Best Evidence Medical Education

Systematic Review

What is the impact of structured resuscitation training on healthcare practitioners, their clients and the wider service?

Contents

Abstract

A large number of resuscitation training courses (structured resuscitation programmes (SRT)) take place in many countries in the world on a regular basis. This review aimed to determine whether after attending SRT programmes, the participants have a sustained retention of resuscitation knowledge and skills after their initial acquisition and whether there is an improvement in outcome for patients and/or their healthcare organisation after the institution of an SRT programme. All research designs were included and the reported resuscitation training had to have been delivered in a pre-defined structured manner over a finite period of time. Data was extracted from the 105 eligible articles and research outcomes were assimilated in tabular form with qualitative synthesis of the findings to produce a narrative summary.

Findings of the review were: SRTs result in an improvement in knowledge and skills in those that attend them, deterioration in skills and to a lesser extent knowledge is highly likely as early as 3 months following SRTs, booster or refresher sessions may improve an individual's ability to retain resuscitation skills after initial training and the instigation of resuscitation training in a healthcare institution significantly improves clinical management of resuscitations and patient outcome (including survival) after resuscitation attempts.

Key words: Cardiopulmonary resuscitation, knowledge retention, mannequins, resuscitation outcome, resuscitation training, simulation.

Executive summary

Period of Review 1970- 2010

Background and context

A large number of resuscitation training courses take place in many countries in the world on a regular basis. These usually involve a standardised curriculum which includes cardiopulmonary and other adjunctive resuscitation techniques delivered to a group of learners over a finite period of time in a pre-defined, structured manner and can be referred to as structured resuscitation programmes (SRT). Intended learning outcomes for participants are the acquisition of new knowledge and skills and to be able to transfer these into the clinical area to thus improve their clinical performance in resuscitation situations. In order for an optimum standard of resuscitation management to be delivered and maintained and for patient outcome to be potentially improved, retention of knowledge and skills is important following SRTs and this retention needs to be sustained for as long as possible.

Review Aims

To determine:

1 Whether after attending SRT programmes, the participants have a sustained retention of resuscitation knowledge and skills after their initial acquisition.

2 Whether participants attending SRT programmes exhibit behaviour change in the work setting.

3 Whether there is an impact on outcome for patients and/or their healthcare organisation after the institution of an SRT programme.

Search Strategy

We searched the English language literature from 1970 to 2010 using: Medline, CINHAL, Pub Med and the Cochrane Database of systematic reviews and by hand searching of bibliographies of relevant retrieved articles. All articles that described an SRT (resuscitation training delivered to a group of learners over a finite period of time in a pre-defined structured manner) were identified.

Inclusion & Exclusions

All research designs were included. The reported resuscitation training had to have been delivered in a pre-defined structured manner over a finite period of time. The participants had to be health care professionals (including pre and post registration, undergraduate and postgraduate). Participants had to be summatively assessed in some manner at the end of the training with assessment results given. If participants were assessed some time after the training, the immediate post-training assessment result also had to be given. Where there was an improvement in outcome for patients and/or their healthcare organisation the magnitude of the effect had to be given.

Data extraction

Data was extracted from the 105 eligible articles using a standardised coding form devised by the authors.

Data Synthesis

Research outcomes were assimilated in tabular form with qualitative synthesis of the findings to produce a narrative summary. Heterogeneity of research designs, educational interventions and outcome measures precluded quantitative data synthesis using meta-analysis.

Headline results

- SRTs result in an improvement in knowledge and skills in those that attend them.
- Deterioration in skills, and to a lesser extent knowledge, is highly likely as early as 3 months following SRTs.
- Booster or refresher sessions may improve an individual's ability to retain resuscitation skills after initial training.
- There are no studies which investigate or report behaviour change in individuals in the works setting after SRT.
- There is strong evidence that the instigation of resuscitation training in a healthcare institution significantly improves clinical management of resuscitations and patient outcome (including survival) after resuscitation attempts.

Conclusions

Despite there being a clear immediate improvement in knowledge and skills following an SRT, there is decay in both and in particular, in skills as early as three months post-training. There is no data available to suggest what the timing and frequency of use of booster sessions, which may prevent this happening, should be. The impact of the skills decay (assessed by simulation) on clinical performance in a real resuscitation is unknown and is a subject for future research.

Key words Cardiopulmonary resuscitation, knowledge retention, mannequins, resuscitation outcome, resuscitation training, simulation.

Members of the review group

Professor Ben (NJ) Shaw: MB ChB, MRCP (UK), FRCPCH, MD, MA (Clin Ed), Consultant in Neonatal and Respiratory paediatrics at Liverpool Women's Hospital and The Royal Liverpool Children's Hospital, Associate Postgraduate Dean at Mersey Deanery and Professor to the Evidence-based Practice Research Centre, Faculty of Health, Edge Hill University. His special interests are acute and chronic neonatal respiratory disease, learning in the clinical setting, retention of skills, work place based assessments and educational interventions that improve clinical care. Contact reviewer, author of the background for the protocol, joint author of the review, main support for the project. Assisted with coding the abstracts and second coder for the final articles. **Ben.Shaw@lwh.nhs.uk**

Chiara Mosley: Msc Health Sciences, ENB Higher award, ENB 405, 997, A19 (Advanced Practice, Dip He Midwifery, Dip He, Nursing. PGCE, Advanced Neonatal Nurse Practitioner, Liverpool Women's Hospital. Currently undertaking a PhD in the retention of knowledge and skills following structured neonatal resuscitation training. Lead for coding, assisted with writing draft protocol and coding the abstracts, first coder for all papers and main author of the BEME review.

Chiara.Mosley@lwh.nhs.uk

Dr Christopher Dewhurst: MB ChB, BSC, PGCTLCP, MRCPCH, Consultant neonatologist, Liverpool Women's Hospital. Contributed to screening articles and to coding of articles, transferred the coding sheet into excel form and set up the reference manager system, reviewed drafts of review manuscript.

Christopher.Dewhurst@lwh.nhs.uk

Stephen Molloy: (Head librarian Liverpool Women's Hospital). Lead for designing search terms and finding the articles for the review. **Stephen.Molloy@lwh.nhs.uk**

Contact details for lead reviewer

Prof Ben (NJ) Shaw

Liverpool Women's Hospital Foundation Trust, Crown Street, Liverpool. L8 7SS UK

0151 702 4087, Ben.Shaw@lwh.nhs.uk

Acknowledgements With thanks to Marilyn Hammick for her support and encouragement with this BEME review.

Sources of support: Neonatal resuscitation funds, Liverpool Women's Hospital.

Abbreviations

ACLS- Advanced cardiac life support

CPR- Cardiopulmonary resuscitation

MCQ- Multiple choice questionnaire

NRP- Neonatal resuscitation programme

NHS-National Health Service

NLS- Newborn Life Support

PALS- Paediatric Advanced Life Support

PRP- Paediatric resuscitation programme

RCT-Randomised controlled trials

SRT-Structured resuscitation training

Background and Context

Structured resuscitation training programmes (SRT)

Structured resuscitation training programmes in the form of resuscitation courses are used worldwide to attempt to optimise standards of clinical practice in resuscitation management, minimise error and decrease patient morbidity and mortality. Most often SRT programmes are evaluated at a local level in terms of participant's enjoyment and engagement. The most important question, however, must be whether these programmes are effective. To date there has been no cross disciplinary systematic review investigating whether this is the case.

SRT programmes differ in their content and target audience (for example the Adult Life Support, Advanced Paediatric Life Support and Neonatal Life Support). However, many aspects are similar, such as the delivery of lectures, use of simulation (often low fidelity) and assessment. Resuscitation governing bodies in different countries (for example the Resuscitation Council in the UK) have attempted to standardise each type of course. Courses generally take place over one day and on each, candidates are assessed in relation to their knowledge and skills in resuscitation. If successful, candidates are issued a certificate which is usually valid for four years.

The Resuscitation Council (UK) oversees SRT for many adult and paediatric (including neonatal) specialities in the United Kingdom. There is a European Resuscitation Council which coordinates and oversees SRT programmes in Europe and an International Liaison Committee on Resuscitation (ILCOR) whose aim is to provide a forum for liaison between principal resuscitation organisations worldwide. A central feature of these SRT courses is that attendees are from a variety of backgrounds (medical, nursing etc) which helps to replicate the multidisciplinary involvement in resuscitations (Resuscitation UK 2010).

Some training programmes are mandatory requirements for health care professionals, and are thus funded by employers as part of a professional update. Others, however, are attended voluntarily by health care professionals who want to further their clinical skills. In the latter case, candidates usually pay an attendance fee and the course must often be attended in the candidates own time which may

potentially result in barriers to learning. For the purposes of this review, courses, whether mandatory or not, were included as long as they fulfilled the definition of an SRT programme as above.

Due to the financial constraints facing most United Kingdom National Health Service organisations, especially in training budgets, organisations are developing their own in-house advanced, immediate and neonatal life support courses. Despite this resolving a problem in the short term (the training and updating of health care workers), it may, unfortunately, have implications regarding the quality and standardisation of resuscitation training provision (Resuscitation UK 2010).

An SRT programme for the purposes of this review was defined as a resuscitation training curriculum (not necessarily accredited) delivered to a group of learners over any reported finite period of time in a pre-defined, structured manner. SRT programmes have been developed around the world to train health care professionals in adult, paediatric and neonatal resuscitation. A health care professional for this review is defined as an individual who as a result of their role, has contact with patients and has direct responsibility for their clinical care.

Learning and SRT programmes

Learning can be defined as changes in knowledge, understanding and skills (Brown et al. 1997). This can occur following organised training similar to that which takes place during SRT programmes or through more casual self directed activities such as browsing the literature. An SRT course aims to equip the participant with the knowledge and skills to perform optimal resuscitation in their clinical work place. Knowledge is enhanced by the use of lectures and skills by repeated exposure to simulation scenarios. Overall the SRT 'experience' takes the candidate through Kolb's learning cycle: they build on their prior knowledge by learning new skills and after practicing these new skills they reflect on their 'action', resulting in behaviour change (learning) (Kolb DA 1984).

Simulation is specifically used in SRTs and incorporates many of the attributes that have been reported to facilitate learning. These are: appropriate use of feedback, engagement in repetitive practice, the simulator being embedded in a controlled

environment and permitting individual learning, and learning outcomes being clearly defined. It is also important that the simulator being used is a valid ('high-fidelity') approximation of clinical practice (Issenberg SB et al. 2005).

Tight (2002) suggests that although adults have considerable experience of education, for some this will have been largely confined to childhood. The concept of andragogy encompasses the idea of how adults learn. This places a greater emphasis on what the learner is doing (Reece and Walker 2000), as opposed to pedagogy, which, as it highlights the teacher dominating and leading the session completely, is used more in the teaching of children. Adults have reached a stage of independence and are therefore successfully able to undertake self-directed study (Knowles 1984). Prior to their attendance on an SRT course, learners are encouraged to read and digest the manuals to assist with their learning experience on the day of the training. Prior knowledge and exposure also appear to be key factors influencing learning (Marton et al. 1997). All candidates attending SRTs have had either, as undergraduates, some prior theoretical exposure, or as postgraduates, practical exposure to resuscitation.

Most SRT courses utilise a visual and kinaesthetic approach to learning enhanced by a behaviourist approach to learning based upon repeated practice, where students learn mainly through association. The SRT courses are designed to give candidates the skills to provide effective resuscitation, partially through an approach of repetitive practice during the training. The principle of the educator acting as the facilitator (Dunn 2000) stems from a belief that human beings have a natural eagerness to learn, thus learners become more empowered to take responsibility for their own learning when facilitated to do so by an expert. On SRT courses, candidates are encouraged by instructors to share their knowledge and experiences with their peers during the various simulation scenarios. Burns (2000) suggests that the majority of 'competency based' training is founded upon the theory of reinforcement to strengthen behaviour. It works on the premise that the learner will repeat the desired behaviour if positive reinforcement follows the behaviour. This is used by faculty on SRT programmes repeatedly: candidates are frequently praised

and given positive feedback when they perceive that a candidate has shown evidence of knowledge acquisition or improved their skills.

Knowledge and skill acquisition and retention

Most individuals can pass resuscitation courses by achieving a certain mark in a written examination together with demonstrating ability to carry out pre-determined tasks on a simulator. The degree of knowledge and skill acquisition may vary (Wynne 1986). Furthermore, the assessment of the magnitude of any transfer of knowledge and skills into the clinical setting may be difficult owing to ethical difficulties observing participants in an acute real life resuscitation scenario and the lack of any validated measures to do so.

In the context of SRTs, behaviour change (achievement of resuscitation competency) may not be permanent: it is possible that learning can be exhibited in the assessment process following an SRT but there may be factors other than the SRT which are responsible for the medium or long term sustenance of the learning (maintenance of competency) (McGaghie WC et al. 2010). One of these may be combining simulation –based medical education as on an SRT with deliberate practice – thus ensuring mastery at a particular skill (Ericsson KA 2006, and McGaghie WC et al. 2011). However, those individuals who are not frequently exposed to resuscitation situations after an SRT may still lose skills and/or confidence quickly. This problem is illustrated by David and Prior-Willeard (1993) who assert that survival to hospital discharge depends greatly upon the initial treatment a patient receives during resuscitation, yet they suggest that, based on a clinical assessment of doctors about to take their MRCP exam, the basic life support skills of many doctors, nurses and medical students (who have previously received resuscitation training) is of poor quality.

<u>Review Aims</u>

To determine:

1 Whether after attending SRT programmes, the participants have a sustained retention of resuscitation knowledge and skills after their initial acquisition.

2 Whether participants attending SRT programmes exhibit behaviour change in the work setting.

3 Whether there is an impact on outcome for patients and/or their healthcare organisation after the institution of an SRT programme.

Review Methodology

Group Formation

A systematic review group was formed of staff from different disciplines working at the Liverpool Women's Hospital Foundation Trust. All group members (two consultant neonatologists (NS and CD), an advanced neonatal nurse practitioner (CM) and a hospital librarian (SM)) attended a one day training course on how to conduct a BEME review. After this, individual roles were defined within the group and a timeline set for completion of the study.

Search Strategies

A search strategy was developed by the group led by CM (see Appendix 1 for the search terms). The following databases were searched by SM: Medline, CINHAL, Pub Med and the Cochrane Database of systematic reviews. This search was confined to the English language literature as there is no evidence of a systematic bias from the use of language restrictions in systematic reviews (Morrison A et al. 2009) and to avoid the long potential time delay that obtaining translations may have entailed. Two search updates were done over the two years of conducting the review to allow for the inclusion of new publications.

All articles that described an SRT, as previously defined, were identified by the presence of one or more of the key words from Appendix 1 in the title.

The majority of reference titles obtained clearly had no relevance to the review (for example those related to basic science or animal work). In order to streamline the process, the decision was taken for one group member (CD) to discard those which unambiguously had no relevance. The abstracts of the remaining articles (where the article was of relevance or where there was uncertainty from just reading the title)

were then distributed throughout the group. Each abstract was initially read by one of the group members who then decided on whether the article was likely to fulfil the inclusion criteria, and if it did, allocated a provisional Kirkpatrick (1994) level (see details in Figure 1).

All abstracts were subsequently reviewed blindly by CM in order to confirm that the provisional Kirkpatrick level had been appropriately assigned and that the article should be included in the review, pending receipt of the full article, or otherwise. If there was disparity between the coder's Kirkpatrick level, and/or disagreement whether the article should be included, further discussion took place between the two coders in order to agree these issues by consensus.

The full article of each included study was then requested. When received each article was categorised according to discipline (adult, paediatric and neonatal) and assigned a unique reference number. Each article was read by CM and the provisional Kirkpatrick level was again reviewed and confirmed or changed accordingly. The full text of all the articles identified for provisional inclusion together with allocated Kirkpatrick levels were then distributed to a second reviewer in the group for confirmation of the Kirkpatrick level allocation and final decision regarding inclusion.

The bibliographies of all articles to be included in the review were also searched to capture any further relevant articles which were categorised and coded as above.

Figure 1: Possible levels of outcome of articles (Modified from Kirkpatrick, 1994)

The Kirkpatrick system below was modified from Kirkpatrick's 1994 model of outcomes at four levels. Articles were allocated a Kirkpatrick level according to the outcomes described – some articles described outcomes relating to more than one level in which case they were included in the analysis for each outcome level.

Kirkpatrick Level 1 Reaction to learning experience

Evidence of learners' views on the overall learning experience and its inter-professional nature including the training programme, rather than any specific learning outcomes.

Kirkpatrick Level 2a Modification of attitudes and perceptions

Evidence of documented changes in reciprocal attitudes or perceptions between participant groups and possible changes in perception or attitude towards the value and/or use of team approaches to caring for a specific client group.

Kirkpatrick Level 2b Acquisition of knowledge and skills

Evidence of knowledge and skills acquisition immediately following completion of a SRT.

Kirpatrick Level 2c

Evidence of the retention of knowledge and/or skills over a period of time after the SRT.

Kirkpatrick Level 3 Behavioural change

Evidence of transfer of learning to clinical practice.

Kirkpatrick Level 4a Change in organisational practice

Evidence of changes within the organisational practice and delivery of care after the SRT.

Kirkpatrick Level 4b Benefits to patients/clients, families and communities

Evidence of documented impacts in the health or well being of patients/clients, families and communities after the SRT.

Quality assessment and final inclusion of articles

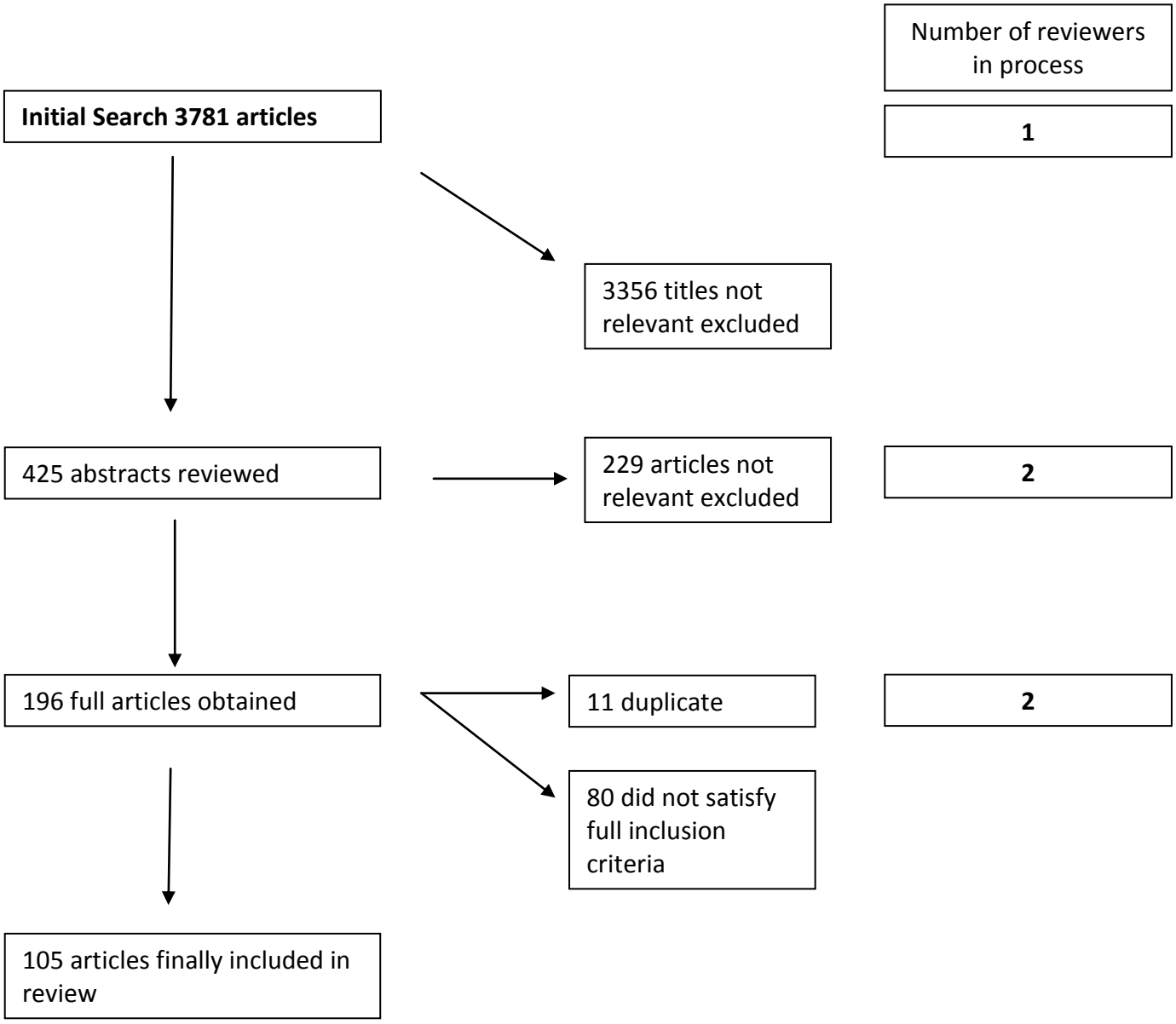
Initially articles were assessed independently by two of the group (CD and CM) and scored in relation to two different quality assessments related to level of evidence presented and clarity of methodology and results reported (Appendix 2B and Appendix 2C). There were few randomised trials (7), but the vast majority of studies were cohort studies reporting data of a similar evidence level. All studies had a clarity of results and methodology reporting sufficient to merit inclusion: as a result it became evident that neither 'quality' assessment could be used to define appropriate articles for inclusion. It was therefore decided to include articles using all research designs and a number of criteria for inclusion criteria based on a minimum requirement for results reporting were agreed upon as follows:

- The reported resuscitation training had to have been delivered in a pre-defined structured manner over a reported finite period of time.
- The participants had to be health care practitioners (including pre and post registration, undergraduate and postgraduate).
- Participants had to be assessed by a marked or scored assessment at the end of the training and the result of this assessment had to be stated.
- If participants were assessed some time after the training, the immediate post-training assessment result also had to be stated.
- Where there was an improvement in any outcome for patients and/or their healthcare organisation the magnitude and type of the effect had to be stated.

Any lack of clarity in an article in relation to the above criteria was discussed and final agreement of the articles inclusion or exclusion was reached by consensus.

The search process yielded 3781 article titles. Of these, 425 abstracts were reviewed and 196 full articles obtained. Of these 105 were included as there were 11 duplicate publications identified and 80 did not completely fulfil the results reporting inclusion criteria (Figure 2)

Figure 2: Flow chart of the process for final inclusion of papers in the review.



Coding and analysis

An initial coding sheet was designed by the group and produced in an Access Data Base electronic format by CY. To pilot this, five of the selected articles were coded by two independent coders (CD and CM) and the sheet was redesigned to exclude any ambiguities. Following this, twenty articles were coded, by the same two coders. It was felt that there were too many fields present with irrelevant information in the electronic format so a simplified (paper) coding sheet was then produced (Appendix

2A). All articles were subsequently coded independently by CM and BS and the results were periodically reviewed to ensure that they were in agreement prior to data being inputted. Very few differences in coding occurred - these were discussed by the two coders in question and agreement by consensus reached.

For ease of reference, the relevant results were displayed on a final coding sheet in tabular form for each Kirkpatrick group for adult, paediatric and neonatal resuscitation separately using a Microsoft word document (appendix 3).

Data relating to Kirkpatrick level 1 (satisfaction with the SRT) have not been analysed or reported here as, although satisfaction with teaching may affect learning, it was not directly relevant to the aims of the review.

Heterogeneity of research designs, educational interventions and outcome measures precluded meta-analysis of quantitative data (for Kirkpatrick level 2c studies, each assessment outcome used a different marking system (tables 4, 5 and 6)and for level 4 studies outcomes were different in many studies (tables 7, 8 and 9). Qualitative data synthesis of research methods and outcomes was carried out by two of the group (CM and BS) independently identifying themes from the interventions, and outcomes from studies at each Kirkpatrick level. CM and BS then discussed these themes and agreed by consensus the key themes that had emerged. The narrative that emerged described the key themes and overall outcomes within groups of studies. This was discussed and refined by the review team who agreed the final narrative findings given below.

Findings

The findings will be presented for each of Kirkpatrick levels 2, 3, and 4, subdivided into adult, paediatric and neonatal resuscitation data. This allows the reader to view data that exists for their own discipline. A description of the studies for each level and each discipline, linked to the tables in Appendix 3 that display the full relevant

data for each level, is followed by a description of the themes which emerged from the data for each Kirkpatrick level.

Kirkpatrick 2A and 2B: modification of attitudes and perceptions (2A) and acquisition of knowledge and skills (2B)

Neonates (Appendix 3 Table 1)

There were three studies in this category (Cavaleiro et al. 2009, Ergenekon et al. 2000, Trevisanuto et al. 2007). The nature of the SRT offered was a mixture of lectures and simulation and one study reported an accredited training programme). All three tested knowledge at the end of the training by MCQ and all three demonstrated statistically significantly improved knowledge at the end of training (p more significant than <0.01 in all cases). None reported testing skills at the end of training, however one assessed confidence (Kirkpatrick level 2A) in resuscitation revealing an improvement (Ergenekon et al. 2000). One sub-group of students in one study (Cavaleiro et al. 2009) using self-study alone showed no improvement in knowledge compared to those receiving a lecture.

Paediatrics (Appendix 3 Table 2)

There were five articles in this category. The nature of the SRT where stated included lectures and simulation (three reporting an accredited training programme). Three studies tested knowledge at the end of training (two with an MCQ and one with written case scenarios) (Gerard et al. 2007, Quan et al. 2001, Waisman et al. 2002). In one there was a statistically significant improvement in knowledge (Waisman et al. 2002) and in one there was no change (Quan et al. 2001). In the third study knowledge change was not stated (Gerard et al. 2007). Three studies reported testing skills at the end via simulation with or without video, two (Donoghue et al. 2009, Quan et al. 2001) reporting statistically significant improvement in skills (one not reporting outcomes (Gerard et al. 2007)). Three studies (Dobson et al. 2003, Gerard et al. 2007, Quan et al. 2001) assessed confidence (Kirkpatrick 2A) by questionnaire and reported statistically significant improvements in confidence score after training. A sub-group of participants in one study who received high

fidelity simulation training had improved skills on testing compared to a low fidelity training group (Donoghue et al. 2009).

Adults (Appendix 3 Table 3)

There were twenty-three articles in this category. The nature of the SRT in most cases included simulation with mannequins combined with lectures (14 used an accredited training programme). Eleven studies reported testing knowledge at the end of training (10 with an MCQ and one with short answer questions)(Aboutanos et al. 2007, Ali et al. 1995, Ali et al. 1996, Ali et al. 1998, Azcona et al. 2002, Dauphin et al. 2007, Girdley et al. 1993, Hoadley 2009, Jenson et al. 2009, Owen et al. 2006, Tippet 2004). All of these studies reported statistically significant improved exam scores at the end compared to before training. Eighteen studies reported testing skills at the end of training using simulation mannequins (Aboutanos et al. 2007, Ali et al. 1995, Ali et al. 1996, Ali et al. 1998, Bilger et al. 1997, Cimrin et al. 2005, Azcona et al. 2002, Dunning et al. 2006, Greig et al. 1996, Devita et al. 2005, Hoadley 2009, Jenson et al. 2009, Mayo et al. 2004, Monsieurs et al., 2005 Marshall et al. 2001, Owen et al. 2006, Rosenthal et al. 2006, Wayne et al. 2005). In three the testing took the form of an OSCE and in one only telephone skills conveying the severity of the collapse requiring resuscitation to other professionals were tested. Seven studies reported statistically significant improvements in post-course skill scores compared to those pre-course (Ali et al. 1996, Ali et al. 1998, Cimrin et al. 2005, Dunning et al. 2006, Devita et al. 2005, Marshall et al. 2001, Rosenthal et al. 2006). In addition four studies reported skill improvement but with no P value reported to indicate whether this was statistically significant (Azcona et al. 2002, Greig et al. 1996, Jenson et al. 2009, Owen et al. 2006), and six studies reported improved scores in skills in a group receiving the training compared to a control group who did not (four of these were randomised controlled trials)(Ali et al. 1995, Ali et al. 1996, Ali et al. 1998, Bilger et al. 1997, Mayo et al. 2004, Wayne et al. 2005). Three studies did not report the levels of skill before and after the training despite reporting testing it (Aboutanos et al. 2007 Hoadley 2009, Monsieurs et al., 2005).

Summary of Kirkpatrick 2A and 2B studies

The overwhelming message from these studies is that both knowledge and skills are significantly improved following SRT compared to pre-training levels. This has been confirmed both when individuals are tested pre- and post- training and also, in the context of randomised controlled trials, when groups of participants who have been trained are compared with control groups who have not. The assessment of knowledge and skills levels and changes in these were reported using scoring systems which were unique to each study in most cases thus precluding meta-analysis. There is a suggestion from one study that high fidelity simulation compared to low fidelity may be more effective in improving skills (Donoghue et al. 2009), and that attending a training session compared to self-study might be more effective in improving knowledge (Cavaleiro et al. 2009). There were no clear differences in outcomes between accredited and non accredited training programmes. Where reported, confidence at performing resuscitation tasks is universally improved in participants who have undertaken SRT. There is no evidence available to indicate whether the improvement in knowledge and/or skills after SRT results in improved clinical performance immediately after SRT.

Kirkpatrick 2C – retention of knowledge and skills over a period of time after SRT

Neonates (Appendix 3 Table 4)

There were eight studies in this category. In those studies that stated the nature of the training, all used simulation with mannequins and most used lectures (four described accredited programmes). The number of participants followed up after SRT in the studies ranged from 6 to 166. The period of follow up ranged from 6 weeks to 12 months. All studies reported knowledge retesting at follow-up with an MCQ and 5 reported skill testing using mannequins. Four studies reported a decrease in knowledge (Curran et al. 2004, Duran et al. 2008, Kuczorowski et al. 1999, Trevisanuto et al. 2005) and four reported that knowledge did not change at follow up (Dunn et al. 1992, Levitt et al.1996, Skidmore +Urquhart 2001, West2000)(only two of these however reported no statistically significant

difference). There did not appear to be any difference with respect to the nature of the training between those studies where knowledge decreased and those where it was maintained. In all but one study which tested skills (Curran et al. 2004, Dunn et al. 1992, Kuczorowski et al. 1999, Skidmore +Urquhart 2001, West 2000), a significant decrease in skills at follow up testing occurred. The study where skills were maintained was small (six participants) and skills were tested only 6 weeks after the training (West 2000).

Paediatric (Appendix 3 Table 5)

There were five articles in this category (two reporting accredited training programmes). The nature of training was variable: in two studies this was unknown, in one it was self-study and in others it was lectures and simulation with mannequins. The period of follow up testing ranged from two to 21 months. All studies reported knowledge testing (three with an MCQ), three demonstrating a decrease in knowledge at follow up (Spaite et al. 2000, Su et al. 2000, Wolfram et al. 2003) and one demonstrating no change (assessment was by telephone questionnaire and no p value was reported) (Durojaiye and O'Meara 2002). Two reported testing skills at follow up, but did not report any assessment data (Nadel et al. 2000, Su et al. 2000).

Adults (Appendix 3 Table 6)

There were 39 articles in this category. The nature of the training was varied and included lectures, simulation with mannequins and videos (in 18 this was part of an accredited programme). The training was delivered over a period of time ranging from 15 minutes to two and a half days. The period between the training and testing at follow up ranged from one to 60 months. Twenty-seven studies reported testing knowledge at a later date (20 with an MCQ, the others with a variety of written assessments). Sixteen of these reported significant deterioration in knowledge at follow up testing (Ali et al. 2002, Ali et al. 1996, Azcona et al. 2002, Blumenfeld et al. 1998, Boonmak et al. 2004, Broomfield 1996, Curry and Gas 1987, Curry and Gas

1983, Fossel et al. 1983, Leith 1997, O'Steen et al. 1996, Semeraro et al. 2005, Stross 1983, Tippett 2004, Wenzel et al. 1997, Young and King 2000) and seven reported no deterioration in knowledge at follow up testing (Aboutanos et al. 2007, Coleman et al. 1991, Cooper et al. 2007, Hammond et al. 2000, Holden et al. 1996, O'Donnell and Skinner 1993, Stross 1983). With respect to the nature of the training, those groups who received a refresher or booster session (in two randomised trials) maintained knowledge better than those who did not (O'Donnell and Skinner 1993, Stross 1983). There were no other clear differences between those retaining and those deteriorating in their knowledge with respect to the nature of their training. Twenty-eight studies reported a deterioration in skills at follow up testing (Ali et al. 2002, Ali et al. 1996, Beckers et al. 2007, Bradley et al. 1988, Broomfield 1996, Cooper et al. 2007, Curry and Gas 1987, Curry and Gas 1983, Erickson et al. 1996, Fabius et al. 1994, Fossel et al. 1983, Hammond et al. 2000, Heidenreich et al. 2004, Holden et al. 1996, Kovacs et al. 2000, Leith 1997, Mancini and Kaye 1985, McKee et al. 1994, O'Steen et al. 1996, Plank and Steinke 1989, Semeraro et al. 2005, Smith et al. 2008, Spooner et al. 2007, Stross 1983, Ten Eyck 1993, Wenzel et al. 1997, Yakel 1989, Young and King 2000) whereas only nine reported maintenance of skills at follow up (Ander et al. 2004, Boonmak et al. 2004, Coleman et al. 1991, De Regge et al. 2005, Heidenreich et al. 2004, Kovacs et al. 2000, McKee et al. 1994, O'Donnell and Skinner 1993, Wayne et al. 2006). In the studies where skills were maintained, two (Boonmak et al. 2004 and Coleman et al.) reported re-testing only a short time period after the SRT (three months), three studies (Ander et al. 2004, De Regge et al. 2005 and Hiedenreich et al. 2004) reported maintenance of isolated discrete skills within a resuscitation scenario (other skills having deteriorated) and three (Kovacs et al. 2000, O'Donnell and Skinner 1993, and Wayne et al. 2006) had as part of their SRT, repeated testing and refresher sessions (all in the context of randomised trials).

Summary of findings from Kirkpatrick 2C studies

It appears that knowledge can be maintained for several months after SRT, however there is no specific aspect of training that can be identified which facilitates this. There were no clear differences in outcomes between accredited and non accredited

training programmes. Skills generally deteriorate from at least three months after SRT. Factors which may prevent this occurring are, providing refresher or booster sessions after training and possibly identifying discrete actions to be assessed within simulation during training and at follow up. Skills were all assessed at follow-up using simulation in mannequins and not in real clinical situations making it impossible to know whether the deterioration or maintenance of skills identified was being reflected in clinical practice. Any association with behavioural change and a change in clinical performance in participants in those studies where their retention of skills and/or knowledge was reported is therefore unknown. In the context of this review, Kirkpatrick level 3 therefore relates to retention of knowledge and skills and their application in a simulated environment. There is a need for work to be carried out to explore any association between behavioural change as evidenced by a simulated environment and behavioural change in a 'real-life' setting. To our knowledge, investigating and identifying behavioural change in individuals in such a setting has not been systematically investigated.

Kirkpatrick 3: evidence of transfer of learning to clinical practice

There were no studies in this category.

Kirkpatrick 4 – evidence of benefit to patients, families and communities after SRT

Neonates (Appendix 3 Table 7)

There were seven studies in this category all following accredited programmes which included lectures and simulation training. These studies reported outcomes following the introduction of SRT programmes within individual institutions, often over a period of years. Four studies reported a significant impact on patient outcome, (Duran et al. 2008, Patel et al. 2001, Patel and Piotrowski 2002, Zhu et al. 1997) three reporting an improved resuscitation (Apgar) score in babies and one reporting a reduction in neonatal mortality (Zhu et al. 1997). Two studies reported improvement in clinical management with respect to the organisation of clinical resuscitations and interventions during resuscitation (improvement in delivery room

preparation and assessment of the baby (Ryan et al. 1999) and reduction in hypothermia and inappropriate use of the drug Naloxone (Singh et al. 2006)).

Paediatrics (Appendix 3 Table 8)

There were two studies in this category. Neither followed an accredited training programme. One involved weekly simulation scenarios and one involved supervised practice. Neither of these studies reported any impact on patient outcome. One study reported an improvement in clinical management (Losek et al. 1994) and one reported a deterioration in clinical management (Lo et al. 2009). The latter study had weekly simulation scenarios as part of the training.

Adults (Appendix 3 Table 9)

There were 13 articles in this category. Programmes, where stated, included lectures and simulation (only two did not follow an accredited programme). The majority of studies compared outcomes following the introduction of training into an institution, however three studies (Dane et al. 2000, Moretti et al. 2007, and Woodall et al. 2007) compared outcomes between groups of individuals who had received training with those who did not within the same institution. Seven studies reported a significant improvement in patient outcome, all of them showing a statistically significant reduction in mortality as well as in some improvement in other patient outcomes (Arreola et al. 2004, Camp et al. 1997, Dane et al. 2000, Moretti et al. 2007, Spearpoint et al. 2009, Van Olden et al. 2004, Woodall et al. 2007). Six studies reported a significant improvement in clinical management (less errors occurring or improved management at specific tasks) (Arreola et al. 2004, Camp et al. 1997, Makker et al. 1995, Van Olden et al. 2004, Vestrup et al.1988, Woodall et al. 2007).

Summary of findings from Kirkpatrick 4

Most of the studies reporting outcomes at Kirkpatrick 4 level were carried out over many years – with a period prior to SRT being introduced (typically 2-3 years) being compared with one after its introduction. From these there is overwhelming

evidence from the reported studies that the introduction of SRT within an institution has a direct positive impact on mortality and also on clinical management. The majority of SRT that were delivered were accredited programmes which include a mixture of lectures and simulation. There were no clear differences in outcomes between accredited and non accredited training programmes.

Discussion

This review has described and analysed the evidence available for the efficacy of SRT on acquisition of knowledge and skills, their retention and the effect of SRT on patient care and outcome. This is the first systematic review of the literature investigating these issues. The following section summarises our conclusions regarding this in relation to the review aims and suggests a number of practice points to guide improvement in training resuscitation practice.

After attending SRT programmes do the participants have a sustained retention of resuscitation knowledge and skills after their initial acquisition?

It is clear that immediately after the vast majority of SRT programmes, knowledge and skills assessed by written examination and simulation are significantly improved (all studies where this was reported showed this to be the case). After some SRT, knowledge, assessed by written examination, may be maintained for three to 12 months after the initial training. There were no differences with respect to the education provided or assessments used in studies where knowledge had deteriorated compared with those where it was retained. Although it is possible that knowledge retention (given that knowledge is necessary to enable an individual to use their skills in resuscitation) may result in an improvement in clinical resuscitation practice, there is no evidence available that demonstrates this. However the ability to demonstrate appropriate resuscitation practice in a simulated scenario is more likely than not to deteriorate after SRT as early as three months after training. Therefore even if knowledge retention did improve clinical resuscitation practice, it

appears not to result in maintenance of appropriate practical skills in a simulated scenario.

There is no evidence available to assess whether ability in resuscitation procedures in clinical practice changes after SRT in individuals, what the time frame for this change (if it occurs) may be and whether there is any correlation with loss of ability in a simulated environment. Further work need to be done to investigate this (see below).

Much of the training offered in SRTs consist of lectures with simulation with a mannequin and is thus very similar across accredited training programmes and even in those studies that reported non-accredited programmes. As previously discussed, educationally this SRT training approach seems to be optimal as it offers experiential learning (Kolb DA 1984) through practical simulation experiences aimed at supporting experiential and reflective learning (Issenberg SB et al. 1999)and incorporates many facets within the simulation scenarios which facilitate learning (Issenberg SB et al. 2005) although learning was not sustained. There were no characteristics of individual training programmes identified that influenced the retention of knowledge and skills at a later date. Deliberate practice, reported to encourage 'mastery' (Ericsson KA 2006, McGaghie WC 2011) does not appear to have been specifically or consistently employed in the SRTs reviewed. Incorporating this into SRTs may involve more time and a higher instructor – candidate ratio to ensure that all participants have achieved mastery.

Support for participants after attending SRTs may also be an important focus in order to try and ensure change in clinical practice and maintenance of skills. Some studies reviewed here suggested that factors which may ameliorate deterioration in knowledge and particularly skills might be the provision of regular booster or refresher sessions and focusing on discrete skills as part of a task during training and at follow up (Ander et al. 2004, De Regge et al. 2005 and Hiedenreich et al. 2004, Kovacs et al. 2000, O'Donnell and Skinner 1993, and Wayne et al. 2006). As well as further simulation sessions, other work has suggested that 'reinforcement' in the clinical area to strengthen behaviour will also improve competence (Burns J 2000).

Is there an impact on outcomes for patients and/or their healthcare organisation?

It is clear from data in this review that the introduction of SRTs within institutions, where no previous training existed, has a positive effect on patient outcome and leads to improvement in clinical management. In particular mortality rates are reduced. There is clearly a 'group' or institutional effect of introducing these courses. However the relative benefits for sub-groups of different disciplines of healthcare practitioners is unclear. Given that there was no training prior to the introduction of SRTs into the institutions who reported improvement, it is likely that resuscitation practice within these institutions was at a low baseline thus making improvement more likely to occur. There is no evidence available to assess whether further improvement might occur in institutions where all staff are trained (ie a higher baseline of resuscitation practice) and extra training offered prior to mandatory updates.

Value for money and practicalities of training

Current mandatory training programmes take place at their most frequent annually, sometimes every two to three years. This review suggests that further, earlier intervention with participants might be appropriate. This not only has cost, but human resource implications. It would not be practical to offer three monthly cycles of booster resuscitation sessions at institutions- rather it might be more feasible to embed aspects of deliberate practice (including resuscitation drills) at staff induction sessions and into daily work.

If institutions are to organise and run their own in-house SRT programmes it is important that they ensure that they incorporate appropriate educational approaches into these.

Further research

Investigation of later clinical performance in individual participants in relation to skills learnt on SRT programmes and whether deteriorations in skills after SRT as assessed by simulation correlates with deterioration of skills in clinical practice are areas that have not been researched. This may be quite difficult to do, possibly

involving routine videoing of resuscitation. There are ethical and consent issues surrounding this practice and, at present, there is no validated assessment tool for this. There are also concerns that videos may be used in litigation cases (O'Donnell CPF et al. 2008).The effects of embedding aspects of deliberate practice into routine work and the use of resuscitation drills require further work and the timing and frequency of booster sessions has yet to be determined.

Where staff of all disciplines in a healthcare institution are trained in resuscitation, there is a need for research which investigates whether the learning that takes place on subsequent resuscitation courses results in improvement in resuscitation management.

Strengths, weaknesses and limitations of the review

This review has systematically obtained literature pertaining to SRTs and their impact. Results have been reported by speciality (adult, paediatric and neonatal) thus facilitating the readers understanding of the evidence available within each speciality.

The systematic review only considered articles from the English language literature to avoid the long potential time delay that obtaining translations may have entailed. This is often standard practice for systematic reviews, making it possible that articles with relevant data (in another language) which could have contributed to the results may have been overlooked. There is however no evidence of a systematic bias from the use of language restrictions in systematic reviews (Morrison A et al. 2009). The nature of the published body of evidence ruled-out a formal meta-analysis for this review. Heterogeneity of research designs and unstandardized outcome measures made a quantitative synthesis of the research evidence impossible. By the nature of qualitative analysis of themes, the quality of the final data collection and analysis depends on the integrity and unbiased approach of the researchers. Bias is possible if the researchers approach the subject with preconceived notions which may affect the findings. In order to minimise this, validation of the analysis was carried out by triangulation of the findings with others members of the review group.

Conclusions

1. SRTs result in an improvement in knowledge and skills in those that attend them.

2. Deterioration in skills and to a lesser extent knowledge is highly likely as early as 3 months following SRTs.

3. There is a small amount of evidence that booster or refresher sessions may improve an individual's ability to retain resuscitation skills after initial training. However, the timing and frequency of these in different disciplines has yet to be determined

4. Ensuring clinical staff of all disciplines in a healthcare institution, where no previous training existed, are trained in resuscitation will improve clinical management during, and mortality rates after resuscitation attempts.

5. Where staff of all disciplines in a healthcare institution are trained in resuscitation, there is a need for research which investigates whether the learning that takes place on subsequent resuscitation courses results attended by individuals from these institutions results in further behavioural change in the clinical area (that is a change in clinical practice) thus further improving resuscitation management.

6. There is an urgent need for research to determine whether deteriorations in skills after SRT as assessed by simulation correlates with deterioration of skills in clinical practice.

Practice Points

1. Ensure all staff in a healthcare organisation attend an SRT programme pertaining to their speciality.
2. Ensure that any reassessment of staff clinical practice skills takes place in an authentic, as well as a simulated, clinical learning context.
3. Assess staff for competency in resuscitation skills three to six months after the SRT.
4. Provide regular booster or refresher sessions three to six months after the SRT.

Appendix 1: Table to show search strategy

Searched		**Searched**		
RESUSCITATION		(CLINICAL ADJ COMPETENCE).MH		
RESUSCITATION#.W..DE.		CLINICAL ADJ SKILLS		
CARDIOPULMONARY ADJ RESUSCITATION		RETAIN OR RETAINED OR RETENTION		
CARDIOPULMONARY-RESUSCITATION#.DE.	**AND**	RETENTION-PSYCHOLOGY.MH.	**AND**	TRAIN$ OR COURS$ OR PROGRAM$
ADVANCED ADJ LIFE ADJ SUPPORT OR BASIC ADJ LIFE ADJ SUPPORT		EDUCATION-MEDICAL.MH.		
		MEDICAL ADJ EDUCATION		
		MEASURE OR MEASUREMENT		
		COGNITION.MH.		
		COMPUTER-SIMULATION.MH.		
		COMPUTER-ASSISTED-INSTRUCTION.MH.		
		PRETEST OR POSTTEST		
		TIME-FACTORS.MH.		

Appendix 2A: Coding Sheet printed computerised version

Title of BEME review

What is the impact of structured resuscitation training on healthcare practitioners, their clients and the wider service?

Administrative Data

Date Coded _____ Kirkpatrick score_____

Reference number _____ Reviewer 1._____

Reviewer 2._____

Agree with coding Y ☐ N ☐ (If N) Why? _____

Impact of intervention studied

Code the level of impact being studied in the item and summarize any results of the intervention at the appropriate level. Note: include both predetermined and unintended outcomes.

- Modified **Kirkpatrick hierarchy**

Level 1 ☐ **Participation -** covers learners' views on structured resuscitation programmes, their presentation, content, teaching methods, and aspects of the instructional organization, materials, quality of instruction

_____

_____

Level 2a ☐ **Modification of attitudes / perceptions** - outcomes here relate to changes in the attitudes or perceptions between participant groups toward structured resuscitation programmes (e.g. do candidates feel more confident following the course).

_____

_____

Level 2b ☐ **Modification of knowledge or skills** –Is there a change in knowledge or skills following a structured resuscitation programme (i.e. does the candidate acquire skills in problem solving, practical and psychomotor skills?)

_____

_____

Level 3 ☐ **Behavioural change** –Identifies the individuals transfer of learning to the workplace or the willingness of learners to apply new knowledge & skills following attendance on a structured resuscitation programme. (Was there retention of knowledge or skills over time?)

_____

_____

Level 4a ☐ **Change in organizational practice** – looks at the wider changes in the organizational delivery of care, attributable to structured resuscitation programmes

_____

_____

Level 4b ☐ **Benefits to patient Identifies** any improvement in the health & well being of patients as a direct result of attending a structured resuscitation programmes

_____

_____

What levels have been obtained? _____

Does the abstract fulfil the objective criteria and how? (Modified Kirkpatrick Hierarchy)

Yes… Level achieved? _____

No…. Why not? _____

Article Volume No _____ Issue _____ Pages_____ Year _____

Qualitative ☐

Quantitative ☐

Search Method

Electronic search ☐ Hand search ☐

Grey literature ☐ Recommendation ☐

Aim of the study

Was the aim/objective? Implied ☐ Stated ☐ unclear (after checking) ☐

Why was the article written?

In an attempt to change practice ☐

In response to new guidelines ☐

To investigate the effects of a training programme on knowledge retention ☐

As a look at patient outcome following attendance on a resuscitation programme ☐

Was ethical approval sought and gained prior to commencing the study? Y ☐ N ☐

Research design

1. Qualitative? Y ☐ N ☐

If so what type? _____

2. Quantitative? Y ☐ N ☐

If so what type? _____

	Y	N		Y	N
Cross-Sectional	☐	☐	Case Control	☐	☐
Trials			Cohort Study		
Non-randomized	☐	☐	Prospective	☐	☐
Randomized	☐	☐	Retrospective	☐	☐

Over what period of time was the data collected? _____

Type of structured resuscitation programme (status)

Title of the training programme if stated (E.g. NLS)_____

_____

Is it a national programme?

_____

Is it an in house training programme? _____

Specify the type of skills that were being taught. _____

Was this a mandatory training update? Y ☐ N ☐

Cost of the course_____ Unknown ☐

Duration of the course (please tick)

< 1 day ☐ 1 day ☐ 2 days ☐ > 2 days ☐ unknown ☐

Location of course _____

Country set in _____

Was there any e-learning involved? Y ☐ N ☐

Number of instructors_____ unknown ☐

Number of candidates in the group _____ unknown ☐

Were the participants Drs ☐ Nurses ☐ Students ☐ Other? ☐

If other please specify _____

Was their place of work specified? Y ☐ N ☐ if yes where did they work?

_____

Was their age specified? Y ☐ N ☐

If yes how old were they _____

Was their gender specified Y ☐ N ☐

If yes were they mostly male or female? _____

Had the attendees any knowledge of the subject before attending? Y ☐ N ☐ unknown? ☐

Had they attended a similar course or been taught to the same level prior to attending? Y ☐ N ☐ unknown? ☐

Were they given any pre-course material to read prior to attending? Y ☐ N ☐

If yes was this an official resuscitation manual? Y ☐ N ☐ unknown? ☐

Certification of course if stated

Is this a pass or fail course? Y ☐ N ☐ not known ☐

Were all the assessments formative ☐ or summative ☐

How much of the course was skills based? <1/3 ☐ 1/3-2/3 ☐ >2/3 ☐

How much was knowledge based? <1/3 ☐ 1/3-2/3 ☐ >2/3 ☐

ASSESSMENT PROCESS

Pre- course (prior to attending)	**Yes**	**No**
Were participants tested 'pre course'?	☐	☐
Was there a written paper prior to instruction? (i.e. was knowledge assessed)?	☐	☐
If yes did they complete the paper prior to attending?	☐	☐
Was a practical exam involved prior to instruction? (i.e. were skills assessed)?	☐	☐

(If Yes) What were these? _____

How many observers where there? _____

Was it done under exam conditions? ☐ ☐

Was 360 degree review used? ☐ ☐

Were candidates asked their confidence levels prior to attending the course? Y ☐ N ☐

Were the pre-course assessments formative ☐ summative ☐

Were there any skill stations **Pre course** (tick any that apply)

- Vascular access (UVC) ☐
- Cannulation ☐
- Inflation breaths ☐
- Chest compressions ☐
- Drug calculations ☐
- Needle thoracentisis ☐
- Crichoidotomy ☐
- Scenarios ☐
- Other ☐ please state _____

During the course (Inc the end) Yes No

Was a practical exam involved (i.e. were skills assessed)? ☐ ☐

(If Yes) What was this? _____

How many observers where there? _____

Was there a written paper (i.e. was knowledge assessed)? ☐ ☐

Was 360 degree review used? ☐ ☐

Was there a behavioural change in candidates? (skills) ☐ ☐

(i.e. had learning occurred?) not known ☐

Was this implied ☐ Stated ☐

Was an improvement noted between pre-course and course test? Y ☐ N ☐

(knowledge/ written paper) e.g had learning taken place? not known ☐

Was this? Implied ☐ Stated ☐

Were the course assessments formative ☐ summative ☐ not known ☐

Were there any skill stations at the final assessment (tick any that apply)

- Vascular access (UVC) ☐

- Cannulation ☐
- Inflation breaths ☐
- Chest compressions ☐
- Drug calculations ☐
- Needle thoracentisis ☐
- Crichoidotomy ☐
- Scenarios ☐
- Other ☐ (state) _____

Post course (if reviewed after a period of time)

Did the candidates get tested at a later date? Y ☐ N ☐

If retesting was done- How many times

1 ☐ 2 ☐ 3 ☐ >3 ☐

How long after the initial exposure was this carried out?

< 1 month ☐ 1-3 months ☐ 4- 6 months ☐ 6 months -1 year ☐

Were the assessments formative ☐ summative ☐

	Yes	No
Was a practical exam involved (ie were skills assessed)?	☐	☐

(If Yes) What was this?_____

How many observers where there? _____

Was there a written paper(ie was knowledge assessed)? ☐ ☐

Were there any skill stations **post-course** (tick any that apply)

- Vascular access (UVC) ☐
- Cannulation ☐
- Inflation breaths ☐
- Chest compressions ☐
- Drug calculations ☐
- Needle thoracentisis ☐
- Crichoidotomy ☐

- Scenarios ☐
- Other ☐ (state)_____

Was 360 degree review used? Y ☐ **N** ☐

Were questionnaires used for self evaluation? Y ☐ N ☐

Was there evidence of loss of confidence? Y ☐ N ☐

Was there any evidence that knowledge had been maintained at the same level as the end of the course? Y ☐ N ☐

Was there any evidence that skills were maintained at the same level as the end of the course? Y ☐ N ☐

Did the candidates feel that they have lost their skills? Y ☐ N ☐

Did the candidates feel that they have lost their knowledge? Y ☐ N ☐

Was there evidence of organisational change? Y ☐ N ☐

Was there evidence of alteration of clinical outcome? Y ☐ N ☐

Conclusions

Did the recommendations of the study:-

Suggest that further studies were required? Y ☐ N ☐

Make recommendations for change? Y ☐ N ☐

Suggest further training was required? Y ☐ N ☐

Suggest that the training should be offered more frequently? Y ☐ N ☐

Quality (Statistical analysis)

Was the study design appropriate? Y ☐ N ☐ unsure ☐

Were statistical tests were used to evaluate the results Y ☐ N ☐

Please list _____

Were these appropriate? Y ☐ N ☐ unsure ☐

Were the results of the main aim of the study statistically significant? Y ☐ N ☐

Comment on the evaluation methods if appropriate

_____

Appendix 2B: Initial assessment of quality

Criteria		Yes (2/good)	Partial (1/fair)	No (0/poor)	N/A
Study aims					
1.	Is the hypothesis/aim/objective of the study clearly & sufficiently described?	Easily identified in introduction/method. Specifies: purpose, subjects/target population, and specific interventions/ associations under investigation.	Vague/incomplete reporting *or* some info has to be gathered from parts of the paper other than intro/background/ objective section.	Question or objective not reported/ incomprehensible.	
Study design & sample characteristics					
2.	Is the study design well described & appropriate? *(If study question not given, infer from conclusions).*	Design easily identified, well described and appropriate.	Design and/or study question not clearly described, *or* design only partially addresses study question.	Design does not answer study question *or* design is poorly described.	
3.	Is the method of intervention group selection described and appropriate?	Described and appropriate.	Selection methods not completely described, but no obvious inappropriateness. *Or* selection strategy likely introduces bias but not enough to seriously distort results.	No information/ inappropriate information provided *or* selection bias which likely distorts results.	
4.	Are the characteristics of intervention group clearly described (i.e. age range, occupation)?	Sufficient relevant demographic information. Reproducible criteria used to categorise participants clearly defined.	Poorly defined criteria *or* incomplete demographic information.	No baseline/demographic info provided.	
Criteria		**Yes (2/good)**	**Partial (1/fair)**	**No (0/poor)**	**N/A**
5.	Have the characteristics of participants lost to follow-up been described?	Losses adequately reported & not likely to affect results.	Losses not well reported, but small & not likely to affect results.	No information *or* losses large and likely to affect results.	No participants lost to follow-up.
6.	Are educational intervention(s) clearly described?	Defined and reproducible.	Partially defined, but insufficient detail to reproduce design.	Not described.	

7.	Is method of delivery of educational intervention and subsequent follow up clearly defined?	Sufficient relevant descriptive information. Reproducible criteria used to replicate intervention defined.	Poorly defined criteria *or* incomplete descriptive information.	No criteria/descriptive info provided.	
Data analysis & results					
8.	Are the main outcomes to be measured clearly described in the introduction/method?	Defined and measured according to reproducible criteria.	Definition leaves room for subjectivity, *or* not sure (i.e. not reported in detail, but probably acceptable). *Or* precise definition(s) are missing, but no evidence of major problems. *Or* instrument/mode of assessment(s) not reported.	Main outcomes first mentioned in results section. *Or* measures not defined/inconsistent / poorly defined.	
9..	If possible, was an attempt made to blind those measuring the main outcomes of the intervention?	Assessor blind to intervention/study group.	Inadequate blinding: i.e. assessor may have been aware of group participant assigned to.	No attempt made to blind assessor.	Not possible/ appropriate – e.g. observational/ before & after study.
10..	Are population characteristics (if measured & described) controlled for and adequately described?	Appropriate control at design/analysis stage *or* randomised study with comparable baseline characteristics.	Incomplete control/ description. *Or* not considered but unlikely to seriously influence results.	Not controlled for and likely to seriously influence results.	
Criteria		**Yes (2/good)**	**Partial (1/fair)**	**No (0/poor)**	**N/A**
11.	Are the outcomes chosen to evaluate the intervention appropriate?	Appropriate outcomes selected and reported.	Some outcomes not relevant to assessing appropriateness of intervention.	Outcome measures do not evaluate intervention *or* poorly reported/not defined/inconsistent.	
12.	Are the main findings clearly described?	Simple outcome data (e.g. mean/prevalence) reported for all major findings.	Incomplete or inappropriate descriptive statistics.	No/inadequate descriptive statistics.	
13.	Are methods of analysis adequately described and appropriate?	Described and appropriate.	Not reported but probably appropriate *or* some tests appropriate, some not.	Methods not described and cannot be determined.	

14.	Are estimates of variance reported for the main results?	Appropriate estimates provided (SD/SE, confidence intervals).	Undefined *or* estimates provided for some but not all outcomes.	No information.	
15.	In trials/cohort studies, do analyses adjust for different lengths of follow-up, or in case-control studies, is the time between intervention and outcome the same for cases/controls?	Different lengths of follow-up adjusted for (e.g. survival analysis) and adequately described.	Different lengths of follow-up probably adjusted for but not adequately described.	Differences in follow-up ignored.	Cross-sectional design *or* same length of follow-up.
Conclusions					
16.	Are the conclusions supported by the results?	All conclusions supported by data.	Some of the major conclusions are supported by the data; some are not. *Or* speculative interpretations are not indicated as such.	None/few of major conclusions supported by the data.	

Appendix 2C: Final quality assessment criteria

Methodology

1. Randomised control Trials-

Individuals are randomly allocated to a control group and another group who receive a specific intervention- groups are identical for significant variables.

2. Cohort Study

Groups are selected based upon their exposure to something and followed up for a specific outcome.

3. Case control studies

"Cases with the condition/subject of interest are matched with "controls" without

4. Cross sectional surveys/studies

Interview/questions are of a sample of the population of interest at a certain point in time

5. Case Study Report

A report based upon a single patient

Quality score

4. Results from this are clear with good methodology.

3. Results are unclear with good methodology

2. Results are clear but with poor methodology

1. Results are unclear and specific to the individual study.

APPENDIX 3

Table 1 Kirkpatrick 2a and 2B Neonates

Author	Accredited training programme	Nature of the training	Tested knowledge at the end of the training	How was knowledge tested	Knowledge significantly improved at the end of the training	Tested skills at the end of the training	How were skills tested	Skills significantly improved at the end of the training	Confidence assessed (if so how)	Significant improvement in confidence at the end of the training
Cavaleiro et al. 2009	No	50 min Lecture then self study or Simulation (RCT)	Yes – after lecture and again after self study/simulation	MCQ	Yes after lecture ($p<0.0001$) No after self study/simulation	No	N/A	N/A	No	N/A
Ergenekon et al. 2000	No	8 hours Lectures simulation	Yes	MCQ	Yes (mean score pre-course 9.5 vs post course 14.2) ($P=0.001$)	No	N/A	N/A	Yes, assessed in evaluation form at the end of the course	72% felt more confident at the end
Trevisanuto et al. 2007	Yes NRP	2 courses 2 day Lectures Simulation	Yes	MCQ	Yes Both courses (52% to 85% and 64% to 94%) P=<0.01	No	N/A	N/A	No	N/A

MCQ- multiple choice questionnaire, NRP- Neonatal Resuscitation Programme, N/A - Not applicable, RCT – randomised controlled trial.

Table 2 Kirkpatrick 2A and 2B Paediatrics

Author	Accredited training programme	Nature of the training	Tested knowledge at the end of the training	How was knowledge tested	Knowledge significantly improved at the end of the training	Tested skills at the end of the training	How were skills tested	Skills significantly improved at the end of the training	Confidence tested at the end of the training (if so how)	Significant improvement in confidence at the end of the training
Dobson et al. 2003	No	6 hours Lectures simulation	No	Not tested	Not tested	No	Not tested	Not tested	Yes – Likert scale	Yes in all 13 areas tested (p=<0.002)
Donoghue et al. 2009	No	Simulation – Hi fidelity vs low (RCT)	No	Not tested	Not tested	yes	Simulation with two different manikins	Both groups improved scores but P value not stated (High fidelity group improved more than low fidelity) (P= 0.007)	No	N/A
Gerard et al. 2007	Yes PALS	Web based course vs traditional PALS	Yes	MCQ	Not stated	Yes	Video of performanc e	Not stated	Yes	Scores improved from 3.77 TO 4.28 in one group and 3.57 to 4.24 in other group (p value not stated but 95% confidence intervals indicate significant)
Quan et al. 2001	Yes PALS	2 days Not stated	Yes	Written case scenarios	No	Yes	Video simulation	Yes P=<0.05 and <0.01 depending upon skill	Yes questionnaire	Mean confidence score increased from 1.9 to 6.2 (p value not stated but 95% confidence intervals indicate significant)
Waisman et al. 2002	Yes PALS	Not stated	Yes	MCQ	Yes – proportion passing exam increased from 62% to 84% (P=<0.001)	No	N/A	N/A	No	N/A

MCQ- multiple choice questionnaires, PALS- Paediatric Advanced Life Support, RCT – randomised controlled trial.

Table 3 Kirkpatrick 2A and 2B Adults

Author	Accredited training programme	Nature of the training	Tested knowledge at the end of the training	How was knowledge tested	Knowledge significantly improved at the end of the training	Tested skills at the end of the training	How were skills tested	Skills significantly improved at the end of the training	Confidence tested at the end of the training (if so how)	Significant improvement in confidence at the end of the training
Aboutanos et al. 2007	No	Lectures simulation	Yes	MCQ	Score increased from 72% to 79% (P=0.032)	Yes	OSCE	Not known – no pre-course score	No	N/A
Ali et al. 1995	Yes ATLS	Not stated (RCT of course vs not course)	Yes	MCQ	Improved compared to control group (p<0.01)	Yes	OSCE	Improved compared to control group (P<0.01)	No	N/A
Ali et al. 1996	Yes ATLS	Not stated (RCT of course vs not course)	Yes	MCQ	Improved compared to control group and pre-course scores (no P value)	Yes	OSCE	Improved compared to control group and pre-course scores (P<0.05)	No	N/A
Ali et al. 1998	No PHTLS	Not stated	yes	MCQ	Improved compared to control group and pre-course scores (P<0.05)	Yes	simulation	Improved compared to control group and pre-course scores (P<0.05)	No	N/A
Bilger et al. 1997	Yes AHA	Model telephone simulation (RCT – phone vs no phone)	No	N/A	N/A	Yes	Use of phone	Improved in group taught with model phone (p<0.01)	No	N/A
Cimrin et al. 2005	No	Lectures simulation	No	N/A	N/A	Yes	simulation	Improved from score of 11.2 pre-course to 15.6 post-course (P<0.001)	No	N/A
Azcona et al. 2002	Yes ATLS	Not stated	yes	MCQ	Improved from 0% to 100% pass	Yes	Simulation	Improved from 5/16 to 16/16 passed	No	N/A

Table 3 Kirkpatrick 2A and 2B Adults (continued)

Author	Accredited training programme	Nature of the training	Tested knowledge at the end of the training	How was knowledge tested	Knowledge significantly improved at the end of the training	Tested skills at the end of the training	How were skills tested	Skills significantly improved at the end of the training	Confidence tested at the end of the training (if so how)	Significant improvement in confidence at the end of the training
Dauphin et al. 2007	Yes ALSO	2 days Lectures simulation	Yes	MCQ	Improved from mean score of 55% precourse to mean 86% post-course (p<0.01)	No	N/A	N/A	Yes questionnaires	8 of 9 felt more confident
Dunning et al. 2006	No	Lectures simulation	No	N/A	N/A	Yes	simulation	Improved times in most tasks (all p<0.05)	No	N/A
Featherstone et al. 2005	Yes ALERT	Not stated	No	N/A	N/A	No	N/A	N/A	Yes questionnaires	Confidence improved in many areas (P<0.01)
Girdley et al. 1993	Yes ATLS	Lectures simulation	Yes	MCQ	Improved from mean score of 28.3% precourse to mean 34.5% post-course p=0.0001	No	N/A	N/A	No	N/A
Greig et al. 1996	Yes BLS	Not stated	No	N/A	N/A	Yes	simulation	Yes (6 weeks later) – p value not stated	No	No
Devita et al. 2005	No	Lectures, simulation, debriefing	No	N/A	N/A	Yes – as a team	Simulation	Improved survival and task completion after training ((p<0.002)	No	N/A

Table 3 Kirkpatrick 2A and 2B Adults (continued)

Author	Accredited training programme	Nature of the training	Tested knowledge at the end of the training	How was knowledge tested	Knowledge significantly improved at the end of the training	Tested skills at the end of the training	How were skills tested	Skills significantly improved at the end of the training	Confidence tested at the end of the training (if so how)	Significant improvement in confidence at the end of the training
Hoadley 2009	Yes ACLS	Lectures simulation	Yes	MCQ	Improved score from mean precourse of 80% to post course mean of 89%(p<0.001)	Yes	simulation	Not known	Yes	N/K
Jenson et al. 2009	Yes ALS	Lectures simulation RCT	Yes	MCQ	Improved scores of means of 73 and 70% pre course to 85 and 83 % post course (no p value reported)	Yes	simulation	Yes (combined score with MCQ)	No	N/A
Mayo et al. 2004	No	2 groups – one received training the other not Simulation	No	N/A	N/A	Yes	simulation	Improved in most areas in group receiving training (p<0.001)	No	N/A
Monsieurs et al. 2005	No	Not stated RCT 2 different bagging systems	No	N/A	N/A	Yes	simulation	Not stated – automatic bagging system better than manualP=0.0001)	No	N/A
Marshall et al. 2001	Yes ATLS	Not stated	No	Not sated	N/A	Yes	simulation	Skills improved in all areas post course (P<0.002)	Yes survey	Increased from mean score of 5.8 to 8.1 (P<0.01)

Table 3 Kirkpatrick 2A and 2B Adults (continued)

Author	Accredited training programme	Nature of the training	Tested knowledge at the end of the training	How was knowledge tested	Knowledge significantly improved at the end of the training	Tested skills at the end of the training	How were skills tested	Skills significantly improved at the end of the training	Confidence tested at the end of the training (if so how)	Significant improvement in confidence at the end of the training
Murphy and Fitzsimmons 2004	Yes ILS	Not stated	No	N/A	N/A	No	N/A	N/A	Yes - qualitative	Improved (qualitative data)
Owen et al. 2006	No	Simulation	Yes	MCQ	Yes P=0.001	Yes	simulation	Improved (p value not stated))	Yes questionnaire	P=<0.001
Rosenthal et al. 2006	No	Simulation	No	N/A	N/A	Yes	Simulation	Improved in nearly all areas (at 6 weeks after)from pre-course score (p<0.0001)	No	N/A
Tippet 2004	Yes ATLS	Not stated	Yes	Short answers	Improved from mean 61% to mean 83% (p=0.006)	No	N/A	N/A	No	N/A
Wayne et al. 2005	No	Simulation RCT	No	N/A	N/A	Yes	Simulation	Improved scores – 38% higher than controls with no training (p<0.0001)	No	N/A

ACLS- Advanced Cardiac Life Support, AHA- American Heart Association, ALERT- Acute Life-Threatening Events: Recognition and treatment, ALSO- Advanced Life Support for Obstetrics, ATLS- Advanced Trauma Life Support, ,BLS- Basic Life Support, MCQ- multiple choice questionnaire, N/A- not applicable, OSCE Objective Structured Clinical Examination, PHTLS- Pre- Hospital Trauma Life support.

Table 4 Kirkpatrick 2C Neonates

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	Components of ability tested S	Knowledge change	Notes	P	Skill change	Notes	P
Curran et al. 2004	No	Computer manikin	60 (D)	4 and 8 months (one group with booster)	Yes MCQ	Yes Simulation	R then NC	RCT - Decreased knowledge at 4 months in both groups then remained same at 8 months	<0.0001 then Not SIGNIF	R	RCT- Both groups at 8 months	<0.0001
Dunn et al. 1992	No	1 day Lectures Demo	166 (N)	6 months	Yes MCQ	Yes Simulation	NC	Mean MCQ score from 91% to 85%	Not SIGNIF	R	All passed after training - All failed at follow-up	N/K
Duran et al. 2008	Yes NRP	Lectures Simulation	42 (D)	6 and 12 months	Yes MCQ	No	R	Mean MCQ score from 94.5% to 59.2% after 6 months and 93.2% to 58.3% after 12 months	N/K	N/A		N/A
Kuczorowski et al. 1999	Yes NRP	Video Practical	44 (D)	6-8 months	Yes MCQ	Yes Simulation	R	RCT - All passed after training –at Follow-up 26 (56%) passed in control group and 2 other groups who had booster	N/K	R	All passed after training - all failed at follow-up	N/K
Levitt et al. 1996	Yes NRP	N/K	10 (D)	6-9 months	Yes MCQ	No	NC	Mean MCQ score from 86.4% to 75.4%	Not SIGNIF	N/A		N/A
Skidmore + Urquhart 2001	No	Lectures Simulation	62 (D and N)	6 months 12 months	Yes MCQ	Yes Simulation	NC		N/K	R	After 6 months (but not back to pre-training score)	N/K
Trevisanuto et al. 2005	Yes NRP	2 days Lectures Simulation	25 (D)	6 months	Yes MCQ	No	R	Mean MCQ score from 94.1% to 62.7%	<0.0001	N/A	N/A	N/A
West 2000	No	2 hours N/K	6 (N)	6 weeks	Yes MCQ	Yes Simulation	NC		N/K	NC		N/K

AP - Accredited programme, Knowledge change:, I – Increased, NC - No change, P- P Value, MCQ-Multiple-Choice Questionnaires, Not SIGNIF- not significant, , N/A-Not applicable, N/K-Not known, NRP-Neonatal Resuscitation Programme, R- Reduced.

Table 5 Kirkpatrick 2C Paediatrics

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	Components of ability tested S	Knowledge change	Notes	P	Skill change	Notes	P
Durojaiye and O'Meara 2002	Yes PLS	N/K	23 (D)	2 weeks and 2 and 4 months	Yes phone questions	No	NC		N/K	N/A		N/A
Nadel et al. 2000	No	8 hours Lectures Simulation video - Then booster in one group	57 (D)	Approx 12 months	Yes MCQ	Yes Simulation video	N/K	Did not report change in knowledge but group who received booster did better than control group	N/K	N/K	Did not report change in skills over time but group who received booster did better than control group	N/K
Spaite et al. 2000	No	Self-study	11 (O)	4 months	Yes 'test'	No	R	Mean score in test fell from 13.04 to 11.59	<0.01	N/A		N/A
Su et al. 2000	No	16 hours Lectures Simulation Sub-groups had simulation or knowledge exam at 6 months	43 (O)	12 months	Yes MCQ	Yes simulation	R	Scores in reduced between 19.7% to 22.3% at follow-up – no difference between groups randomised to have test at 6 months and controls	<0.05	N/K		N/K
Wolfram et al. 2003	Yes PALS	N/K	99 (O)	Mean 21 months	Yes MCQ	No	R	25% passed exam at follow-up	N/K	N/A		N/A

AP-Accredited programme, Knowledge and Skill change: I – Increased, NC - No change, MCQ, Multiple-Choice Questionnaires, N/A-Not applicable, N/K-Not known, P- P Value, PALS Paediatric Advanced Life Support, PLS- Paediatric Life Support, R – Reduced.

Table 6 Kirkpatrick 2C Adults

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	Components of ability tested S	Knowledge change	Notes	P	Skill change	Notes	P
Aboutanos et al. 2007	No	Lectures simulation	12 (D)	2 years	Yes MCQ	No	I	Mean score increased from 65% to 77%	<0.05	N/A		N/A
Ali et al. 2002	Yes ATLS	Lecture Simulation	144 (D)	6 months, 2,4,6,8 years	Yes MCQ	Yes OSCE Simulation	R	High and low trauma-exposed groups reduced scores from 83.9% to 74.8% and 81.9% to 74.6% respectively at 6 months. After this no group passed MCQ	N/K	R		N/K
Ali et al. 1996	Yes ATLS	N/K	60 (D)	6 months, 2,4,6 years	Yes MCQ	Yes OSCE	R	Scores after ATLS 85.3 – 87.7% in four groups. At 6 months = 77.8% (50%) pass, at 2 years 70.6% (0 passes), at 4 years 69.4% (0 passes), at 6 years (68.9% (0 passes)	N/K	R	Score after ATLS 16.6. Score at 6 months = 16.8, at 2 years = 13.9, at 4 years 12.0, at 6 years 11.9	N/K
Ander et al. 2004	No	4 hour lectures 2 hours and Simulation	40 (D)	6 and 12 months	No	Yes Simulation	N/A		N/A	I	2 out of 3 skills improved at follow-up	N/K
Azcona et al. 2002	Yes ATLS	Not stated	59 (D)	Less than 2 years (38) and more than 2 years (21)	Yews MCQ	No	R	8/38 and 2/21 passed at follow-up	N/K	N/A		N/A
Beckers et al. 2007	No	15 minute lecture	59 (S)	6 months	No	Yes Simulation	N/A		N/A	R	Time to first shock elongated from mean of 56.5 seconds post-training to 59.9 seconds at follow-up (but not back to pre-training level)	<0.01
Blumenfeld et al. 1998	Yes ATLS	N/K	220 (D)	3 to 60 months	Yes MCQ	No	R	Mean score 84% post-course and 66% at follow-up. 50% participants scored above 80% by 180 weeks	N/K	N/A		N/A
Boonmak et al. 2004	No	1 hour lecture, 1 hour Simulation	30 (N)	3 months	Yes MCQ	Yes Simulation	R	Mean score fell from 75.4% to 60.5% at follow-up (back to pre-training levels)	N/K	N/C	(Mean skill score after training 79.7, at follow-up 75.7)	Not SIGNIF
Bradley et al. 1988	No	10 hour and 4 hour lectures and Simulation	51 (O)	18 months (after 6 month test at follow-up)	Yes MCQ And written	Yes Simulation	?R	RCT Proportion of failures may have increased in both groups at follow-up – no formal analysis	N/K	?R	Proportion of failures may have increased at follow-up – no formal analysis	N/K

Table 6 Kirkpatrick 2C Adults (continued)

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	 S	Knowledge change	Notes	P	Skill change	Notes	P
Broomfield 1996	Yes ENB	3 hours Lectures Simulation	19 (N)	10 weeks	Yes MCQ	Yes Simulation	R	Mean score 23.9 post-course and 19.4 at follow-up (higher than pre-training)	<0.0001	R	Mean score 7.2 post-course and 5.1 at follow-up (higher than pre-training)	<0.0001
Coleman et al. 1991	No	4 hours of either lectures,discussion,handouts and simulation or e-learninhg	49 (S)	3 months	Yes MCQ	Yes Simulation	NC	Maintained scores in both groups	Not SIGNIF	NC	Maintained scores in both groups	Not SIGNIF
Cooper et al. 2007	Yes ILS	1 day Lectures Simulation	29 (D,N,O)	6 months	Yes MCQ	Yes Simulation	N/C	Mean score 82% post course and 80% at follow-up	Not SIGNIF	R	Mean score 99% post-course and 85% at follow-up (higher than pre-training)	0.02
Curry and Gas 1987	No	N/K	85 (D an N)	6 and 12 months	Yes MCQ	Yes Simulation	R	Doctors mean score 89.6% post-course, 84% at 6 months and 83.4% at 12 months Nurses mean score 92.3% post-course, 82% at 6 months and 79.4% at 12 months (Both back to pre-training levels)	N/K	R	Both for doctors and nurses – numerical data not reported (Both back to pre-training levels)	N/K
Curry and Gas 1983	Yes CPR	N/K	12(N)13(D) 12(N)6(D)	6months 12 months	Yes MCQ	Yes Simulation	R	D and N had decreased after 6 months – back to pre-training levels by 12 months	<0.05	R	D skills decreased after 6 months, N by 12 months – both back to pre-training by 12 months	<0.01
De Regge et al. 2005	No	Simulation	2 groups of 16 (N)	3 and 6 months	No	Yes Simulation	N/A		N/A	N/C	2 groups with different resuscitation bags - Efficiency of ventilation stayed the same in both	Not SIGNIF
Erickson et al. 1996	No	30 minute lectures and Simulation	11 (D,N,O)	2 months	No	In clinical area	N/A		N/A	R	Airway and trauma skills decreased at follow-up (to pre-training levels)	N/K

Table 6 Kirkpatrick 2C Adults (continued)

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	S	Knowledge change	Notes	P	Skill change	Notes	P
Fabius et al. 1994	No	Computer demo and Sim	54 (N,O)	6 months	No		N/A		N/A	?R	RCT – two groups – 1 person in each group 'passed' at follow-up compared to 6 and 34 respectively immediately post-training	N/K
Fossel et al. 1983	No	Simulation	41 (S)	1 year and 2 years	Yes MCQ	Yes Simulation	R	Score lower at 1 and 2 years compared to those followed up at 2-3 weeks after training	<0.001	R	CPR performance lower at 1 and 2 years compared to those followed at 2-3 weeks after training	<0.05
Hammond et al. 2000	Yes ALS	2 days Lectures Simulation	40 (N)	18 months	Yes MCQ	Yes Simulation	N/C	Mean score 81.7% post course, 83.8% at follow-up	Not SIGNIF	R	75% percent passed at follow-up	N/K
Heidenreich et al. 2004	Yes AHA course	25 minutes Instruction Video Simulation	28 (S)	6 and 18 months	No	Yes Simulation	N/A		N/A	R and N/C	In standard CPR – reduction percentage correct chest compressions from 54 to 35 then 32. In uninterrupted chest compressions stayed the same	<0.02
Holden et al. 1996	No	N/K	55 (N)	6 months	Yes MCQ	Yes Simulation	N/C	Number achieving more than 50% correct answers did not deteriorate	N/K		21 (38%) passed skills test at 6 months	N/K
Jensen et al. 2009	Yes ALS	Lectures simulation	2 groups (immedaitely and 6 months after qualification)	6 months	Yes composite	Yes composite with MCQ	N/K		N/A	N/K	Mean scores reduced from 85% and 83% post course to 82% and 78% at follow-up	N/K

Table 6 Kirkpatrick 2C Adults (continued)

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	Components of ability tested S	Knowledge change	Notes	P	Skill change	Notes	P
Kovacs et al. 2000	No	1 hour lecture, 5 hours simulation and half an hour/week for 3 weeks	84 (S)	16,25,40 weeks	No	Yes Simulation	N/A		N/A	N/C And R	RCT – groups with practice and feedback maintained skills. Control group and group receiving feedback alone deteriorated by 16 weeks (Mean score 45.2 to 34 and 45.2 to 35.4 respectively)	<0.05 in D groups
Leith 1997	No	'Defibrillation training'	10 and 10 (N)	6 and 12 months	Yes write exam	Yes Simulation	R	Mean score reduced from 89% post course to 76% at 6 months and 70% at 12 months	N/K	R	Pass rate of practical test decreased from 70% to 0% at 6 and 12 months	N/K
Mancini and Kaye 1985	Yes AHA	N/K	33 (D)	mean 8 and 22 months	Yes Assessment and action	Yes Simulation	?R	Less than 100% of candidates responded correctly in all aspects except for assessing unresponsiveness (presume all needed to be correct immediately post-training)	N/K	?R	Less than 100% of candidates performed correctly in all aspects except for ventilating (presume all needed to be correct immediately post-training)	N/K
McKee et al. 1994	No	Lectures Simulation	50 (N)	1 week, 1, 3 and 6 months	No	Yes Simulation	N/A		N/A	R and N/C	Delay to defibrillation increased – resuscitation score deteriorated then improved to post training score at 6 months	<0.05 and Not SIGNIF
O'Donnell and Skinner 1993	No	20 min lecture and Simulation	44 K 60 S	6 months	Yes Questionnaire	Yes Simulation	N/C and R	N/C in the 2 groups with refresher sessions and D in group with no refresher prior to follow-up	Not SIGNIF and <0.05	I	Group with monthly refresher sessions improved in 'pass rate' for performing cardiac massage from 39 to 69%	<0.05
O'Steen et al. 1996	Yes ACLS	N/K	40 (N)	Mean 344 days (0-1034)	Yes MCQ	Yes Simulation	R	After 12 months – no further deterioration after	<0.05	R	After 12 months – no further deterioration after	<0.05
Plank and Steinke 1989	No	2 hours Lecture and simulation vs video	36(N)	6-8 weeks	Yes MCQ	Yes simulation	N/K	Pass score not stated	N/A	R	26 failed at follw-up	Not stated

Table 6 Kirkpatrick 2C Adults (continued)

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	Components of ability tested S	Knowledge change	Notes	P	Skill change	Notes	P
Semeraro et al. 2005	Yes ALS	Lectures Simulation	47 (D)	6 months	Yes MCQ	Yes Simulation	R	Mean score 85.9% post-course and 79.5% at follow-up	<0.001	R	All passed post-course and 30 passed at follow-up	<0.001
Smith et al. 2008	Yes ACLS BLS	N/K	133 (N)	3,6,9,12 months	Yes MCQ	Yes Simulation	N/K	Results not reported	N/K	R	4 groups – all deteriorated – some to pre-training	N/K
Spooner et al. 2007	Yes BLS	8 hours Lectures simulation	66 (S) RCT standard vs feedback manekin	6 weeks	No	Yes simulation	N/A		N/A	R	Fail rate increased from 16% and 25% to 10% and 38% respectively	N/K
Stross 1983	Yes ACLS	N/K	132 (D)	1 year	Yes ECG recognition and mock arrest	Yes Simulation	N/C and R	RCT. All 3 groups maintained ECG recognition but deteriorated in mock arrest – the 2 groups receiving booster sessions performed better at follow-up	N/K	R	39% performed successful ventilation and 47% external cardiac massage compared to all having passed ACLS course	N/K
Ten Eyck 1993	No	4 hours lectures and Simulation	48 (O)	6 months	No	Yes simulation	N/A		N/A	R	5 failed resuscitations and others did not perform other required aspects of simulation	N/K
Tippett 2004	Yes ATNC	21/2 days Lectures simulation	14 (N)	3 months	Yes Short answers	No	R	Mean score 83% post course and 73% at follow-up (back to pre-course levels)	<0.05	N/A		N/A
Wayne et al. 2006	No	4 x 2 hours teaching and HI fidelity Simulation	38 (D)	6 and 14 months	No	Yes Simulation	N/A		N/A	N/C	In context of RCT previously over 6 months which involved 3 lots of testing	Not SIGNIF
Wenzel et al. 1997	No	2 hours Instruction Simulation	113 (S)	6 months	Yes MCQ	Yes Simulation	R	Mean score 6.4 post-course and 6.2 at follow-up	<0.05	R	5 out of 9 skills deteriorated significantly	<0.0001

Table 6 Kirkpatrick 2C Adults (continued)

Author	AP	Nature of the training	No of participants Followed up (D=doctors, N=nurses, S=students O=other)	When tested at follow-up	Components of ability tested K	Components of ability tested S	Knowledge change	Notes	P	Skill change	Notes	P
Yakel 1989	Yes 2 BLS courses	45 minutes or 8 hours Lectures Simulation	81 then 86 (N)	4 months and 8 months	No	Yes Simulation	N/A		N/A	R	Mean score 55 post-course and 38 at 4 months. Improved to 42 at 8 months ($p<0.001$) – 4 month test acted as booster (remedial training given). Longer course did better at follow-up ($p<0.05$)	N/K
Young and King 2000	No	N/K	10 (N)	6 and 12 weeks	Yes Oral questions	Yes Simulation	R	5 failed at 6 weeks, 5 failed at 12 weeks	N/K	R	5 failed at 6 weeks, 6 failed at 12 weeks	N/K

AP-Accredited programme, ACLS- Advanced Cardiac Life Support, AHA- American Heart Association, ALS- Advanced Life Support, ATLS- Advanced Trauma Life Support, BLS- Basic Life Support, CPR Cardio-pulmonary Resuscitation, ILS- Immediate Life Support, Knowledge and Skill change D – Decreased, MCQ-Multiple-Choice Questionnaires, N/A-Not applicable, NC - No change, N/K-Not known, Not SIGNIF- not significant, P- P Value, R – Reduced.

Table 7 Kirkpatrick 4 Neonates

Author	Accredited programme	Nature of the training	Period studied	Significant impact on patient outcome	Nature of the impact on patients (data)	Significant increase in survival rates (data)	Significant improvement in clinical management	Nature of the improvement (data)
Boo 2009	Yes NRP	Lectures Simulation	5 years pre-training and 8 years post-training	Not stated	Numerical decline in perinatal and neonatal mortality but no P values	? Less mortality	Not stated	Not stated
Duran et al. 2008	Yes NRP	Not stated	Over 3 year period including pre and post implementation of training	Yes	After training: significant increase in 1 minute Apgar score (5.43-6.5 - P=0.01) Babies with ischaemic changes on CT reduced from 91% to 62% (P=0.02) Reduction in inpatient stay from 12 to 6.1 days P=<0.05	No statistically significant difference	Not stated	Not stated
Patel et al. 2001	Yes NRP	Not stated	Before training (1985-1988), during transition (1989-1990) and after training (1991-1995)	yes	Fewer babies with low 1 and 5 min Apgar scores post-training P=<0.001	Not stated	Not stated	Not stated
Patel and Piotrowski 2002	Yes Neonatal resuscitation programme (NRP)	Not stated	Before NRP-1985-1988, after 1991-1995.	Yes	Higher 1 minute Apgar score (7-10) (24% pre versus 31% post NRP - P=0.001) and higher 5 minute (53% versus 65% - p<0.001). More changed from low 1 minute to high 5 minute after NRP (39% to 49% - p<0.001)	Not stated	Not stated	Not stated
Ryan et al. 1999	Yes NRP	Lectures Simulation	51 deliveries before and 51 deliveries after the training (1994-5)	Not stated	Not stated	Not stated	Yes	Improvement in delivery room preparation (P=0.01), management (P=0.01) assessment (P=0.02) and interventions (p=0.02)

Table 7 Kirkpatrick 4 Neonates (continued)

Author	Accredited programme	Nature of the training	Period studied	Significant improvement in patient outcome	Nature of the impact on patients (data)	Significant increase in survival rates (data)	Significant improvement in clinical management	Nature of the improvement (data)
Singh et al. 2006	Yes NLS	Lectures simulation	Data collected pre-course in 1990-1994 and post-course in 1997 and 2003.	Not stated	Not stated	Not stated	Yes for par of findings	Inappropriate use of naloxone fell from 75% to 10 % (P=0.0001). Total use of naloxone fell from 13% to 0.5%, incidence of hypothermia fell from 9% to 2.3% (both not statistically significant)
Zhu et al. 1997	Yes NRP	Not stated	Pre-training 1992, post-training 1993 to 1995	yes	3x reduction in neonatal mortality (9.9 to 3.4 per 1000) P<0.001	Yes		

NLS – Neonatal life support, NRP- Neonatal Resuscitation Programme.

Table 8 Kirkpatrick 4 Paediatrics

Author	Accredited programme	Nature of the training	Period studied	Significant impact on patient outcome	Nature of the impact on patients (data)	Significant increase in survival rates (data)	Significant improvement in clinical management	Nature of the improvement (data)
Lo et al. 2009	No	Simulation Weekly scenarios	23 weekly training sessions of approximately 30 minutes	Not documented	N/A	Not documented	No	Median time for chest re-opening significantly longer- P=0.002. Longer to give medication P= 0.002
Losek et al. 1994	No (PALS for emergency medicine in State)	Lectures as before but with additional supervised practice from 1986	Patients 0-18 years from January 1990 to December 1991 compared with data from January 1983 to June 1985	Not documented	N/A	Not documented	Yes	<18 month old improved intubation P=0.000008 and vascular access P= 0.000003 Older child improved vascular access p<0.05

N/A- not applicable, PALS- Paediatric Life Support

Table 9 Kirkpatrick 4 Adults

Author	Accredited programme	Nature of the training	Period studied	Significant improvement in patient outcome	Nature of the impact on patients (data)	Significant increase in survival rates (data)	Significant improvement in clinical management	Nature of the improvement (data)
Arreola et al. 2004	Yes PHTLS, BLS and ALS (some in house)	Not stated	3 ambulance services October – December 1994, pre-training and January – June 1995 post-training. January –September 2000 pre-training and October 2000 – June 2001 post training	Yes	Not stated	Improvement in survival in those patients transported in 1 intervention centre (p=0.04)	yes	Improved airway management in the 2 intervention centres (P<0.001) Improved spinal immobilisation in 1 intervention centre P<0.001 Some improved iv fluid administration in 2 intervention centres (p<0.001)
Camp et al. 1997	ACLS	Not stated	1980 to 1984 pre-training and from 1985 to 1990 post -training	Yes	Increased 'death events' reversed by intervention increased from 2% to 11% (p<0.001)post-training	Yes	Yes	Increased intervention at 'death events' post training (from 5% to 37% - p<0.001)
Curry and Gas 1987	No	Not stated	1981 -1985 – one hospital received training – the other not	No		No	No	No difference in death rates between trained and untrained staff
Dane et al. 2000	Yes ACLS	Not stated	1996 and 1997 Compared resuscitation outcome of nurses ACLS trained with those not	Yes	4x more likely to survive when treated by trained nurses (38% to 10%) P=0.02	Yes	Not stated	Not stated
Makker et al. 1995	Yes ACLS	Not stated	1991 – 225 cardiac arrests	No		No	Yes	Certified doctors made less errors in first semester after training (5.9%) compared with second semester (14.7%) (p=0.05)
Moretti et al. 2007	Yes ACLS	2 day course Lectures Simulation	January 1998 to March 2001 Compared resuscitation outcome of personnel ACLS trained with those not	Yes	Increase in return of spontaneous circulation with trained versus non-trained (49/113 versus 16/59 P=0.04)	Better survival in ACLS trained group: at 30 days (27% versus 6% - P=0.02) and 1 year (22% versus 0% P=0.002)	Not stated	Not stated
Murphy and Fitzsimmons 2004	Yes ILS	Not stated	1999 – 2000 and 2001 - 2002	Not stated	Not stated	Not stated	No	No difference in personell who inserted mask or defibrillated

Table 9 Kirkpatrick 4 Adults (continued)

Author	Accredited programme	Nature of the training	Period studied	Significant improvement in patient outcome	Nature of the impact on patients (data)	Significant increase in survival rates (data)	Significant improvement in clinical management	Nature of the improvement (data)
Seidlein and Bridges 1993	No	6 hours simulation	6 month period Aug 1987 to January 1987 compared to 1985	No		No	No	
Spearpoint et al. 2009	Yes ILS	1 day Lectures simulation	January 2002 to December 2007 – training ongoing during this period	Yes	Increase in survival to return of spontaneous circulation P=<0.005	Reduced deaths at cardiac arrest over time period (p<0.0002) Survival to discharge after emergency call increased to 39% (2007) from 28% (2004) P< 0.005	Not stated	Not stated
Van Olden et al. 2004	Yes ATLS	Not stated	May 1996 to September 1997 pre-course and December 1997 to April 1999 post-course	Yes	Significant reduction in mortality 24.2% to 0% in first 60 minutes following resuscitation	Yes	Not stated	Not stated
Van Olden et al. 2004	Yes ATLS	Not stated	Compared period pre-training (June 1996-November 1997) to post-training (January 1998 to July 1999)	Not stated	Not stated	Not stated	Yes	10 (out of 14) procedures were performed better post-training and management scores increased from 4.2 pre-training to 5.8 post-training (P<0.0001)
Vestrup et al. 1988	Yes ATLS	Not stated	Compared periods of pre-training (April 1983 to March 1984) to post training (April 1985 to 1986)	Not stated	Not stated	Not significantly different	yes	Significant increase in rectal examinations for trauma patients P=0.03
Woodall et al. 2007	Yes ACLS	Lectures clinical placement	January 2000 to December 2002 Compared resuscitation outcome of paramedics ACLS trained with those not	Yes	Pulse on admission more likely in ACLS trained (21%) compared to non-trained (8.5%)P= 0.0001	Yes Increased survival to discharge in ACLS trained (6.7%) versus non-trained (4.66%) P=0.03	Yes	Quicker mean time to first shock in ACLS trained (9.44 minutes) vs non-trained (10.07 minutes)

ACLS-Advanced Cardiac Life Support, ATLS- Advanced Trauma Life Support, ILS-Immediate Life Support, BLS- Basic Life Support, PHTLS- Pre-Hospital Trauma Life Support Course

References

Aboutanos MB, Rodas EB, Aboutanos SZ, Mora FE, Wolfe LG, Duane TM, Malhotra AK, Ivatury RR. Trauma education and care in the jungle of Ecuador, where there is no advanced trauma life support. J Trauma Inj 2007;62:714-719.

Ali I, Cohen R, Reznick R. Demonstration of acquisition of trauma management skills by senior medical students completing the ATLS Program. J.Trauma 1995;38:687-691.

Ali J, Adam R, Josa D, Pierre I, Bedsaysie H, West U, Winn J, Ali E,Haynes B. Effect of basic prehospital trauma life support program on cognitive and trauma management skills. World J.Surg. 1998;22:1192-1196.

Ali J, Cohen R, Adam R, Gana TJ, Pierre I, Ali E, Bedaysie H, West U, Winn J. Attrition of cognitive and trauma management skills after the Advanced Trauma Life Support (ATLS) course. J Trauma Inj 1996;40:860-866.

Ali J, Cohen R, Adam R, Gana TJ, Pierre I, Bedaysie H, Ali E, West U, Winn J.Teaching effectiveness of the advanced trauma life support program as demonstrated by an objective structured clinical examination for practicing physicians. World J.Surg. 1996;20:1121-1125.

Ali J, Howard M, Williams J. Is attrition of advanced trauma life support acquired skills affected by trauma patient volume? Am J Surg 2002;183:142-145.

Ander DS, Hanson A, Pitts S. Assessing resident skills in the use of rescue airway devices. Annals. Emerg-Med. 2004;44;314-319.

Arreola RC, Mock C, Herrera-Escamilla AJ, Contreras I, Vargas J. Cost-effectiveness and benefit of alternatives to improve training for pre-hospital trauma care in Mexico. Prehosp Disast Med. 2004;19:318-325.

Azcona LA, Gutierrez-Guillermo EO, Fernandez-Cesar JP, Octavio M, Ruiz SO, Ali J. Attrition of advanced trauma life support (ATLS) skills among ATLS instructors and providers in Mexico. J Am Coll 2002;195:372-377.

Beckers SK, Fries M, Bickenbach J, Skorning MH, Derwall M, Kuhlen R, Rossaint R.. Retention of skills in medical students following minimal theoretical instructions on semi and fully automated external defibrillators. Resuscitation 2007;72:444-450.

Bilger MC, Giesen BC, Wollan PC, White RD. Improved retention of the EMS activation component (EMSAC) in adult CPR education. Resuscitation. 1997;35:219-24.

Blumenfeld A, Ben Abraham R, Stein M, Shapira SC, Reiner A, Reiser B, Rivkind A, Shemer J. Cognitive knowledge decline after Advanced Trauma Life Support courses. J.Trauma 1998;44:513-516.

Boo NY. Neonatal resuscitation programme in Malaysia: an eight-year experience. Singapore Med J 2009;50:152-159.

Boonmak P, Boonmak S, Srichaipanha S, Poomsawat S. Knowledge and skill after brief ACLS training. J Med.AssocThai. 2004;87:1311-1314.

Bradley K, Sokolow AE, Wright KJ, McCullough WJ. A comparison of an innovative four-hour EMT-D course with a 'standard' ten-hour course. Ann.Emerg.Med. 1988;17:613-619.

Broomfield R. A quasi-experimental research to investigate the retention of basic cardiopulmonary resuscitation skills and knowledge by qualified nurses following a course in professional development. J Adv Nurs 1996;23:1016-1023.

Brown, G., Bull, J. and Pendlebury, M. Assessing student learning in higher education. London: Routledge 1997.

Burns J. Training and Development Competence: a practical guide. Kogan Page. London. *Cited in* Dunn L, Teaching in Further Education, 5th Edition, Continuum London, 2000.

Camp BN, Parish DC, Andrews RH. Effect of advanced cardiac life support training on resuscitation efforts and survival in a rural hospital. Ann Emerg.Med 1997;29:529-533.

Cavaleiro AP, Guimaraes H, Calheiros F. Training neonatal skills with simulators? Acta Paediatr 2009;98:636-639.

Cimrin AH, Topacoglu H, Karcioglu O, Ozsarac M, Ayrik C. A model of standardized training in basic life support skills of emergency medicine residents. AdvTher 2005;22:10-18.

Coleman S, Dracup K, Moser DK. Comparing methods of cardiopulmonary resuscitati on instruction on learning and retention. J Nurs Staff Devel 1991;82-87.

Cooper S, Johnston E, Priscott D. Immediate life support (ILS) training. Impact in a primary care setting? Resuscitation 2007;72:92-99.

Curran VR, Aziz K, O'Young S, Bessell C. Evaluation of the effect of a computerized training simulator (ANAKIN) on the retention of neonatal resuscitation skills. Teach.Learn.Med 2004;16:157-164.

Curry L, Gas DA Effects of training in cardiopulmonary resuscitation on competence and patient outcome. CMAJ 1987;137:491-496.

Dane FC, Russell-Lindgren KS, Parish DC, Durham MD, Brown TD Jr. In-hospital resuscitation: Association between ACLS training and survival to discharge. Resuscitation 2000;47:83-87.

Dauphin MN, Celestin MJ, Brown D, González Q V. The advanced life support in obstetrics course as an orientation tool for obstetrics and gynecology residents. Am.J Obs Gyn 2007;196:e27-28.

David J, Prior-Willeard PF. Resuscitation skills of MRCP candidates. BMJ 1993;306:1578-1579.

De Regge M, Vogels C, Monsieurs KG, Calle PA. Retention of ventilation skills of emergency nurses after training with the SMART BAG® compared to a standard bag-valve-mask. Resuscitation 2006;68:379-384.

Devita, M. Schaefer, J. Lutz, J., Wang, H. Dongilli, T. Improving medical emergency team(MET) performance using a novel curriculum and a computerized human patient simulator. Qual Saf in Health Care 2005;14:326-331.

Dobson JV, Brancati DS, Nagel R Pediatric resuscitation: Evaluation of a clinical curriculum. Med Ed Online 2003;8:15.

Donoghue AJ, Durbin DR, Nadel FM, Stryjewski GR, Kost SI, Nadkarni VM. Effect of high-fidelity simulation on Pediatric Advanced Life Support training in pediatric house staff: a randomized trial. Ped Emerg Care 2009;25:139-144.

Dunn L. Teaching in Further Education, 5th Edition, Continuum London, 2000.

Dunn S, Niday P, Watters NE, McGrath P, Alcock D. The provision and evaluation of a neonatal resuscitation program. J.Cont Educ Nurs 1992;23:118-126.

Dunning J, Nandi J, Ariffin S, Jerstice j, Danitsch D, Levine A. The cardiac surgery advanced life support course (CALS): Delivering significant improvements in emergency cardiothoracic care. Ann Thorac Surg 2006;81:1767-1772.

Duran R, Aladag N, Vatansever U, Kucukugurluoglu Y, Sut N, Acunas B. Proficiency and knowledge gained and retained by pediatric residents after neonatal resuscitation course. Pediatr Int 2008;50:644-647.

Duran R, Aladag N, Vatansever U, Sut N, Acunas B. The impact of Neonatal Resuscitation Program courses on mortality and morbidity of newborn infants with perinatal asphyxia. Brain Dev 2008;30:43-46.

Durojaiye L, Meara M. Improvement in resuscitation knowledge after a one-day paediatric life-support course. J Paediatr Child Health. 2002;38:241-245.

Ergenekon E, Koc E, Atalay Y, Soysal S. Neonatal resuscitation course experience in Turkey. Resuscitation. 2000;45:225-227.

Ericsson KA. The influence of experience and deliberate practice on the development of superior expert performance. In Ericsson KA, Charness N, Feltovich PJ, Hoffman RR, eds. The Cambridge Handbook of Expertise and Expert Performance. New York, NY: Cambridge University Press;2006:683-703.

Erickson TB, VanRooyen MJ, Werbiski P, Mycyk M, Levy P. Emergency medicine education intervention in Rwanda. Ann Emerg Med 1996;28:648-651.

Fabius DB, Grissom EL, Fuentes A. Recertification in cardiopulmonary resuscitation. A comparison of two teaching methods. J.Nurs Staff Dev 1994;10:262-268.

Featherstone P, Smith GB, Linnell M, Easton S, Osgood VM. Impact of a one-day inter-professional course (ALERT(trademark)) on attitudes and confidence in managing critically ill adult patients. Resuscitation 2005;65:329-336.

Fossel M, Kiskaddon RT, Sternbach GL. Retention of cardiopulmonary resuscitation skills by medical students. J.Med.Educ. 1983;58:568-575.

Gass DA, Curry L. Physicians' and nurses' retention of knowledge and skill after training in cardiopulmonary resuscitation. Canadian. Med-Assoc. 1983;128:550-556.

Gerard JM, Scalzo AJ, Laffey SP, Sinks G, Fendya D, Seratti P. Evaluation of a novel Web-based pediatric advanced life support course. Arch Pediatr Adolesc Med 2006;160:649-655.

Girdley FM, Cohen DJ, Birnbaum ML, Bowman RM. Advanced trauma life support: assessment of cognitive achievement. Mil Med 1993;158:623-627.

Greig M, Elliott D, Parboteeah S, Wilks L. Basic life support skill acquisition and retention in student nurses undertaking a pre-registration diploma in higher education/nursing course. Nurse Educ Today 1996;16:28-31.

Hammond F, Saba M, Simes T, Cross R. Advanced life support: retention of registered nurses' knowledge 18 months after initial training. Austral Crit Care. 2000;13:99-104.

Heidenreich JW, sanders AB, Higdon TA, Kern KB, Berg RA, Ewy GA. Single-rescuer cardiopulmonary resuscitation: 'Two quick breaths' - An oxymoron. Resuscitation 2004;62:283-289.

Hoadley TA. Learning advanced cardiac life support: a comparison study of the effects of low- and high-fidelity simulation. Nurs Educ Perspect 2009;30:91-95.

Holden CG, Monaghan D, Cassidy M. Retention of cardiopulmonary resuscitation skills of dental nurses. SAAD Dig 1996;13:3-7.

Issenberg SB, Mc Gaghie WC, Hart IR, Mayer JW, Felner JM, Petrusa ER, Waugh RA, Brown DD,Safford RR, Gessner IH, Gordon DL, Ewey GA. Simulation technology for health care professional skills training and assessment. JAMA1999;282:861-866.

Issenberg SB, Mc Gaghie WC, Petrusa ER, Gordon DL,Scalese RJ. Features and use of high-fidelity medical simulation that lead to effectrive learning: a BEME systematic review. Med Teac 2005;27:10-28.

Jensen ML, Lippert F, Hesselfeldt R, Rasmussen MB, Mogenson SS, Jensen MK, Frost T, Ringsted C. The significance of clinical experience on learning outcome from resuscitation training-a randomised controlled study. Resuscitation 2009;80:238-243.

Kaczorowski J, Levitt C, Hammond M, Outerbridge E, Grad R, Rothman A, Graves L. Retention of neonatal resuscitation skills and knowledge: A randomized controlled trial. Fam Med 1998;30:705-711.

Kirkpatrick, D. L. Evaluating Training Programs. San Francisco: Berrett-Koehler Publishers, Inc. 1994

Knowles M, The Modern Practice of Adult Education. Cambridge: The Adult Education Company. 1984.

Kolb DA (1984) Experiential Learning: experience as the source of learning and development New Jersey: Prentice-Hall.

Kovacs G, Bullock G, Ackroyd-Stolarz S, Cain E, Petrie D. A randomized controlled trial on the effect of educational interventions in promoting airway management skill maintenance. Ann Emerg Med 2000;36:301-309.

Leith B. Retention of defibrillation training by intensive care nurses. CACCN 8-1 Spring 1997. 9-11.

Levitt C, Kaczorowski J, Outerbridge E, Jimenez V, Connolly B, Slapcoff B. Knowledge gained following neonatal resuscitation program courses. Fam Med 1996;28:403-406.

Lo TY, Morrison R, Atkins K, Reynolds F. Effective performance of a new post-operative cardiac resuscitation simulation training scheme in the Paediatric Intensive Care Unit. Int Care Med 2009;35:725-729.

Losek JD, Szewczuga D, Glaeser PW. Improved prehospital pediatric ALS care after an EMT-paramedic clinical training course. Am J Emerg Med 1994;12:429-432.

Kirkpatrick, D.L. *Evaluating Training Programs: The Four Levels* San Francisco, CA, Berrett-Koehler Publishers, 1994

Makker R, Gray SK, Evers M. Evaluation of advanced cardiac life support in a community teaching hospital by use of actual cardiac arrests. Heart and Lung: J Crit Care 1995; 24:116-120.

Mancini ME, Kaye W. The effect of time since training on house officers' retention of cardiopulmonary resuscitation skills. Am.J Emerg Med 1985;3:31-32.

Marton, F., Hounsell, D. And Entwistle, N. The Experience of learning. Implications for Teaching and Studying in Higher Education. 2nd Edition. Scottish Academic Press 1997.

Mayo PH, Hackney JE, Mueck JT, Ribaudo V, Schneider RF. Achieving house staff competence in emergency airway management: Results of a teaching program using a computerized patient simulator. Crit Care Med 2004;32:2422-2427.

McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation –based medical education research:2003-2009. Med Ed 2010;44:50-63.

McGaghie WC, Issenberg B,Cohen E,Barsuk JH, Wayne DB. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A Meta-analytic comparative review of the evidence Ac Med 2011;86:1-6.

McKee DR, Wynne G, Evans TR. Student nurses can defibrillate within 90 seconds. Resuscitation 1994;27:35-37.

Monsieurs KG, De Regge M, Vogels C, Calle PA. Improved basic life support performance by ward nurses using the CAREvent® Public Access Resuscitator (PAR) in a simulated setting. Resuscitation 2005;67:45-50.

Moretti MA, Cesar L-AM, Nusbacher A, Kern KB, Timerman S, Ramires J-AF. Advanced cardiac life support training improves long-term survival from in-hospital cardiac arrest. Resuscitation 2007;72:458-465.

Morrison A, Moulton K, Clark M, Polisena J, Fiander M, Mierzwinski-Urban M, Mensinkai S, Clifford T, Hutton B. English-Language Restriction When Conducting Systematic Review-based Meta-analyses:Systematic Review of Published Studies. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2009.

Murphy M, Fitzsimons D. Does attendance at an immediate life support course influende nurses' skill development during cardiac arrest? Resuscitation 2004;62: 49-54.

Nadel FM, Lavelle JM, Fein JA, Giardino AP, Decker JM, Durbin DR. Teaching resuscitation to pediatric residents: The effects of an intervention. Arch Pediatr Adol Med 2000;154:1049-1054.

O'Donnell CPF, Kamlin COF, Davis PG, Morley CJ. Ethical and legal aspects of video recording neonatal resuscitation Arch Dis Child 2008;92:F82-F84.

O'Donnell CM, Skinner AC. An evaluation of a short course in resuscitation training in a district general hospital. Resuscitation 1993;26:193-201.

O'Steen DS, Kee CC, Minick MP. The retention of advanced cardiac life support knowledge among registered nurses. J Nurs Staff Dev 1996;12:66-72.

Owen H, Mugford B, Follows V, Plummer JL. Comparison of three simulation-based training methods for management of medical emergencies. Resuscitation 2006;71:204-211.

Patel D, Piotrowski ZH. Positive changes among very low birth weight infant Apgar scores that are associated with the Neonatal Resuscitation Program in Illinois. J Perinatol 2002;22:386-390.

Patel D, Piotrowski ZH, Nelson MR, Sabich R. Effect of a statewide neonatal resuscitation training program on Apgar scores among high-risk neonates in Illinois. Pediatrics 2001;107:648-655.

Plank CH, Steinke KR. Effect of two teaching methods on CPR retention. J Nurs Staff Devel 1989;145-147.

Quan L, Shugerman RP, Kunkel NC, Brownlee CJ. Evaluation of resuscitation skills in new residents before and after pediatric advanced life support course. Pediatrics 2001;108:E110.

Reece I, Walker S. Teaching and learning- A practical guide. 4th edition- incorporating FENTO standards. Business Education Publishers Ltd. 2000.

Resuscitation Council UK. Resuscitation Guidelines October 2010.

Rosenthal ME, Adachi M, Ribaudo V, Tristan MJ, Schneider RF, Mayo PH. Achieving housestaff competence in emergency airway management using scenario based simulation training: Comparison of attending vs housestaff trainers. Chest 2006;129:1453-1458.

Ryan CA, Clark LM, Malone A, Ahmed S. The effect of a structured neonatal resuscitation program on delivery room practices. Neonatal Netw 1999;18:25-30.

Seidelin PH, Bridges AB. Cardiopulmonary resuscitation: effect of training junior house officers on outcome of cardiac arrest. J.R.Coll.Physicians Lond 1993;27:52-53.

Semeraro F, Signore L, Cerchiari EL. Retention of CPR performance in anaesthetists. Resuscitation 2006;68:101-108.

Singh J, Santosh S, Wyllie JP, Mellon A. Effects of a course in neonatal resuscitation - Evaluation of an educational intervention on the standard of neonatal resuscitation. Resuscitation 2006;68:385-389.

Skidmore MB, Urquhart H. Retention of skills in neonatal resuscitation. Paediatr Child Health 2001;6:31-35.

Smith KK, Gilcreast D, Pierce K. Evaluation of staff's retention of ACLS and BLS skills. Resuscitation 2008;78:59-65.

Spaite DW, Karriker KJ, Seng M, Conroy C, Battaglia N, Tibbitts M, Meislin HW, Salik, RM, TD. Increasing paramedics' comfort and knowledge about children with special health care needs. Am J Emerg Med 2000;18:747-752.

Spearpoint KG, Gruber PC, Brett SJ. Impact of the Immediate Life Support course on the incidence and outcome of in-hospital cardiac arrest calls: an observational study over 6 years. Resuscitation 2009;80:638-643.

Spooner BB, Fallaha JF, Kocierz L, Smith CM, Smith S-CL, Perkins GD. An evaluation of objective feedback in basic life support (BLS) training. Resuscitation 2007;73:417-424.

Stross JK. Maintaining competency in advanced cardiac life support skills. JAMA 1983;249:3339-3341.

Su E, Schmidt TA, Mann NC, Zechnich AD. A randomized controlled trial to assess decay in acquired knowledge among paramedics completing a pediatric resuscitation course. Acad Emerg Med 2000;7:779-786.

Ten Eyck RP. Automated external defibrillator training and skills maintenance in air force emergency medical services systems. Mil Med 1993;158:579-581.

Tight, M. Key Concepts In Adult Education 2d ed 2002 Routledge Press.

Tippett J. Nurses' acquisition and retention of knowledge after trauma training. Accid Emerg Nurs 2004;12:39-46.

Trevisanuto D, Ferrarese P, Cavicchioli P, Fasson A, Zanardo V, Zacchello F. Knowledge gained by pediatric residents after neonatal resuscitation program courses. Paed Anaesth 2005;15:944-947.

Van Olden GD, Meeuwis JD, Bolhuis HW, Boxma H, Goris RJ. Clinical impact of advanced trauma life support. Am J Emerg Med 2004;22:522-525.

Vestrup JA, Stormorken A, Wood V. Impact of advanced trauma life support training on early trauma management. Am J Surg 1988;155:704-707.

Waisman Y, Amir L, Mimouni M. Does the pediatric advanced life support course improve knowledge of pediatric resuscitation? Pediatr Emerg Care 2002;18:168-170.

Wayne DB, Siddall VJ, Butter J, Fudala MJ, Wade LD, Feinglass J, McGaghie WC. A Longitudinal Study of Internal Medicine Residents' Retention of Advanced Cardiac Ife Support Skills. Acad Med 2006;81:S9-S12.

Wayne DB, Butter J, Siddall VJ, Fudala MJ, Linquist LA, Feinglass J, Wade LD, McGaghie WC: Simulation-based training of internal medicine residents in advanced cardiac life support protocols: a randomized trial. Teach Learn Med 2005;17:210-216.

Wenzel V, Lehmkuhl P, Kubilis PS, Idris AH, Pichlmayr I. Poor correlation of mouth-to-mouth ventilation skills after basic life support training and 6 months later. Resuscitation 1997;35:129-134.

West H. Basic infant life support: retention of knowledge and skill. Paediatr Nurs 2000;12:34-37.

Wolfram RW, Warren CM, Doyle CR, Kerns R, Frye S. Retention of Pediatric Advanced Life Support (PALS) course concepts. Journal of Emerg Med 2003;25:475-479.

Woodall J, McCarthy M, Johnston T, Tippett V, Bonham R. Impact of advanced cardiac life support-skilled paramedics on survival from out-of-hospital cardiac arrest in a statewide emergency medical service. Emerg Med J 2007;24:134-138.

Wynne G. Training and retention of skills. BMJ 1986;293:30-32.

Yakel ME. Retention of cardiopulmonary resuscitation skills among nursing personnel: What makes the difference? Heart and Lung: J Crit Care 1989;18:520-525.

Young R, King L. An evaluation of knowledge and skill retention following an in-house advanced life support course. Nurs Crit Care 2000;5:7-14.

Zhu XY, Fang HQ, Zeng SP, Li YM, Lin HL, Shi SZ. The impact of the neonatal resuscitation program guidelines (NRPG) on the neonatal mortality in a hospital in Zhuhai, China. Singapore Med J 1997;38:485-487.