WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

Worksheet author(s)

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Clinical question.

In laypersons and HCP's performing CPR, does the use of CPR feedback devices when compared to no device improves CPR skill acquisition, retention and real life performance?

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention/ therapy

State if this is a proposed new topic or revision of existing worksheet: Review of existing worksheet

Conflict of interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? no

Search strategy (including electronic databases searched).

Cinahl
Medline
Cochrane Database of systematic review.
AHA Endnote database
Embase

Cochrane Database - Resuscitation; basic life support
AHA Endnote database – "feedback" or "prompt" in abstracts
Medline and Embase – "prompt" or "feeback" AND "cardiopulmonary resuscitation" (MeSH) OR "heart arrest" (MeSH)

- State inclusion and exclusion criteria

Inclusion Criteria:

Studies discussing audio or visual feedback on CPR skill acquisition, retention or performance.

Exclusion Criteria:
Studies involving physiology

- Number of articles/sources meeting criteria for further review:

66 – for the purposes of this writing, all were utilized to add to the knowledge base, however, not all were referenced in the body of the paper.
Total number of resources, 697.

44 studies met criteria for further review. Of these 0 were LOE 1 (RCTs), 3 LOE 2 (non-randomised, concurrent controls), 5 LOE 3 (retrospective controls), 2 LOE 4 (no controls), and 20 LOE 5 supporting, 5 neutral studies and 8 opposing studies.

There were 697 articles in the initial search in July of 2008. Some of the articles were removed due to age of the article, information contained which has become an industry standard or information that appeared to be inconclusive.

Summary of evidence

Evidence Supporting Clinical Question

Good			**Abella 2007 (E3)** **Kramer-Johansen 2006 (E3)**		**Choa 2008 E3** **Dine 2008 E3** **Ertl 2007 E3** **Spoooner 2007 E1 E2** **Spooner 2006 E3** **Sutton 2007 E1, E2** **Wik 2001 E1, E3** **Handley 2003 E3** **Perkins 2005 E3** **Wik 2005 E3** **Williamson 2005 E1, E3** **Elding 1998 E3** ***Milander 1995 E3***
Fair		**Kern 1992 (E3)**	**Chiang 2005 (E3)** **Fletcher 2008 E** **Niles 2009 E3**	**DeRegge 2006 E3**	**Jantti 2009 E3** **Beckers 2007 (E2, E3)** **Noordergraaf 2006 E3** **Monsieurs 2005 E1, E3** **Wik 2002 E1, E3**
Poor		**Berg 1994 (E3)**			**Lynch 2005 E1** **Boyle 2002 E3**
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation

B = Survival of event

C = Survival to hospital discharge

D = Intact neurological survival

E = Other endpoint
E1 – Depth of compression
E2 – Rate of compression
E3 – Ventilation Volume
E4 – Skill retention
Italics = Animal studies

Summary of evidence

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Evidence Neutral to Clinical Question

Good					**Bolle 2009 E3** **Yang 2009 E** **Williamson 2005 E1 E2**
Fair		**Isbye 2008 E4**			
Poor					**France 2006 E3**
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
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Evidence Opposing Clinical Question

Good					**Nishisaki 2009 E3** **Perkins 2009 E3** **Van Berkom 2008 E3** **Isbye 2008 E2** **Zanner 2007 E3** **Hostler 2005 E3**
Fair					**Cho 2009 E4** **Perkins 2005 E4**

Poor					
	1	**2**	**3**	**4**	

A = Return of spontaneous circulation
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REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

In laypersons and HCP's performing CPR, does the use of CPR feedback devices when compared to no device improve CPR skill acquisition, retention and real life performance?

Skills Learning theory may provide strategies for learning retention of CPR skills. The learner needs to know what is expected during the acquisition of skills. For CPR training, this translates into demonstration of each component of the skill, as well as the entire skill sequence. The purpose of each of the components of CPR is necessary for the learner to know why it is in the skill sequence and what it provides (Lovell, 1980).

Sensory feedback from a learner's performance is vital to the success of learning the skill of CPR. Properly performed ventilations and compressions, look, feel and sound a specific way. Feedback is essential due to the complexity of the task. Simultaneous feedback is more effective than feedback at the end of performance. Feedback provided during the performance of CPR provides simultaneous feedback to correct any noted deficiencies. Practice of the skill is essential for ongoing performance to maintain competence (Lovell, 1980).

CPR Skill retention following cardiopulmonary resuscitation for health care providers has been documented over the past twenty years. Kaye (1990, 51) tested the retention of more than fifty house officers, discovering the knowledge base remained virtually unchanged after a period of five months, but that skills had declined significantly during the same amount of time. Moser and Coleman (1992, 372) agreed, determining knowledge is retained longer than the actual skill of CPR, but skills decline as quickly as two weeks post training, and are at pre-training levels by 1-2 years. Frequent skill updates may be appropriate in order to retain CPR skills. Woollard (2006, 237) examined optimal refresher intervals for laypersons who had initially sat through a four hour course. Some twenty four individuals received refresher classes at seven and twelve months or at the twelve month interval. Results concluded there was greater skill loss when the refresher course occurred at twelve months rather than seven months, leading to the conclusion refresher training should not exceed seven month intervals.

Brown (2006, 253) explored the relationship between the knowledge of the basic life support guidelines and skill performance. Using more than sixty emergency medical technicians were randomly chosen to assess their performance and their knowledge base. Although knowledge base correlated with the correct compression to ventilation rate, the actual performance of the skill in terms of compression depth and ventilation volume did not correlate with the knowledge base. The conclusion was drawn overall performance of skills remains poor in spite of adequate knowledge base.

Madden (2006, 218) examined nursing students in Ireland and determined knowledge and skills were retained as a result of the four hour training course, but deteriorated within a 10 week time frame. This supports a theory that skills deteriorate at an international level, and is not simply unique to one population.

Laypersons are just as susceptible to loss of skill level as the healthcare provider. Mahoney (2007, 413) examined the knowledge of CPR and AED skills twelve months after training in thirty five airline cabin crew members. Most crew members failed to deliver CPR correctly in spite of a high level of first aid knowledge and some experience in CPR. AED operation was noted to be safe, although electrode placement was variable dependent upon individual placement.

A small study of six nurses by West (2000, 34) looked at the skills for basic infant life support. The same conclusions were drawn. By six weeks, nursing personnel were incorrectly performing the steps of infant basic life support. The conclusion may be drawn skills deteriorate in both adult as well as infant basic life support.

Length of time spent in class has been identified as a variable, and several studies have examined the optimal length of class time in relation to skill retention. Andresen (2008, 419) took more than one thousand volunteers and randomly selected individuals to be a part of courses lasting two, four or seven hours. Immediate testing demonstrated more correct responses than the other groups, however, skill retention decreased significantly. Skill retention improved if a refresher is held at the six month time frame, however, was the lowest at twelve months with no refresher course.

Einspruch (2007, 476) noted adults aged 40-70 who had taken a video self training course were just as proficient at CPR skills as the individual who had been through a four hour course. Both groups were fairly proficient at the completion of the course, but both groups showed deterioration in skills at the two month level. Lynch (2005) noted older adults learned fundamental skills of CPR in about 30 minutes.

Roppolo (2007, 276) compared layperson long term retention at the six month time interval of airline crew members. Determining basic cardiac life support skills and AED placement to be the core of survival for the patient with cardiac arrest, these two skills need to be retained in order for positive outcomes to occur. More than one hundred subjects were randomized into two groups, one using a 30 minute course and the other the traditional heartsaver four hour course. In terms of initial skill performance, there was little difference between the two groups. Most importantly, after six months, the skills performance was virtually identical between the two groups, although both exhibited a similar level of deterioration.

Improvement measures for CPR skill retention have been studied, some proving to be more effective than others. Olasveengen (2007, 427) looked at providing performance feedback on CPR to ambulance services might improve overall skill performance. Eighty five out of hospital cardiac arrests were compared after performance evaluations were provided. No improvement was noted in the quality of basic life support was noted after providing performance evaluation as before the implementation of performance evaluation. Attempts to improve the quality of CPR were unsuccessful.

Parnell (2007, 271) theorized poor performance in CPR may be due to poor instruction on the part of the teacher. Investigating a number of classes taught in New Zealand, it was noted approximately ¾ of the courses passed students although hand placement and depth compression was correct 57% of the time. Learners who are determined to be competent with inaccurate hand placement and depth compression will not be able to perform CPR effectively. Further, studies to determine if the learner is retaining CPR may not be deterioration in skills but rather a symptom of the student never being competent to begin with.

Rittenberger (2006, 365) measured the ability of thirty six pre-hospital providers to manage the skills of ventilation, chest compressions and AED usage. Randomly assigning subjects to three different groups of skills, it was noted the more skills added to the scenario, the quality and quantity of basic life support diminishes. Providing ventilations was correct more often when provided alone than when in combination with chest compressions. More compressions were delivered with basic life support alone than when combined with the use of an AED. The use of a prompt or automatic device during the performance of CPR may improve basic life support during resuscitation.

AED Skill retention seems to be better than CPR skill retention based on a study by Riegel (2006, 927). Assessing volunteers in terms of pad placement and the action of “clearing” the patient had the highest rate of failure, potentially due to the lack of audio and visual prompts provided by the AED. The majority of the participants were able to function adequately with the AED seventeen months after the initial training had occurred. Further, very little time appeared to be needed to bring the participant back to adequate levels of performance.

CPR feedback devices during skill performance have been studied by a number of individuals over the course of the last several years. One of the initial studies was by Kern (1992, 145). Ultimate survival of the patient is dependent upon the ability of the individual performing CPR to consistently maintain a high rate of cardiac compressions. The authors created an audiotape which emitted a tone in order to maintain proper timing of compressions. Utilizing the emergency department, the tape was played during resuscitation efforts. The ending result was the use of the audio tone increased the number of individuals successfully resuscitated.

Elding (1998, 169) studied the use of a non-invasive hand held devise to assist the student to monitor and modify compression technique during CPR on a manikin. Using forty nurses who had been determined to be qualified to perform CPR, the use of the device was effective in correctly applying compressions. Determining effective CPR requires a high level of skill, and inadequate compressions lead to ineffective CPR, the use of an external device was shown to be significantly more effective than when no external device was used. There was also noted to be a decrease in excessive application of pressure and incorrect hand position.

DeRegge (2006, 379) determined nursing personnel have a difficult time retaining resuscitation skills, particularly those associated with ventilation. Hypothesizing that a bag valve mask device with pressure flow response valve would assist nursing personnel in appropriate ventilations, almost forty nurses were tested for initial skill levels, then trained with the feedback device vs the standard bag valve mask. At three months, there was very little variation in ability to ventilate the patient. By six months there was a marked difference between the two groups, noting the group trained with the feedback device was much more proficient in ventilations. This would appear to support the premise that a feedback device during ventilation compensates for the deterioration over time in ventilation skills.

Hostler (2005, 53) used 114 pre-hospital providers to determine if a voice activated manikin system would improve performance during simulated resuscitation. Randomizing the pre-hospital providers, each group performed three minutes of CPR on a VAM. During one round the VAM was turned on, and during one round the VAM was turned off. A general decay was initially noted in the compression depth over the three minute time frame, but with the use of the VAM, the decay was decreased. While the use of the VAM did not directly improve ventilation or compression quality or the rates, the use of the VAM did improve the gradual decay in compressions and ventilations by the pre-hospital provider.

Isbye (2008, 73) used forty three medical students measured the difference in skill level between instructor facilitated training and an automated voice advisory mannequin. Two randomized groups were used to compare training between CPR and the use of a bag valve mask immediately after training and again at a three month interval. There was no statistical difference between the two groups in CPR skills immediately after training or three months later. The instructor facilitated group scored higher overall when the bag valve mask skill was added into the total score. Bag valve mask skills were performed better when an instructor facilitated the training. The authors concluded the retention of bag valve mask skills were better when an instructor facilitated the training than the use of an automated voice advisory mannequin.

The use of a feedback device during an unannounced manikin study proved effective for appropriate depth of chest compressions according to Noordergraaf (2006, 241). Using the theory chest compression skills deteriorate rapidly after training, two hundred and twenty four hospital personnel were chosen at random to deliver chest compressions on a manikin. Half were provided a feedback device and the other half were not. Chest compressions were noted to be ineffective in 36% of the control group. With a few seconds of training with the feedback device, the compression depth improved to an acceptable level. Further study needs to be done to determine if the use of this particular feedback device during training would lead to an improvement in skill retention over time. Perkins (2005, 103) had virtually the same results the previously. Using twenty medical students and a manikin on a hospital bed, three minutes of CPR was performed. Use of the feedback device led to a decrease in the number of shallow compressions (23%) in comparison to no feedback device (44%). Perkins concluded the use of a feedback device improved ECC performance.

Dine (2008, 2817) hypothesized a multimodal training method using audiovisual feedback and debriefing would improve the performance of CPR in the hospital setting. Simulating cardiac arrests, eighty nurses were randomized into two groups. After three trials of simulated cardiac arrest, the quality of CPR was recorded using a sensing defibrillator that measures chest compression and depth, as well as delivers audiovisual feedback. Finding the debriefing only group improved compressions significantly (from 38%-68%), the combination of feedback and debriefing was noted to be more impressive. The number of individuals providing adequate rate and depth of compressions moved from 29% to 64%. Debriefing and feedback during CPR may improve rescuer training for cardiac arrest patients.

Yang (2009, 490) performed a randomized controlled study with a scenario developed to simulate cardiac arrest in a public place. Using 96 adults without CPR training for at least five years were randomized to receive dispatch assistance on compressions with either voice instruction alone or interactive voice and video demonstration and feedback. It was determined the addition of interactive video communication to dispatcher-assisted chest compression-only CPR initially delayed the commencement of chest compressions, but subsequently improved the depth and rate of compressions.

Objective feedback improved acquisition and retention of chest compressions among healthcare students in a 2007 study by Spooner. The feedback group demonstrated better compression depth and more correct compressions at initial testing. Skill retention remained high for six weeks following the initial training, however, deteriorated significantly afterwards, which is consistent with other studies.

Sutton (2007, 161) used a voice activated manikin system to compare immediate, standardized, corrective audio feedback training (VAM) to quality standardized instructor feedback during pediatric basic life support. Results concluded the VAM group provided more chest compressions and correct ventilations per minute, with an overall lower error rate, indicating the use of VAM during initial pediatric basic life support improves initial performance and skill acquisition.

Wik (2001, 167) determined manikins which provide auditory feedback to an individual during the performance of CPR improved skills. Performance immediately improved when the prompt was activated and deteriorated when it was discontinued. The voice activated manikin (VAM) suggests this training tool minimizes the number of mistakes, never alters from the CPR guidelines and never misses inaccuracies during administration of CPR. The VAM may be an effective instruction tool.

Wik (2002, 273) also tested the retention of CPR skills following training with a voice activated manikin (VAM). When baseline CPR skills were noted to be poor, within 20 minutes there was improvement noted in the VAM. Over training included thirty minute extra practice sessions in three minute sessions and were found to exhibit improved retention in chest compressions and adequate ventilations at six months, whereas the control group was no longer competent

Wik (2005, 27) evaluated retention of CPR skills at twelve months using a VAM. Thirty five volunteers had individual training sessions on a VAM, with one third receiving another 30 minutes of instruction in three minute increments. Ventilation and compression variables were measured immediately after training, at the six month interval as well as at twelve months. There were virtually no variables in CPR skills when tested with active feedback 12 months post training, with some decline in the number of chest compressions being performed after 12 months in the group trained for 20 minutes. VAM can improve the performance of CPR skills on a manikin with no deterioration in performance after 12 months.

Williamson (2005, 140) noted the use of AED audio prompts on CPR performance improved the quality of CPR in the untrained layperson. Using 24 subjects, all were asked to perform CPR on a manikin with and without the assistance of an audio prompt device. All subjects were trained in CPR, then retested eight weeks later. Untrained subjects were noted to perform poorly, but repeat performance after audio prompts resulted in significant improvements in compression rate and percentage of correct ventilations. After training, there was no difference in CPR performance with or without audio prompts, although ¾ of the subjects stated they felt more comfortable performing CPR with the prompts.

Prompt devices during CPR skill performance have been reviewed in a number of studies. Beckers (2007, 100) took first year medical students and examined their performance using CPREzy. Use of this device improved rate, depth, and correct depth of compression on manikins. Van Berkom (2008, 66) reviewed CPREzy device in terms of how much work was involved with the use of the device than without. While no additional force is required of the compressor, additional work was noted. Handley (2003, 57) determined the use of audible corrective instruction during CPR skill performance improved inflations and chest depth compressions. Jantti (2009, 453) determined the use of a metronome improved the rate of compressions, but had no effect on depth of compressions or ventilations. Monsieurs (2005, 41) utilized a public access resuscitator to improve CPR performance. Immediately after training BLS performance on the number of ventilations and compressions which mirrored the current guidelines. Chiang (2005, 297) determined audio prompts could improve adherence to CPR guidelines in the clinical setting by improving the hands off period for CPR with the use of an audio prompt device. Fletcher (2008, 127) and Boyle (2002, 63) concurred in separate studies. Niles (2009, 553) took an approach of measuring leaning on the chest in the pediatric population during compressions. Automated feedback during CPR decreased the amount of leaning with chest compressions. Milander (1995, 708) was an early study on animals, noting chest compressions and ETCO2 improved with audible tones during CPR. Berg (1994, 35) determined ETCO2 improved in children with an audio prompt during CPR. The improved ETCO2 suggested an overall improvement in the quality of CPR. In a two phase study by Williamson (2005, 140) one group improved with the use of audio prompts and the other showed no improvement. France (2006, 160) noted in a letter to Williamson a study which used prompts in some instances and not in others. The conclusion was there was no difference in performance with or without the use of prompts.

Abella (2007, 54) retrieved data from 101 resuscitations using sensing and feedback technology and compared the data to 55 resuscitations not using the technology. The trend was compression and ventilation rates were improved. No statistical differences were noted in return of spontaneous circulation for the patients. Kramer-Johansen (2006, 283) looked at out of hospital adult arrests with the use of similar technology. Compression depth improved with a patient outcome of increased short term survival.

Two studies utilized mobile devices during CPR. Choa (2008, 87) and Ertl (2007, 286) showed the use of a multi-media phone improved quality of CPR improved and faster initiation of CPR with their use. Zanner (2007, 487) determined the use of multimedia determined phone CPR required more time to complete the tasks, as did Bolle (2009, 116). Bolle concluded video communication is unlikely to improve telephone CPR.

Several studies noted the use of CPR prompt devices may be dependent upon the surface in which CPR is being performed. Nishisaki (2009, 540) noted compression devices may overestimate the compression depth if performed on a soft surface. Perkins (2005, 103) reported an individual doing CPR was injured using the CPR feedback device when their hand got stuck. Cho (2009, 600) noted soft tissue injury to two patients caused by a feedback sensor during prolonged CPR.

Acknowledgements:

Citation List

Abella, B. S., D. P. Edelson, et al. (2007). "CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system." Resuscitation **73**(1): 54-61.

LOE 3 – Good, Supportive for ventilation volume. Feedback during in-hospital cardiac arrests using historical controls, and “real-time CPR-sensing and feedback technology.”

Beckers, S. K., M. H. Skorning, et al. (2007). "CPREzy improves performance of external chest compressions in simulated cardiac arrest." Resuscitation **72**(1): 100-7.

LOE 5 – Before and after study in humans. Supports an external device is able to improve performance in ECC in simulated cardiac arrest.

Bolle, S. R., J. Scholl, et al. (2009). "Can video mobile phones improve CPR quality when used for dispatcher assistance during simulated cardiac arrest?" Acta Anaesthesiol Scand **53**(1): 116-20.

LOE 5 – Randomized controlled trial manikin study. Good evidence in lay persons. Neutral to the question.

Boyle, A. J., A. M. Wilson, et al. (2002). "Improvement in timing and effectiveness of external cardiac compressions with a new non-invasive device: the CPR-Ezy." Resuscitation **54**(1): 63-7.

LOE 5 – Before and after comparison of a new device. Poor quality.

Brown, T. B., J. A. Dias, et al. (2006). "Relationship between knowledge of cardiopulmonary resuscitation guidelines and performance." Resuscitation **69**(2): 253-61.

LOE 5 – manikin study. Determined accurate knowledge was associated with better performance, overall psychomotor performance remains poor.

Chiang, W. C., W. J. Chen, et al. (2005). "Better adherence to the guidelines during cardiopulmonary resuscitation through the provision of audio-prompts." Resuscitation **64**(3): 297-301.

LOE 3 – Before and after study with humans. Instruments were employed to remind operators of rate of compressions and need to oxygenate when intubating. Supportive to the question.

Cho, G. C. (2009). "Skin and soft tissue damage caused by use of feedback-sensor during chest compressions." Resuscitation **80**(5): 600;

Case report of two patients sustaining soft tissue and skin injuries in association with an accelerometer device used during prolonged resuscitation attempts. LOE 5 – Fair quality and discussion patient injury.

Choa, M., I. Park, et al. (2008). "The effectiveness of cardiopulmonary resuscitation instruction: animation versus dispatcher through a cellular phone." Resuscitation **77**(1): 87-94.

LOE 5 – Good quality discussion on lay person performance. Audiovisual instruction improved time interval compliance.

Curran, V. R., K. Aziz, et al. (2004). "Evaluation of the effect of a computerized training simulator (ANAKIN) on the retention of neonatal resuscitation skills." Teach Learn Med **16**(2): 157-64.

LOE 5 – Before and after control group design determined computerized system as effective as video for maintaining knowledge base and skills.

De Regge, M., C. Vogels, et al. (2006). "Retention of ventilation skills of emergency nurses after training with the SMART BAG compared to a standard bag-valve-mask." Resuscitation **68**(3): 379-84.

LOE 4 – Nursing personnel trained on a BVM and one with a positive flow valve. Measuring ventilation skills at three and six months, there was no deterioration in the skills. Supportive of the question.

Dine, C. J., R. E. Gersh, et al. (2008). "Improving cardiopulmonary resuscitation quality and resuscitation training by combining audiovisual feedback and debriefing." Crit Care Med **36**(10): 2817-22.

LOE 3 – Before and after human study, randomized and controlled. Audiovisual feedback improved depth performance and reduced the variance of the compression rate.

Edelson, D. P., B. Litzinger, et al. (2008). "Improving in-hospital cardiac arrest process and outcomes with performance debriefing." Arch Intern Med **168**(10): 1063-9.

Elding, C., P. Baskett, et al. (1998). "The study of the effectiveness of chest compressions using the CPR-plus." Resuscitation **36**(3): 169-73.

LOE 5 – Randomized, controlled cross-over study demonstrated improved chest compressions and hand position. Supportive of the question

E. L., B. Lynch, et al. (2007). "Retention of CPR skills learned in a traditional AHA Heartsaver course versus 30-min video self-training: a controlled randomized study." Resuscitation **74**(3): 476-86.

LOE 5 – Using video programs individuals were trained in CPR. There was no significance between the use of the video program in individuals from those who took traditional courses.

Ertl, L. and F. Christ (2007). "Significant improvement of the quality of bystander first aid using an expert system with a mobile multimedia device." Resuscitation **74**(2): 286-95.

LOE 5 – Use of a PDA improved hand position, airway management and quality of CPR. Supportive of the question.

Fletcher, D., R. Galloway, et al. (2008). "Basics in advanced life support: a role for download audit and metronomes." Resuscitation **78**(2): 127-34.

LOE 3 – looked at before and after comparisons of individual performance with and without the use of a cuing device. Noted improvements with the use of the metronome. Supportive of the question.

France, J., S. Wilson, et al. (2006). "Auditory and visual prompts during cardiopulmonary resuscitation in the emergency department." Emerg Med J **23**(2): 160-1.

Letter to the editor describing a randomized trial of different types of audio assistance on manikins. No major effect on rates appeared to have been found.

LOE 5 – Neutral to the question. Difficult to determine the methodology and detail of the trial.

Gruben, K. G., J. Romlein, et al. (1990). "System for mechanical measurements during cardiopulmonary resuscitation in humans." IEEE Trans Biomed Eng **37**(2): 204-10.

Handley, A. J. and S. A. Handley (2003). "Improving CPR performance using an audible feedback system suitable for incorporation into an automated external defibrillator." Resuscitation **57**(1): 57-62.

LEO 5 – manikin performance with two groups, one being provided feedback and the other not. Groups receiving feedback showed significant improvement. Supportive of the question.

Hostler, D., H. Wang, et al. (2005). "The effect of a voice assist manikin (VAM) system on CPR quality among prehospital providers." Prehosp Emerg Care **9**(1): 53-60.

LOE 5 – Randomized, controlled study evaluating the voice assist manikin. Improved ventilations over time, but no difference in compressions. Supportive to ventilation question.

Isbye, D. L., P. Hoiby, et al. (2008). "Voice advisory manikin versus instructor facilitated training in cardiopulmonary resuscitation." Resuscitation **79**(1): 73-81.

LOE 5 – Skill retention was better with an instructor when using BVM after 3 months. Neutral to the question for skill acquisition and performance. Opposes the question for skill retention.

Jantti, H., T. Silfvast, et al. (2009). "Influence of chest compression rate guidance on the quality of cardiopulmonary resuscitation performed on manikins." Resuscitation **80**(4): 453-7.

LOE 5 – Before and after manikin study. Viewed rescuer fatigue and compression rate and depth. Use of metronome improved rate of compressions. Supportive of the question.

Kaye, W., G. Wynne, et al. (1990). "An advanced resuscitation training course for preregistration house officers." J R Coll Physicians Lond **24**(1): 51-4.

LOE 5 – Before and after study to measure retention and determine if actual use of a skill improves performance. Experience does not substitute practical training.

Kern, K. B., A. B. Sanders, et al. (1992). "A study of chest compression rates during cardiopulmonary resuscitation in humans. The importance of rate-directed chest compressions." Arch Intern Med **152**(1): 145-9.

LOE 2 – Interventional study in cardiac arrest adults. End tidal CO2 rates were measured. Using this measure, rates were improved with the use of audible rate guidance. Supportive of the question.

Kramer-Johansen, J., H. Myklebust, et al. (2006). "Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: a prospective interventional study." Resuscitation **71**(3): 283-92.

LOE 3 – Prospective non-randomized study of out of hospital cardiac arrest. Providing feedback improved average compression depth. Increased compression depth associated with improved short term survival. Supportive of the question.

Lovell, R.B. Adult Learning. New York: John Wiley & Sons, 1980.

Lynch, B., E. L. Einspruch, et al. (2005). "Effectiveness of a 30-min CPR self-instruction program for lay responders: a controlled randomized study." Resuscitation **67**(1): 31-43.

LOE 5 – Randomized study to variety of training methods. Video based self instruction appeared to be favorable in comparison to instructor led training methods. Supportive to question of skill acquisition, neutral to skill retention and performance.

Madden, C. (2006). "Undergraduate nursing students' acquisition and retention of CPR knowledge and skills." Nurse Educ Today **26**(3): 218-27.

LOE 5 – Before and after study to determine if practice and training in CPR is better than no training in CPR.

Milander, M. M., P. S. Hiscok, et al. (1995). "Chest compression and ventilation rates during cardiopulmonary resuscitation: the effects of audible tone guidance." Acad Emerg Med **2**(8): 708-13.

LOE 2 – Observed CPR in real life, then a before / after study on animals. CPR quality improved compression rate with audible tones. Supportive of the question.

Monsieurs, K. G., M. De Regge, et al. (2005). "Improved basic life support performance by ward nurses using the CAREvent Public Access Resuscitator (PAR) in a simulated setting." Resuscitation **67**(1): 45-50.

LOE 5 – Before and after training comparisons of manikin CPR using pocket mask and positive pressure device with prompts. Improved performance with the prompting device. Supportive of the question.

Moser, D. K. and S. Coleman (1992). "Recommendations for improving cardiopulmonary resuscitation skills retention." Heart Lung **21**(4): 372-80.

LOE 5 – Meta analysis of skill retention in relation to resuscitation is reviewed.

Niles, D., J. Nysaether, et al. (2009). "Leaning is common during in-hospital pediatric CPR, and decreased with automated corrective feedback." Resuscitation **80**(5): 553-7.

LOE 3 – feedback provided to students regarding leaning in the pediatric population at the discretion of the instructor. Providing feedback decreased the amount of leaning being done by the student. Supportive to the question.

Nishisaki, A., Nysaether, J., Sutton, R., Maltese, M., Niles, D., Donoghue, A., Bishnoi, R., Helfaer, M., Perkins, G. D., Berg, R., Arbogast, K.Nadkarni, V. (2009). "Effect of mattress deflection on CPR quality assessment for older children and adolescents." Resuscitation 80(5): 540.

LOE 5 – chest compressions on soft surface and rigid surface were measured. The use of a force and deflection sensor may not be accurate and overestimate compression depth on soft surfaces. Opposes the clinical question.

Noordergraaf, G. J., B. W. Drinkwaard, et al. (2006). "The quality of chest compressions by trained personnel: the effect of feedback, via the CPREzy, in a randomized controlled trial using a manikin model." Resuscitation **69**(2): 241-52.

LOE 5 – manikin study with two groups of individuals. Use of a training device with feedback mechanism improved compression depth. Supportive of the question

Olasveengen, T. M., A. E. Tomlinson, et al. (2007). "A failed attempt to improve quality of out-of-hospital CPR through performance evaluation." Prehosp Emerg Care **11**(4): 427-33.

LOE 5 – Quality of CPR was reviewed before and after performance evaluations. No improvement was noted. Performance evaluations do not lead to improvement in CPR performance or increase in survival rates.

Parnell, M. M. and P. D. Larsen (2007). "Poor quality teaching in lay person CPR courses." Resuscitation **73**(2): 271-8.

Perkins, G. D., C. Augre, et al. (2005). "CPREzy: an evaluation during simulated cardiac arrest on a hospital bed." Resuscitation **64**(1): 103-8.

LOE 5 – Randomized control study with improved chest compression depth. Caused more fatigue than the use of no device. Supportive of the question.

Perkins, G. D., L. Kocierz, et al. (2009). "Compression feedback devices over estimate chest compression depth when performed on a bed." Resuscitation **80**(1): 79-82.

LOE 5 – Measured chest compression on a soft mattress vs rigid surface. Device used failed to compensate for compressions being performed on a soft surface. Opposing the question.

Riegel, B., A. Birnbaum, et al. (2005). "Predictors of cardiopulmonary resuscitation and automated external defibrillator skill retention." Am Heart J **150**(5): 927-32.

Riegel, B., S. D. Nafziger, et al. (2006). "How well are cardiopulmonary resuscitation and automated external defibrillator skills retained over time? Results from the Public Access Defibrillation (PAD) Trial." Acad Emerg Med **13**(3): 254-63.

LOE 5 – Observational follow up study on AED skills by laypersons. Retraining of laypersons took very little time to bring back to adequate performance.

Rittenberger, J. C., G. Guimond, et al. (2006). "Quality of BLS decreases with increasing resuscitation complexity." Resuscitation **68**(3): 365-9.

LOE 5 – Prospective observational study randomly assigned healthcare providers were given scenarios. Increasing the number of skills in a scenario led to decreased performance of BLS skills.

Roppolo, L. P., P. E. Pepe, et al. (2007). "Prospective, randomized trial of the effectiveness and retention of 30-min layperson training for cardiopulmonary resuscitation and automated external defibrillators: The American Airlines Study." Resuscitation **74**(2): 276-85.

LOE 5 – Randomized study reviewing length of time to skill acquisition and knowledge. Six months later, deterioration of skills was comparable. Favorable to decreasing amount of time to learn the skill.

Spooner, B. B., J. F. Fallaha, et al. (2007). "An evaluation of objective feedback in basic life support (BLS) training." Resuscitation **73**(3): 417-24.

LOE 5 – Randomized controlled cross over study. Feedback from a device improved initial training and retraining at 6 weeks over an instructor. Over time skills declined similarly. Supportive of the question.

Sutton, R. M., A. Donoghue, et al. (2007). "The voice advisory manikin (VAM): an innovative approach to pediatric lay provider basic life support skill education." Resuscitation **75**(1): 161-8.

LOE 1 – Randomized control trial. Manikin training which was either scripted with practice session or an instructor. Improved skill acquisition was noted with the voice activated manikin over the instructor and differences persisted after training. Supportive of the question.

van Berkom PF, Noordergraaf GJ, Scheffer GJ, Noordergraaf A (2008) Does use of the CPREzy involve more work than CPR without feedback? Resuscitation 78:66-70

LOE 5 – use of the CPRezy leads to increase in rescuer fatigue, potentially due to the improvement in chest compressions. Opposing the question.

West, H. (2000). "Basic infant life support: retention of knowledge and skill." Paediatr Nurs **12**(1): 34-7.

LOE 5 – Confirmation of deterioration in skills by healthcare professionals in skills retention.

Wik, L., H. Myklebust, et al. (2002). "Retention of basic life support skills 6 months after training with an automated voice advisory manikin system without instructor involvement." Resuscitation **52**(3): 273-9.

LOE 5 – Non randomized study using voice feedback. Measured compression and ventilation variables. Prompt devices improved skill acquisition. Supportive of the question.

Wik, L., H. Myklebust, et al. (2005). "Twelve-month retention of CPR skills with automatic correcting verbal feedback." Resuscitation **66**(1): 27-30.

LOE 5 – No changes in CPR skills when test with active feedback at 6 or 12 months. Improved ventilation and compression performance. Supportive of the question.

Williamson, L. J., P. D. Larsen, et al. (2005). "Effect of automatic external defibrillator audio prompts on cardiopulmonary resuscitation performance." Emerg Med J **22**(2): 140-3.

LOE 5 – Randomized controlled cross study over time. No feedback and feedback used. Determined feedback improved chest compressions, rate of compressions, ventilations rate. No difference in second group when tested later without feedback. Supportive to the question for untrained providers.

Woollard, M., R. Whitfield, et al. (2006). "Optimal refresher training intervals for AED and CPR skills: a randomised controlled trial." Resuscitation **71**(2): 237-47.

LOE 5 – Supportive for skills deterioration at short time interval. Randomized study. Good .

Yang, C. W., H. C. Wang, et al. (2009). "Interactive video instruction improves the quality of dispatcher-assisted cardiopulmonary resuscitation in simulated cardiac arrests." Crit Care Med.

LOE 5 manikin study – randomized group to receive voice alone assistance or voice and video demonstration and feedback. Supportive to the question.

Zanner, R., D. Wilhelm, et al. (2007). "Evaluation of M-AID, a first aid application for mobile phones." Resuscitation **74**(3): 487-94.

LOE 5 – Use of cell phones to prompt high school students (laypersons) in the performance of CPR. RCT. No difference in scores. Skill acquisition by practical training preferable.