evidence. One of the most commonly referenced validity frameworks was proposed by Messick.[241a-243] This framework classified sources of validity evidence into 5 categories. Content evidence refers to the relationship between test content and the construct of interest (Do the items on the assessment capture the breadth of the construct to be measured?). Internal structure evidence includes the analysis of reliability or reproducibility of the assessment. Response process evidence refers to how the assessment responses reflect the observed performance. Evidence for response process could include information about test security or item quality. Relationship to other variable evidence evaluates the correlations between the assessment data and data external to the assessment such as performance in similar contexts or previous assessment data. Finally, consequential evidence looks at the consequences of the test use and the decisions that are made.

Kane and colleagues[244–246] built on Messick's work[241a] in an argumentative approach to validity in which assumptions associated with a decision are empirically tested (the interpretation/use argument). This framework considers evidence starting with the scoring of an observation into a single score (such as with a multiple-choice question or an objective structured clinical examination station). The scoring inference is influenced by the design of test items, including wording of questions and rating scales, training of raters, and how data are collected. Single scores are collected into an overall test score (generalization). Questions about adequate sampling across the construct of interest and reliability of assessments can help strengthen this inference. Data from the test environment are extrapolated to the real world. Evidence for extrapolation may come from a comparison of test results to other external assessments (such as an assessment of performance in a related domain). Finally, the implications of the final interpretation are considered, including intended and unintended consequences.[242,244–246] Regardless of which framework is used, validity evidence is collected, analyzed, and then used to build an argument for the interpretation of the data and the decision made.

There are common challenges to validity in assessment tools. The most common of these is not using a validity framework. In a recent meta-analysis, Cook and colleagues[247] reviewed 217 studies on simulation-based assessment and found that 24% of them made no reference to a validity framework and that only 3% referenced Messick's 5 sources of evidence.[241a] Other major sources of validity threats occur when a test fails to measure critical aspects of the construct (ie, construct underrepresentation). A test may also be affected by variables other than the construct being measured (ie, construct irrelevant variance).

Assessment Tool Creation Versus Modification

The creation of a new assessment tool is a difficult process. First, the construct to be assessed must be clearly defined. A broad consultation process is often required to ensure that relevant aspects of the construct (ie, the content of the assessment) are being assessed on the basis of the best practices in resuscitation. Decisions about the structure of the tool (eg, written versus performance, checklist versus global rating scale) need to be made, and individual items with appropriate rating scales need to be developed and piloted. The process of tool and rating scale development is beyond the scope of this section, but several reviews on these topics exist.[248,249] Raters need to have a common view of performance and receive feedback about their assessments to ensure reliability across raters.[250] Rater orientation is designed to prevent common rater errors such as the avoidance of rating at the extreme ends of a scale (ie, central tendency), basing all ratings on 1 observation (ie, halo effect), or rating groups relative to the performance of a previous group or experience (ie, contrast effect).[251] The assessment is piloted to identify sources of bias. Finally, the tool needs to be used on a larger scale, and validity evidence needs to be collected and analyzed. Given this complex process, it is preferable to use or modify an assessment tool that is already available, especially if some validity evidence has already been collected on its use. It is important to recognize that if the tool is being used in a different context or has been modified, evidence must be collected to assess whether decisions based on the tool remain valid.

Summary of Evidence

A recent consensus statement identified several factors that are critical in good assessment practices.[252] The first, and possibly the most important, is the use of a contemporary validity framework to collect validity evidence. The amount of validity evidence required depends on the nature of the decision being made with the assessment data. The construct being assessed must be clearly identified. In resuscitation education, constructs of interest may include knowledge, technical skills, team leader skills, or team member skills. Assessments should be longitudinal to get a broader view of performance. If a learner in a resuscitation course performs poorly in an end-of-training assessment, his or her performance on multiple assessments throughout the course can help the instructor decide whether the student is competent but struggled in the final assessment for other reasons (such as anxiety) or truly is not yet competent.

Assessment results should be reproducible both at the individual level and across different institutions. The assessment must be feasible and acceptable to key stakeholders, including learners, instructors, and patients. Prior work highlights the importance of assessment as learning, the idea that a good assessment can catalyze future learning.[252–254]

Several assessment tools in the resuscitation field exist (Table 1).[295,296] Educators are encouraged to use assessment tools that go beyond minimal validity evidence (eg, a comparison of performance of senior and junior learners). An example of a tool with strong validity evidence is the Team Emergency Assessment Measure, a 12-item rating scale (including a global rating scale) on team performance, including leadership, situational awareness, prioritization, and adaptability, that has been used[257] and retested in large groups of nursing students, medical students, and resuscitation teams in both simulated and real patient encounters[258,297,298] and translated into French.[299] This tool has now been assessed in several patient populations in both simulated and real-world contexts over several studies, giving it strong validity evidence. Another example is a 12-point checklist on intraosseous needle insertion, which has undergone rigorous validity testing, with demonstration of 4 sources of validity evidence for the tool (content, response process, internal structure, and relationship to expertise).[293]

Suggestions

- High-quality assessment should be part of the instructional design of any resuscitation education program.
- Assessment should be longitudinal throughout the course to identify learners who are struggling early and to reduce the stakes of a final end-of-training assessment. It can also provide better data for feedback, coaching, and deliberate practice during the course.
- Resuscitation course designers should not rely on only 1 form of assessment but rather a program of assessment of knowledge, skills, and integration in different contexts.
- When possible, learners should be assessed between courses in their workplace to ensure competence in actual patient care.
- Learners should be assessed in their own context/role. If learners would never run a full resuscitation team as part of their scope of practice, we should not assess them as a team leader.

Rater Orientation

- Instructors require faculty development to conduct good assessment and to provide feedback. Rater orientation is key to reliable assessments.
- Raters should focus on a small number of relevant constructs at any one time to minimize their cognitive load.

Assessment Tool Selection

- Assessment tools (and programs) used in resuscitation should have supporting validity evidence and be feasible/practical in the context in which they are being used.
- If modifying a tool (eg, translation to other language, adding context-specific items), it is important to regather validity evidence.
- When data are collected for assessment from devices (such as CPR feedback devices), validity evidence must still be gathered.
- Assessments should measure what is truly important for patient outcomes rather than what is easy to assess.
- Assessments should focus on the individual (eg, CPR skills) but also include assessment of collective ability (eg, teamwork skills) in relevant contexts.

Implementation Issues

- Developing assessments that can be used within or between educational sessions, either in simulation sessions or during actual patient care, and then tracking the results of these assessments, will present logistical challenges. If using real patient encounters for assessment, it will be important to consider the challenges of observing real patient resuscitation events (eg, how to capture the event, how to get the right assessor for the specific event type).
- Training many instructors (and instructor trainers) in assessment principles and orienting raters will require the development of tools that are easy to use and organizing programs to orient (and reorient) raters.

FACULTY DEVELOPMENT

Background

The literature on the acquisition and retention of resuscitation knowledge and skills clearly indicates that learner outcomes are suboptimal.[22,300–302] If resuscitation outcomes are to be maximized, faculty development of resuscitation instructors requires specific attention, with intentional focus on developing faculty to optimally deliver curricular elements in a contextualized manner for learners. There is, however, wide variability of instructor expertise and backgrounds, making the initial and ongoing development of instructors particularly daunting. Furthermore, research on faculty development for teaching resuscitation skills is limited and rarely relates any particular faculty development strategy to faculty

Table 1. Sample of Assessment Tools for Resuscitation

Tool Name	Construct Assessed	Question Type	Unit of Analysis	Simulated vs Actual	Subjects Assessed	Validity Evidence Presented				
						Co	RP	IS	RV	Cs
Mayo High-Performance Teamwork Scale[255]	Teamwork	Global rating scale	Team	Simulated	Resident and nurse resuscitation teams	Co		IS	RV	
Modified Mayo High Performance Teamwork Scale[256]	Teamwork	Global rating scale	Team	Simulated	Critical care teams	Co		IS	RV	
Team Emergency Assessment Measure (TEAM)[257–259]	Teamwork	Global rating scale	Team	Simulated	Critical care teams	Co		IS	RV	
Emergency Physician Nontechnical Skills[260,261]	Leadership	Global rating scale	Individual	Simulated actual	Emergency physicians	Co		IS	RV	
Self-Efficacy of Crisis Resource Management[262]	Teamwork	Global rating scale	Individual	Simulated	Resident resuscitation teams	Co		IS	RV	
Teamwork in EMTs (EMT-TEAMWORK)[263]	Teamwork	Checklist	Individual	Simulated actual	Emergency medical technicians	Co		IS		
Observational Skill-Based Clinical Assessment Tool for Resuscitation (OSCAR)[264]	Teamwork	Global rating scale	Teamwork	Simulated	Resuscitation teams	Co		IS		
Comprehensive Pediatric Resuscitation Team Leadership Evaluation Tool[265]	Teamwork resuscitation	Global rating scale	Individual	Simulated	Pediatric residents	Co		IS	RV	
Imperial Paediatric Emergency Training Toolkit (IPETT)[266]	Teamwork resuscitation	Global rating scale	Individual	Simulated	Pediatric resuscitation teams	Co		IS		
Simulation Team Assessment Tool (STAT)[267,268]	Teamwork resuscitation	Checklist	Individual	Simulated	Pediatric emergency department teams	Co		IS	RV	
Team Performance Drug Simulated Crises Instrument (TPDSCI)[269]	Teamwork resuscitation	Global rating scale	Team	Simulated	Pediatric resuscitation teams	Co		IS		
Tool for Resuscitation Assessment Using Computerized Simulation (TRACS)[270]	Resuscitation	Checklist	Individual	Simulated	Pediatric residents	Co		IS	RV	
KidSIM Team Performance Scale (KTPS)[271]	Resuscitation	Global rating scale	Team	Simulated	Medical and nursing students	Co		IS	RV	
Clinical Performance Tool (CPT)[161,272–274]	Resuscitation	Checklist	Individual	Simulated	Resuscitation teams	Co		IS	RV	
European Resuscitation Council Advanced Life Support (ERC-ALS)[275]	Resuscitation	Checklist	Individual	Simulated	ACLS students		RP	IS	RV	Cs
Emergency Response Performance Tool (ERPT)[276]	Resuscitation	Checklist	Individual	Simulated	Acute care nurses	Co		IS	RV	
Simulation-Based Acute Care Skills Assessment[277]	Resuscitation	Checklist	Individual	Simulated	Medical students and residents	Co		IS	RV	
Neonatal Resuscitation Megacode Skill Performance Checklist[278]	Neonatal resuscitation	Checklist	Individual	Simulated	NRP	Co		IS	RV	
Ottawa Global Rating Scale (OGRS)[279–281]	Teamwork	Global rating scale	Individual	Simulated	Internal medicine and pediatric residents	Co	RP	IS	RV	
Assessment of Paramedic Resuscitation Skills[282]	Resuscitation teamwork	Checklist	Individual	Simulated	Paramedics	Co		IS	RV	
Queen's Simulation Assessment Tool (QSAT)[283]	Resuscitation teamwork	Global rating scale	Individual	Simulated	Emergency medicine residents	Co		IS	RV	
Critical Care Direct Observation Tool[284]	Resuscitation teamwork	Checklist	Individual	Actual	Emergency medicine residents	Co		IS		
Behavioural Assessment Tool (BAT)[161,285]	Teamwork	Checklist	Team	Simulated	Nurses and pediatric resuscitation teams	Co		IS		
Resuscitation Formative Assessment Tool[286]	Teamwork	Checklist	Team	Simulated	ACLS students	Co		IS		

(*Continued*)

Table 1. Continued

Tool Name	Construct Assessed	Question Type	Unit of Analysis	Simulated vs Actual	Subjects Assessed	Validity Evidence Presented				
						Co	RP	IS	RV	Cs
Detailed ACLS Checklist[287]	Resuscitation	Checklist	Individual	Simulated	ACLS students	Co		IS		
Neonatal Resuscitation Skills[288]	Neonatal resuscitation	Checklist	Individual	Simulated	Neonatal resuscitation teams	Co		IS	RV	
Queen's BLS Checklist[289]	BLS	Checklist	Individual	Simulated	Medical students	Co			RV	
BLS Checklist[71]	BLS	Checklist	Individual	Simulated	Medical students	Co			RV	
BLS for Laypeople Checklist[290]	BLS	Checklist	Individual	Simulated	Laypeople	Co		IS		
BLS for Laypeople Checklist[291,292]	BLS	Checklist	Individual	Simulated	Laypeople	Co		IS	RV	
Intraosseous Insertion Checklist[293]	Intraosseous insertion	Checklist	Individual	Simulated	Emergency physicians	Co	RP	IS	RV	
Airway Management Checklist[293a]	Bag-mask ventilation intubation	Checklist	Individual	Actual	Anesthesia residents	Co		IS	RV	
Noninvasive Airway Management[294]	Bag-mask ventilation	Checklist	Individual	Simulated	Pediatric residents	Co		IS	RV	

ACLS indicates advanced cardiovascular life support; BLS, basic life support; CO, content; Cs, consequential; EMT, emergency medical technician; NRP, neonatal response team; IS, internal structure; RP, response process; and RV, relationship to other variable.

outcomes,[303–305] student outcomes,[304] or patient outcomes. In this section, we summarize the literature and provide recommendations for improving faculty development based on best practices in education science. Our review of the literature was focused on identifying the most effective methods to develop resuscitation instructors with respect to both initial preparation and ongoing development of teaching skills.

Definitions

Content experts, subject-matter experts, and domain experts are knowledgeable about the material and skills to be learned but may not have received formal instructor training for the course being taught.[306] Instructors or faculty are those who hold a credential to teach in a specific resuscitation training program. Faculty development, or a set of strategies to improve the knowledge, skills, and attitudes of faculty,[307] has a role in both the initial preparation of resuscitation instructors and the ongoing lifelong improvement of instructors as they hone their skills over time. A coach typically assists individuals to improve their skills, often one-on-one, and to focus predominantly on a particular task. Coaches use strategic, ongoing evaluation and timely, corrective feedback, assistance, and encouragement with the mutual goal of performance improvement.[308]

Summary of Evidence

We describe 2 distinct phases of faculty development to address maximizing performance and creating self-directed, lifelong learners—both characteristics of consistently outstanding instructors. They are the initial preparation of the instructor and ongoing instructor development activities.[309]

Initial Preparation of the Instructor

Currently, instructors for resuscitation courses are drawn from a pool of volunteers and individuals paid to provide instruction. Ideally, the initial preparation of an instructor should ensure that the essential building blocks needed for teaching resuscitation courses are in place. Although lecture and demonstration are familiar teaching techniques, these modalities are primarily transmissive in nature and can be replaced with written materials or audio or video recordings in standardized courses or transformed into more interactive "flipped classroom" dynamics.[310] When preparing resuscitation instructors, we must ensure that they not only understand these concepts but also are able to demonstrate these teaching skills before they move forward to teach resuscitation courses.

Key Instructor Competencies

Instructors should be aware of the rationale for training to make appropriate adaptations for specific learners or learner groups. In addition, instructors should focus on the learner outcomes most relevant to key patient outcomes, not just the process of content delivery, and should have a clear understanding of the key instructional design features to be able to implement them effectively. For example, the effective use of CPR feedback devices in resuscitation education requires the instructor to be comfortable with the features of the feedback device, to be familiar with coaching during training (even when a feedback device is in use), and to provide a summary of CPR performance after both skills practice and team-based simulations.

Optimal implementation of instructional design features requires instructors to possess specific skill sets. For example, debriefing is a skill that requires initial training and ongoing practice with feedback to achieve mastery. The previously described debriefing tools (ie, Debriefing Assessment for Simulation in Healthcare and Objective Structured Assessment of Debriefing)[170,171] can be used to support initial training and ongoing improvement of debriefing skills. Demonstration of good debriefing during instructor training helps to build intuition for how this looks in practice, and having a tool to use for evaluation gives instructors a basis for peer coaching.

In addition, familiarity with the basic principles of different teamwork training paradigms can help instructors integrate and relate resuscitation teamwork training into the working knowledge of their students. Team training methods include information sharing (often through didactics), demonstration (by modeling or video), or practice-based learning with feedback (typically with simulation).[311] Demonstration is useful for modeling desired behaviors, but practice-based learning is critical for students to learn how to integrate teamwork skills into their work. For practice to be effective for learning, it should be structured so that it builds on learners' preexisting knowledge and skills and should be variable to build pattern recognition.

Instructors should have enough content expertise that they can explain both the evidence for and the limitations of the content being taught. They should also know enough to be able to appropriately contextualize the information so that their students have a rational basis for applying guidelines to their practice environment without compromising the integrity of the material.

Design of Initial Instructor Training

Several approaches to instructor training such as workshops, seminar series, short courses, longitudinal programs, and fellowships have been shown to be effective,[309,312] but consistent elements that should be considered central to effective initial instructor training include experiential learning (applying and practicing what has been learned with feedback),[313–317] feedback as an instructional strategy to promote change,[318,319] and use of peers as role models and leveraging collegial relationships to support and maintain change.[320,321] In addition, the use of multiple instructional methods (eg, interactive exercises, group discussions, and role play) has been advocated to accommodate varying learning styles and to meet diverse learning objectives.

Ongoing Instructor Development

Instructors should anticipate ongoing efforts to improve their teaching skills and those of their peers in a model of lifelong learning. Given the continual efforts to improve both the science of resuscitation and the education science behind the best practices in teaching, faculty development must provide tools for instructors to develop and maintain their skills. Our review of the literature identified 4 areas that should be specifically addressed to optimize ongoing development of resuscitation instructors: reflective practice, peer coaching, communities of practice, and outcomes-based education.

Reflective practice is the ability to examine one's own impact, actions, cognitive routines, or emotional reactions. In general, physicians and other healthcare providers have a limited ability to accurately self-assess.[123,322–326] This literature supports the need for faculty development activities that encourage meaningful reflective practice. The idea of strengthening professionals' ability to reflect on their own practice builds a level of quality assurance into professional practice.[327–329] Developing the skills to use reflective practice to detect and correct errors allows resuscitation instructors to be self-directed learners using processes of self-regulation (self-reflection) to improve their skills. In a 2016 systematic review, only 36% of studies (n=111) of healthcare faculty development had a conceptual framework that included reflective practice, highlighting this important gap in faculty development.[309]

Early studies found that peer coaching had a strong impact on teachers' transfer of learning from training settings to classroom practice.[330] Teachers could be trained to coach their peers, resulting in adoption of new teaching strategies into their practice compared with practice alone.[330] Receiving and reflecting on feedback from others can provide insight into what is going well and what can be improved[132,309,331,332] and provides both parties the opportunity to learn from each other as they reflect on action together.[333,334] This approach to coaching has several advantages: It reinforces communities of practice, provides rich and relevant feedback to individuals, and can benefit both peers as they learn from each other.

The term *community of practice* refers to people with similar interests working together to make improvements.[335] Knowledge is co-constructed within a community of practice and situated in a specific context rather than a transmissive process of giving abstract and decontextualized knowledge from the teacher to the learner.[336] Well-developed professional learning communities of teachers have an impact on both teaching practice and student achievement.[337] Communities of practice are characterized by mutual engagement and connectedness, shared work with collaboratively constructed goals, and a sense of mutual accountability. A primary benefit of this approach is the ability to communicate around the unique challenges associated with the specific content and learners taking these courses. In addition, in higher education, communities connect people, provide shared context, enable dialogue, capture and diffuse existing knowledge and resources, introduce collaborative processes, and help generate new knowledge. These communities can exist in physical locations (eg, within an organization) or in a virtual setting (eg, digital/online). The process of sharing information, experiences, and resources fosters engagement as members of the community learn from each other and experience professional and personal growth.[336] Examples of current infrastructures that could serve as a foundation for a community of practice for resuscitation instructors include the AHA's Instructor Network and the Heart and Stroke Foundation of Canada's Resuscitation Portal. As instructors begin to view themselves as a part of a community, they can strive to assist and support each other, share experiences, learn to contextualize, mentor new instructors, and build teaching skills over time for improved performance as instructors.

Instructors must remember that learners work within particular systems of care that will affect their performance as much as the education provided will. To have the impact that they wish, instructors must be engaged in outcomes-based education, namely focusing on meaningful ways to improve learners' performance that will positively affect patient outcomes. Kirkpatrick and colleagues[338–340] first introduced the idea that educational activities should be focused on their intended educational outcome. They divided education outcomes into 4 levels based on impact. Levels 1 and 2 relate to what happens in the classroom. Level 1, the lowest level of educational outcomes, measures participant satisfaction and reaction to training. Level 2 outcomes determine what participants learned during training and may include assessment of knowledge (eg, multiple-choice test), skill proficiency (eg, CPR skills), or attitudes. Educators should, to the extent possible, look for measures of the impact that their education has on attaining the goal or intent of the education. Level 3 outcomes measure whether the skills taught are used in actual practice, and Level 4 outcomes are direct indicators of whether the goals of the program, namely a reduction in morbidity and mortality, are being achieved. Although the test scores serve as indicators or milestones on the path to achieving a goal, if patient outcomes are not improved, then factors other than teaching must be considered. These might include systems elements, technology, or gaps in resuscitation science. In the Kirkpatrick model, the end goal is the starting point for all education program evaluation.

Although they are not responsible for every aspect of clinical practice for every student, it behooves instructors to be cognizant of the conditions and outcomes of their student cohorts. This allows instructors not only to contextualize learning to be relevant to learners but also to focus on the known shortcomings of the system that the students will encounter. Instructors should consider themselves agents of change, not just teachers. Therefore, they should actively pursue knowledge and skills that support the education and implementation interface. They should consider the system that their learners are embedded within and prepare students to be successful within the context of that system. Furthermore, educators should strive to make a positive impact on those systems when possible so that their teaching leads to better resuscitation outcomes.

Suggestions

Initial Instructor Training

- Initial preparation of resuscitation educators should include content on, practice with, and evaluation of key instructor competencies, including the following:
  - Knowledge and skills associated with the science of resuscitation and the science of education
  - Use of feedback devices and approaches to dealing with the most common challenges
  - Ability to effectively debrief others and facilitate peer coaching
  - Contextualization of content to various audiences and practice settings
  - Facilitation of the development of teamwork training skills
- The design of the initial instructor training program should include content related to the key competencies through various approaches:
  - Workshops
  - Seminars
  - Short and long courses
  - Giving and receiving feedback (eg, peer coaching)

Ongoing Instructor Development

- Systems to support instructors becoming self-directed, lifelong learners should be established, including mechanisms that enhance reflective practice, peer coaching, communities of practice, and outcomes-based education to facilitate the development of instructors as change agents.

Implementation Issues

Initial Instructor Training

- Teaching key skills: Identifying time to cover and practice key instructor skills will be challenging.
- Teaching teamwork: There are many different strategies and methods for teaching teamwork, but the best method for instructor preparation remains unknown.

- Mastering feedback and debriefing: Tools used to guide feedback as instructors practice debriefing are required.
- Matching best training design to goals of instructor training: Because instructors come from varied backgrounds, instructor training courses need to be flexible to prepare new instructors.

Ongoing Instructor Development and Improvement

- Reflective practice: Orienting instructors to the initial and ongoing use of reflective practice will require organizational and programmatic support.
- Peer coaching: Building confidence and trust between instructors to perform peer coaching will require a change in culture of many resuscitation instructors.
- Communities of practice: Although instructor groups currently exist, they are woefully underdeveloped.
- Helping teachers to become change agents: Instructors should begin to see themselves as change agents, not just teachers. This will require instructors to look beyond the classroom and implement strategies that will ensure that students perform in their particular clinical environment. Data must be collected from the clinical environment and shared with instructors to help facilitate this change in mentality.

KNOWLEDGE TRANSLATION AND IMPLEMENTATION

Background

Dissemination and implementation of resuscitation science from research to high-quality operational performance is challenging. Before 2005, the AHA directed most of its efforts toward disseminating postpublication guidelines for CPR and ECC and developing courses. The variable time from guideline publication to implementation of the 2005 guidelines by agencies participating in the Resuscitation Outcomes Consortium, which spanned 49 to 750 days, sparked an effort to better understand and facilitate the implementation of scientific recommendations at both the curbside and the bedside.[341,342] At the same time, emerging technology allowed CPR process data to be collected routinely, and evidence of both prehospital and in-hospital noncompliance with CPR guideline–quality targets emerged.[343,344] Several systems of care demonstrated that attention to the principles of quality improvement and implementation science could make a difference in patient outcomes.[128,130,345–348]

Specific barriers to implementation of resuscitation guidelines have been identified. Bigham et al[341] found 10 barriers that delayed implementation of the 2005 AHA guidelines by as many as 750 days in emergency medical services within the Resuscitation Outcomes Consortium. Barriers included regulatory hurdles, overcoming resistance to change, delays in the training material supply chain, the financial burden of training, the need to replace outdated technology, interservice collaboration challenges, and isolation among the guideline writers and the emergency medical services administrators who were responsible for local implementation.[349]

Implementation efforts in health care have had limited and varied effects.[350] With this in mind, the AHA committed to expediting the implementation of its resuscitation guidelines to harness the full potential of scientific advancements and to save more lives.[351] Editorials have lamented the slow pace of change in resuscitation practices, defying decades of globally derived guidelines and one of the most rigorous scientific review processes in the world.[352–354]

Education plays a large role in implementing scientific evidence. Ensuring that frontline providers are capable of and willing to apply scientifically supported practices to real-life cases requires that they be educated, but knowledge translation requires the integration of not only practitioners but also policy makers, educators, healthcare administrators, and healthcare organizations as knowledge users. Education can be thought of as aiming to elicit a series of desired behaviors by providing instruction and feedback to providers before, during, and after a resuscitation event. Education can also be considered for knowledge users upstream from a resuscitation event: those who manage, direct, and lead organizations that perform resuscitation. At the highest level, this includes politicians who lead societies that must have a prepared citizenry capable of delivering effective CPR and activating emergency medical services. Thus, the term *education* applies broadly and includes knowledge users who can influence frontline care as targets of education. Person-based interventions, such as education sessions and bulletins, are less effective than system-based interventions like resuscitation checklists, forcing functions, environmental designs (eg, CPR feedback defibrillators placed directly across from the CPR provider), and automation (eg, automated defibrillation for shockable rhythms). In this section, we review the evidence for knowledge translation and implementation strategies, provide specific suggestions for how they might be applied to resuscitation, outline potential challenges for implementation, and highlight areas for future research.

Definitions

Passive knowledge translation describes actions that potential knowledge users must seek out such as an academic publication; active knowledge translation describes actions that target and access potential knowledge users directly without the recipient needing to seek the information.[355–358] Change theory considers human biases, the behavioral response to change, and how best to communicate and facilitate change in the human context. Design thinking takes human factors, ergonomics, and architecture into account during the planning of the physical environment in which practice occurs such as the back of an ambulance or a hospital ward. Performance measurement involves collecting data on measurable events such as ambulance response time, chest compression depth, and tracheal intubation rates. Audit involves using performance measures to assess compliance with a standard, whereas continuous quality improvement uses data to inform decisions that enhance future performance. Dashboarding involves real-time performance summaries with reference to a standard or goal. Deadoption (deimplementation or unlearning) describes the systematic deimplementation of an entrenched practice in light of evidence that supports stopping the practice. Performance incentives can be either positive (a reward) or negative (a penalty). Champions are local influencers who can use their relationships with people to win hearts and minds and bring about sustained change. Marketing psychology is a field that determines how to communicate a message in a way that resonates with the intended target audience.

Summary of Evidence

Passive Knowledge Translation Techniques

Passive knowledge translation strategies include posters, stickers, e-mail reminders, and mailings. Several trials have failed to demonstrate that passive knowledge translation techniques significantly and persistently change human behavior and clinical outcomes.[356,359–361] Nonetheless, strategies that use multiple passive methods are more effective than single-method approaches, as are strategies that are more interactive such as consensus building processes and direct outreach (eg, local champions). In a 2001 systematic review, passive interventions were found to have variable effectiveness, with audit/feedback and local champions being more likely to have a modest impact.[362] To effect lasting change, however, permanent behavior change is required.[350]

Recently, the use of social media has become a prominent form of knowledge translation. In a 2013 editorial, Young et al[363] suggested that "to defeat dogma and improve patient outcomes, we need to enter the battle for hearts and minds wherever it takes place, whether that is in the hospital corridors or on the Internet." Several recent critical trials have used tweets, blogs, podcasts, and even songs to engage clinicians in breaking research, often using allegory to convey key concepts. The 2015 AHA guidelines update for CPR and ECC was released in collaboration with a popular emergency medicine blog, CanadiEM, which released a series of infographics highlighting changes in the recommendations. These infographics were downloaded >100 000 times and translated into languages for distribution all over the world. Current research is attempting to quantify the degree to which social media, and which social media strategies, provides the most effective knowledge translation. There are documented correlations between highly cited and highly tweeted articles.[364] Although passive strategies on their own are rarely effective, combining them with active techniques, as described below, can facilitate behavior change.

Active Knowledge Translation Techniques

Change Theory

Healthcare organizations are considered some of the most complex operations in the world, making change difficult to achieve and sustain.[365] Change theory addresses human behavior and motivation as a factor to establish change.[366] It acknowledges an employee's reaction, resistance, and acceptance of change and places weight on motivation of frontline personnel as agents of change. The Beckhard formula[367] is commonly cited as an illustration of worker motivation to enable organizational success when change is required. The formula multiples dissatisfaction with the status quo (D), vision (V), and first steps (F), which must outweigh resistance to change (R): D×V×F>R.

Understanding dissatisfaction, communicating vision, introducing first steps to change, and managing resistance require coordinated and considered effort by leaders.[368] In many ways, change theory abandons the notion of passive knowledge translation by going beyond awareness of the desire for change. A practical model for change in health care was recently described, outlining how to define a gap, to identify barriers and enablers to behavior change, to plan a strategy to achieve behavior change, and to create metrics that will indicate success or the need to develop an alternative approach.[369] It offers a framework for resuscitation stakeholders interested in advancing the science of resuscitation and the delivery of resuscitation care.

Design Thinking

The resuscitation environment should be designed purposefully to account for human factors and operationalization of guidelines. Design thinking combines concepts of human factors, ergonomics, engineering, and architecture with the physical space that resuscitators occupy and has been used in health care to streamline patient handovers at shift change and to create spaces that are purpose-built.[370] When a space is designed with the resuscitation attempt in mind, human behavior may be modified. A simple example of design thinking in health care is the placement of handwashing stations near the doors of patient rooms; this improved hand hygiene compliance from 13% to 35% (P<0.001).[371] In resuscitation, design thinking could be applied to the placement of a CPR feedback defibrillator, which should ideally be in clear view of both the CPR provider and the team leader (or coach). Placement of the device in the corner of the room, far away from the line of sight, would likely reduce the overall effectiveness of CPR feedback and negatively affect patient outcomes.

Performance Measurement, Audit and Feedback, and Continuous Quality Improvement

The 2015 ILCOR Consensus on CPR and ECC Science With Treatment Recommendations supports performance measurement and quality improvement initiatives in organizations that treat cardiac arrest.[372] It has been demonstrated that goal setting can improve system performance[373] and that measurement and feedback of individual performance can improve performance of various components of CPR for real cardiac arrest events and in training settings.[42,127,130,347,374,375] Furthermore, survival in the Resuscitation Outcomes Consortium increased during a 10-year period despite no randomized trial showing benefit for 1 therapy. It did, however, require careful data collection, comparisons across sites, enhanced training, and implementation of feedback to emergency medical services and providers. It is widely believed that the impact of "shining a light" on the organizations involved led to a Hawthorne-like change.

Public Reporting and Dashboarding of Standards

When performance data are collected, they can be compared, reported, and fed back to various stakeholders. Systems that measure resuscitation training and performance data may publicly report relevant data and make comparisons within and between institutions against an established standard. For example, aggregate data of chest compression fraction and chest compression rates could be publicly reported and compared with the AHA guidelines. Public reporting of hand hygiene compliance in Ontario, Canada, led to a 50% improvement in adherence, from 60% to 90%, in a 5-year period.[376] The AHA's Get With The Guidelines initiative recognizes hospitals that self-report data and achieve guideline-compliant performance with Bronze, Silver, or Gold public recognition awards. The program facilitates data collection, feedback, coaching, and ongoing education to improve performance at the point of care and has been used by >500 healthcare organizations.[377] By setting benchmarks for clear and meaningful metrics and facilitating collection and analysis of case data, Get With The Guidelines has improved performance during resuscitation events (eg, reducing the time to defibrillation and increasing survival after in-hospital cardiac arrest events).[378] This practice of performance measurement and improvement has been cited by the Institute of Medicine as a key recommendation in improving cardiac arrest survival.[379]

Deadopting Old Practices (Deimplementation)

When established practices are shown to be ineffective or harmful, "deadopting" those practices has proven difficult. For example, it was very difficult for paramedics to transition from 3 stacked defibrillation shocks to single shocks in 2005 when the guidelines changed.[349] In critical care, tight glycemic control was shown to increase mortality, yet practice change was sluggish.[380] That contrasts to the rapid abandonment of therapeutic hypothermia with the release of a single randomized controlled trial showing that targeted temperature management of 33°C was no different from 36°C.[381] Resuscitation knowledge translation has focused on the adoption of new guidelines, but history has shown that perhaps the greatest changes come from deadopting current practices that may be neutral or harmful.

Incentives and Penalties

About three quarters of American companies remunerated their employees in part with a pay-for-performance scheme.[382,383] Properly designed incentive programs can drive improvements in performance.[384] On the basis of a behaviorist theory of motivation, individual and organization goals can be met when drivers (eg, bonuses, commissions, rewards) are implemented. Pay-for-performance programs have been shown to improve performance and to change behavior when combined with other strategies. For instance, modest improvements (2.6%–4.1%) in patient outcomes related to heart failure, acute myocardial infarction, and pneumonia have been demonstrated in US hospitals with pay-for-performance systems.[385] In Ontario, Canada, an analysis of government pay-for-performance programs found modest improvements in adherence to mammogram, Pap smear, senior flu shot, and colorectal cancer screening guidelines.[386]

Penalties can also drive improvements in health care. The Hospital Readmissions Reduction Program of the Affordable Care Act applies financial penalties to hospitals with high readmission rates for patients discharged after myocardial infarction, congestive heart failure, and pneumonia. Penalties have been reported to cost some hospitals more than US $1 million. A pre-post analysis of >15 million patients between 2000 and 2013 found that 95 readmissions per 10 000 discharges were averted per year in the cohort of lowest-performing hospitals after passage of the law.[387] However, some organizations have experienced unintended consequences from performance incentives that have led to shortcuts and created counterproductive conditions. In aviation, pilots were financially incentivized to push back from the gate on time. The metric used to determine pushback time was release of the parking brake. It was found that pilots would release the brake at the scheduled departure time before the aircraft was secured for pushback, leading to safety concerns. Such "gaming" of pay-for-performance plans can lead to unintended harms and highlights the importance of choosing the right measure by which to judge performance.

Psychological Marketing and Champions

Psychology and marketing science may decrease stigma or change attitudes to increase individual or community action. Numerous books have been written about how to influence the behaviors of others—whether through negotiating, managing, public speaking, arguing, or even romantic dating. These books generally depend on psychological principles that elicit the beliefs and motivators of a target population and devise an approach that appeals to these factors. Surveys of the public revealed that mouth-to-mouth contact, the fear of doing harm, and perceived complexity prevented bystanders from acting.[388] A messaging campaign was devised to address these barriers. The AHA has used a variety of short video media to promote this researched messaging after conducting qualitative research revealing the reasons behind the stigma around bystander CPR. The "Push Hard, Push Fast" campaign used pop culture personalities and carefully crafted phrases to address those research findings, including the phrase "You can only make things better."[389] Such colloquial slogans are often best derived by marketing experts, as in the examples above.

Similar expertise in psychology marketing could be applied to scientific advancements and evolving educational models. Drug companies have famously applied these techniques in their relationship building with physicians.[390] Although the idea of marketing staff influencing physicians is generally met with disdain, lessons can be learned from the successes of the pharmaceutical industry in influencing provider behavior. The idea of "evidence reps" (akin to infamous "drug reps" who are trained in psychological marketing) has best been summarized with the term *champion*. Champions use word of mouth and influence to promote change to their colleagues. Knowledge brokers, similar to champions, have also been described in healthcare literature. Knowledge brokers are advocates, coaches, and thought leaders who promote evidence-based practice within their organizations. The formal implementation of knowledge brokers has led to modest improvements in knowledge acquisition and practice change.[391]

Suggestions

- Passive knowledge translation: Organizations should combine passive knowledge translation techniques with active techniques to improve awareness of, agreement with, adoption of, and adherence to scientific guidelines.
- Change theory: Organizations should use change theory when planning to introduce new scientific guidelines to address system, physical, and cultural barriers to change.
- Design thinking: Organizations should consider human factors, ergonomics, and the physical space when planning to implement educational measures to support people by making the right thing to do the easy thing to do.
- Performance measurement: Organizations should also participate in a performance measurement program that features benchmarks, feedback, and public reporting. Collaboration and data sharing contribute to strengthened systems of care.
- Continuous quality improvement: Organizations should adopt formal, continuous quality-improvement programs for cardiac arrest response that outline who is responsible and accountable for important metrics.
- Deadoption strategies: Organizations should have a strategy, considering local contexts, to rapidly achieve the deadoption of therapies that are no longer supported by science.
- Incentive and penalties: Systems should carefully consider whether incentives/penalties can play a role in individual, team, or organizational performance metrics.
- Psychological marketing: Marketing strategy can be used to reach national audiences for community measures like bystander CPR or local measures through the use of champions who appeal directly to the beliefs and emotions of local providers.

Implementation Issues

Although the initial education provides foundations in knowledge, skill, and judgment, we have identified several ways to elicit desired behaviors that expand the traditional definition of education. Effective implementation focuses on individuals, organizations, systems, and communities and requires dedicated effort and a commitment (eg, human resources, finances, strategic planning) to pursue these activities with the goal of improving patient care and outcomes.

Table 2. Research Gaps

	Research Questions
Mastery learning and deliberate practice	Do approaches other than rapid cycle deliberate practice focused on chronometry enable mastery of skill and a reliable decrease in time to completion of skill? What is the interaction or synergy between deliberate practice and context of learning? What should the minimum passing standards be for different resuscitation skills? What components of deliberate practice and mastery learning are most strongly linked to improving clinical outcomes?
Spaced learning	Is spaced training feasible and generalizable for all resuscitation content? What are the optimal timing, duration, frequency, and intensity of training for acquisition and retention of specific knowledge, skills, and behaviors? What is the cost risk/benefit of changing the frequency and intensity of training (economic evaluation, value=quality+outcomes/cost)? Can we interface real-life performance with course training to attain a true portfolio of an individual's performance capability?
Contextual learning	Does context-specific team training (eg, scenario type, team composition, fidelity/realism) improve team performance or clinical outcomes? What instructional design features and instructor training strategies are most closely associated with improved care delivery and patient outcomes in a low-resource medical setting? Can remote or telemedicine support extend and contribute to training and learning?
Feedback and debriefing	What characterizes optimized prebriefing for resuscitation education in different contexts (eg, in situ simulation vs course-based training vs postevent clinical debriefings)? What characterizes optimized debriefing for resuscitation education in different contexts (eg, in situ simulation vs course-based training vs postevent clinical debriefings)? Does the use of objective CPR data during debriefings affect subsequent performance in the short and long term? How do scripts for prebriefing and debriefing for specific elements of the educational encounter affect performance in the short and long term?
Innovative educational strategies	What are the attributes of immersive technologies (eg, virtual reality, augmented reality) that facilitate optimal resuscitation training, performance, and retention? Can crowdsourcing be used for developing and evaluating resuscitation educational materials, assessing skills, and augmenting educational experiences or performance? Can the optimal approach for teaching resuscitation skills using nontraditional online resources for students and instructors be identified? Which game attributes and associated game features (eg, variability, novelty, changes over time, narrative, competition, incremental difficulty, socialization) contribute most to resuscitation training skill acquisition, proficiency, and retention?
Assessment	What is the validity of assessments that are currently being used in resuscitation education programs? Are there novel methods of assessment that would be useful in resuscitation education such as serious games? What is the consequence of passing or failing learners who do not meet a minimum standard of competence? Does a change in patient outcome–focused assessment improve the performance of students in those metrics that are most highly associated with patient outcome (eg, high-quality CPR, compliance with AHA algorithms)?
Faculty development	How does one motivate, teach, reinforce, and support reflective practice? What is the best way to teach/develop instructors/facilitators/peer mentors to optimize trainee acquisition of resuscitation skills? What are the best means of ensuring that instructors maintain competency in key instructor skills over time?
Knowledge translation and implementation	How do incentives and penalties affect the observed behaviors of resuscitation teams and their organizations? Which marketing strategies best influence bystanders to engage in the chain of survival? What are the most effective techniques to "deimplement" interventions and algorithms that are deemed ineffective or harmful (eg, 3 stacked shocks, high-dose epinephrine)?

AHA indicates American Heart Association; and CPR, cardiopulmonary resuscitation.

DISCUSSION AND FUTURE DIRECTIONS

Although survival after cardiac arrest has improved in the past decade, overall survival rates remain low.[392–394] In part, the reason is gaps in resuscitation performance despite ongoing training and certification.[3,343,395] Although studies have assessed methods to improve strategies for resuscitation education and knowledge translation,[396,397] a synthesis of the current evidence of best training strategies and knowledge gaps in these approaches has been lacking. In this statement, we have sought to provide the resuscitation community with guidance on the domains of mastery learning and deliberate practice, spaced learning, contextual learning, assessment, feedback and debriefing, educational innovation, faculty development, and knowledge translation and implementation, with a goal of improving translation of skills to real-world environments and ultimately enhancing survival after cardiac arrest. Considerations for implementation are variable across these domains. Decisions to implement specific suggestions at various levels (eg, national, regional, local) should take into account programmatic needs, resource availability, capacity and desire for change, and the potential savings and benefits to the system.

Dissemination of the Formula for Survival in Resuscitation

Our work expands on the elements of the ILCOR formula for survival in resuscitation and provides assistance in understanding how the components of resuscitation education, knowledge translation, and implementation interact with the original formula.[9,10] By providing this resource, we hope to help facilitate implementation of these strategies in health systems, academic facilities, and communities. Few publications have brought together these 8 key elements, thereby allowing instructors and administrators to identify knowledge gaps in current educational strategies. Future dissemination efforts may consider methods to communicate these considerations to improve implementation among faculty, performance among learners, and survival among individuals with cardiac arrest.

Limitations

There are several limitations to this work. We did not formally evaluate or grade the level of evidence, thus making it difficult for us to make formal recommendations based on quality of evidence. In addition, we did not assign priority to suggestions because needs are variable across programs/institutions and implementation of these suggestions is highly dependent on local resources and expertise. We did not specifically discuss some education and implementation strategies because the literature is limited or the strategies have been adequately discussed in other AHA scientific statements. These include educational strategies for dispatch-assisted CPR (key for improving bystander CPR rates),[398] the use of drones to carry AEDs to the patient,[399] the use of cognitive aids in resuscitation[89] (eg, AHA Full Code Pro app,[400] Code CPR by Remarkable Edge[401]), and the use of social media as a strategy to alert potential rescuers.[402]

Need to Improve Education and Implementation Research

Our review of the literature has highlighted opportunities for future research in resuscitation education, knowledge translation, and implementation that is required to advance the field (Table 2). Overall, these findings highlight an important gap in resuscitation education research: answering questions by using clinically relevant learning or performance outcomes (ie, learning or performance outcomes with established links to patient outcomes) or by measuring actual patient outcomes. Epidemiological studies using large in-hospital and out-of-hospital registries have assisted our understanding of biological mechanisms to improve outcomes from sudden cardiac arrest.[403–405] Aside from seminal articles,[406,407] studies have used secondary data sets to examine the effect of resuscitation education strategies on patient care processes or patient outcomes. With the development of new technology that provides clinical quality assurance data in and out of the hospital, these large data sets may provide an opportunity to further our understanding of resuscitation education strategies, knowledge translation, and implementation while examining actual events. Future investigations may consider using these resources to further our knowledge of effective resuscitation education and knowledge translation strategies.

CONCLUSIONS

Application of effective resuscitation education strategies and knowledge translation within institutions and communities may increase resuscitation quality and subsequently improve survival after cardiac arrest. Future focus on the domains of improving mastery learning and deliberate practice, spaced learning, contextual learning, assessment, feedback and debriefing, educational innovation, faculty development, and knowledge translation and implementation may assist instructors and implementers in improving resuscitation quality and ultimately survival after cardiac arrest.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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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.

*Modest.

†Significant.

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