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

Worksheet author(s)

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Clinical question.

In participants undergoing BLS/ALS courses (P), does the inclusion of more realistic techniques (eg. high fidelity manikins, in-situ training) (I), as opposed to standard training (eg. low fidelity, education centre) (C), improve outcomes (eg. skills performance on manikins, skills performance in real arrests, willingness to perform etc.) (O)?

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

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

Conflict of interest specific to this question:

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

Search strategy (including electronic databases searched).

MEDLINE search (last updated 22 October 2009)

#	Searches	Results
1	exp Resuscitation/	62474
2	exp Heart Arrest/	27456
3	basic life support.mp.	1054
4	advanced life support.mp.	1354
5	Life Support Care/ or life support.mp.	12161
6	(high-fidelity or low-fidelity).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]	2541
7	simulation.mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]	125323
8	computer-assisted instruction.mp. or Computer-Assisted Instruction/	7147
9	exp *Education/	323281
10	(1 or 2 or 3 or 4 or 5) and (6 or 7 or 8) and 9	197

After removal of duplicate records, Titles and Abstracts (where present) were reviewed for all 178 records and 42 selected for review of the full paper.

EMBASE search (last updated 22 October 2009)

#	**Searches**	**Results**
1	exp resuscitation/ or resuscitation.mp.	30002
2	cardiac arrest.mp. or exp heart arrest/	18004
3	basic life support.mp.	686
4	advanced life support.mp.	958
5	simulation.mp. or simulation/	78965
6	high fidelity.mp.	1705
7	low fidelity.mp.	258
8	education.mp. or exp education/	302775
9	(1 or 2 or 3 or 4) and (5 or 6 or 7) and 8	181

Titles and Abstracts (where present) were reviewed for all 181 records and 24 selected for review of the full paper, of which 6 were already identified in the MEDLINE sear, resulting in 18 new papers for review

MASTER ENDNOTE LIBRARY SEARCH
Key words in “Any Field” included “fidelity” (12 hits, none selected) and “simulation” (90 hits – no new papers identified)

COCHRANE SEARCH

ID	Search	Hits
#1	(simulation):ti,ab,kw	2332
#2	(fidelity):ti,ab,kw	201
#3	(life support):ti,ab,kw	3165
#4	(cardiac arrest):ti,ab,kw	980
#5	(education):ti,ab,kw	19231
#6	(training):ti,ab,kw	20415
#7	((#1 OR #2) AND (#3 OR #4) AND (#5 OR #6))	30

From 30 hits (no systematic reviews) all titles and abstracts were reviewed, of which 5 were selected for review of the full paper – but all had been previously identified in MEDLINE

• State inclusion and exclusion criteria Inclusion criteria – Human studies, research studies Exclusion criteria – Editorials, conference papers, narrative review articles. Studies that focused on teaching resources/techniques that did not specifically enhance the ‘realism’ of the teaching context , such as automated voice advisory manikins. Studies that only included description of simulation techniques/equipment without any testing of knowledge or skills.
• Number of articles/sources meeting criteria for further review: 59-3 DUPLICATE = 56 full articles reviewed plus several relevant papers identified from secondary references. A total of 36 studies were included in the FINAL Worksheet Evidence Tables.

Summary of evidence

Evidence Supporting Clinical Question

Good	Schwid,1999[E1]				
Fair	Wayne,2005[E1,E5] [1]Mayo,2004[E1] [3]Donoghue,2009[E1] Owen,2006[E1] [4]Ali,2009[E4] Knudson,2008[E5] Wang,2008[E5]	[4]Ali,1998[E1] Christenson,1998[E1] Wayne,2008[E2] Rodgers, 2009[E1,E4,E5]	[1]Kory,2007[E1] [4]Barsuk,2005[E1] [1]Levitan, 2001[E5]	Wayne,2006a[E1] Wayne,2006b[E1,E5] [1]Rosenthal,2006[E1,E2] [4]Marshall,2001[E1,E5]	
Poor	Campbell,2009[E1,E5]		Attia,1975[E4]	[1]Mayo,2004[E2] Bruce,2009[E4] Dunning,2006[E1]	
	1	**2**	**3**	**4**	**5**
Level of evidence					

[1] Airway management skills only; [2]Neonatal resuscitation; [3]Paediatric resuscitation; [4]Trauma; [5]Other scenario

E1 = Skills performance on manikin
E2 = Skills performance in real arrests
E3 = Patient survival in real arrests
E4 = Knowledge
E5 = Other outcome

Evidence Neutral to Clinical question

	1	2	3	4	5
Good	[1]Hall,2005[E5] Schwartz,2007[E1] [4]Cherry,2007[E1,E4]				
Fair	[2]Cavaleiro,2009[E4] Owen,2006[E4,E5] Knudson,2008[E2,E4] [5]Tan,2008[E1] Wang,2008[E1] [2]Kaczorowski, 1998[E1,E4] Miotto, 2008[E4] [1]Friedman, 2008[E1] Iglesias-Vazquez, 2007[E1,E4,E5]	Wayne,2008[E3] Christenson,1998[E4]			
Poor	[2]Campbell,2009[E4] Hoadley,2009[E1,E4,E5] [2]Curran,2004 [E1,E4,E5] Fabius,1994 [E1,E4]			Bruce,2009[E1,E5]	
	1	**2**	**3**	**4**	**5**
	Level of evidence				

[1] Airway management skills only; [2]Neonatal resuscitation; [3]Paediatric resuscitation; [4]Trauma; [5]Other scenario

E1 = Skills performance on manikin **E3 = Patient survival in real arrests** **E5 = Other outcome**
E2 = Skills performance in real arrests **E4 = Knowledge**

Evidence Opposing Clinical Question

	1	2	3	4	5
Good					
Fair	Kim,2002[E4]				
Poor					
	1	**2**	**3**	**4**	**5**
	Level of evidence				

[1] Airway management skills only; [2]Neonatal resuscitation; [3]Paediatric resuscitation; [4]Trauma; [5]Other scenario

E1 = Skills performance on manikin **E3 = Patient survival in real arrests** **E5 = Other outcome**
E2 = Skills performance in real arrests **E4 = Knowledge**

REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

This worksheet sought to address the question of whether increased 'realism' (high-fidelity) in simulation improved basic or advanced life support knowledge or skills (in manikin or real arrests) and/or patient outcomes. Only human research studies (no editorials, commentaries, narrative reviews were included) where the focus of the study was an attempt to improve BLS/ALS skills (or related skills such as airway management / trauma management) through the use of a simulation technique that sought to enhance the realism of the training process. The underlying premise is that *a "high-fidelity simulation experience allows the participants to suspend disbelief and perform in a manner that more closely reflects the way they would act in caring for a real patient in a comparable situation."*[1,p139] Moreover there is a belief (and some evidence) that repetitive performance of specific skills, coupled with assessment and feedback, will lead to acquisition of expertise in medicine. [2] The use of high-fidelity simulation in medicine has been suggested as a useful teaching method for clinical situations that, although infrequent, are critical in nature and require the maintenance of a high level of skill and preparedness.[1,p142] Cardiac arrest clearly fits this description.

A total of 36 studies were included in this worksheet, most (53%) related to adult ALS/BLS skills (n=19), with n=5 relating to neonatal/paediatric ALS/BLS skills; n=6 relating specifically to airway management; n=5 relating to trauma and n=1 relating to anaphylaxis. A large proportion (61%) of the studies were RCTs (LOE=1) but all but one had a small sample size (< 100), and most had some methodological flaws / limitations. The overall quality assessment was: Good(11%); Fair (70%) and Poor (19%).

The papers included in this worksheet highlight that the field is plagued by inconsistent definitions – beginning with what the term 'high-fidelity simulation' actually means. Moreover there is overwhelming variation in a) the type of intervention under test, including: computerized interactive videodisk (Fabius,1994,p262); screen-based simulation (Tan,2008,p565); high-fidelity human patient simulators (Wayne,2005,p210), and b) the intensity of the 'intervention' used, which ranged from a 30min 'one off' simulation session (Cavaleiro,2009,636), to 10-hours of simulator practice sessions (Wayne,2005,210) to a 3-day course (Dunning,2006,1767). Similarly the 'control' group varies from comparisons with low-fidelity simulation (rare), didactic lectures, reading materials alone or simply 'no-training'. Given the clinical and methodological heterogeneity of the studies, meta-analysis would be problematic, and as such summarization of the literature is restricted to descriptive methods. As asserted in a recent paper by Donoghue(2009), *"as simulation research in resuscitation continues to expand, it will be necessary to design and validate instruments to measure team and individual performances to be used as reproducible outcomes of interest for future studies."*[1,p142]

The outcomes of interest for the 30 studies were categorized as follows: E1=Skills performance on a manikin (n=24); E2=Skills performance in real arrests (n=4); E3=Patient survival after arrest (n=1); E4=Knowledge (n=13); and E5=other (n=7). (Note total numbers add to more than N=36, since 53% of the studies had more than one of the outcomes of interest reported.) In addition many studies reported participant satisfaction with the simulation technique, with most reporting good to excellence evaluations. The 'Other outcome' category also includes self-assessed confidence in performing the respective resuscitative procedure. Most studies showed an increase in confidence after the simulation intervention. However, it has been established that student self-reported confidence in resuscitation skills does not necessarily correspond to competence.[2]

Of the 36 studies included in the evidence evaluation, 22 (61%) of studies reported at least one 'positive' outcome. Nonetheless, given the number of 'neutral' studies, the evidence for the efficacy of more realistic ('high-fidelity') techniques in resuscitation training remains equivocal. Notwithstanding this, it is generally well accepted by students and has a persuasive pedagogy underpinning it. The simulation literature is fraught with heterogeneity and as such the future challenge is to improve the standard and comparability of research studies in the field.

Acknowledgements:
Ms Bekah Andrews (Sir Charles Gairdner Hospital Centre for Nursing Research, Perth, Western Australia) for assistance with obtaining the journal articles required for this worksheet.

Citation List

Ali, J, Al Ahmadi, K, Williams, JI*, et al.* (2009). "The standardized live patient and mechanical patient models--their roles in trauma teaching." Journal of Trauma-Injury Infection & Critical Care **66**(1): 98-102.

Notes
Ali,2009, p98
EVIDENCE=Support (knowledge)
LOE= 1
QUALITY=Fair
COMMENTS
The aim of this study was to compare the performance of students with and without the models and also to compare the effectiveness of the live patient model with the computerized mechanical model. All (n=70) final year medical students undertook the TEAM program and were then randomised to one of three groups: Gp1= Focused discussion (no models); Gp2= Standardised live patient model; Gp3=Computerized trauma manikin (Laerdal SimMan). Outcomes measured: Knowedge was assessed using a 20-item MCQ before and after the intervention. An evaluation questionnaire re course outcomes consisting of 5-items - scored on a 5-point likert scale. After completing the evaluation questionnaire, groups II and III switched models, i.e., the standardized patient model group used the computerized mechanical model and vice versa. These students were then requested to complete a form
comparing the mechanical model and the patient model using six parameters: which model was more: challenging, interesting, dynamic, enjoyable, realistic, and better over all model. No assessment of skills performance. Results: Mean pre-TEAM MCQ scores similar for all 3 gps. Stat sig improvement in post-TEAM scores for all 3 gps compared to the pre-test. Gps II&III (simulation) demonstrated a great improvement than Gp I (p< 0.05). In the evaluation questionnaire students in Gp I (no models) rated their skills improvement lower than students in Gp II and III. Students (n=48) who experienced both the patient and mechanical model overwhelmingly preferred the mechanical model.
Limitation: Only self-assessment of skill improvement - no objective assessment.

Ali, J, Cohen, RJ, Gana, TJ*, et al.* (1998). "Effect of the Advanced Trauma Life Support program on medical students' performance in simulated trauma patient management." Journal of Trauma-Injury Infection & Critical Care **44**(4): 588-91.

Notes
Ali, 1998, p588
EVIDENCE - Support
LOE= 2
QUALITY=Fair
COMMENTS
Non-randomised comparison of the performance of senior medical students depending on whether they had a) participated in an ATLS course; b) audited an ATLS course; or c) not attended an ATLS course. No details are provided about the ATLS course. All students from the same class / institutions. All students received the standard trauma undergraduate curriculum consisting of seminars, lectures, and case discussions on trauma topics. Outcome measure = performance assessed by (blinded) examiners in simulated scenarios using life models - assessed by examiner using a checklist at each station. standardised to a score out of 20. Plus the overall management approach of the students was graded on a scale of 1 to 5 for each trauma station, and the student's global performances were graded (before computing the scores) as honors, pass, borderline, or fail.
Results: For Trauma stations the ATLS-trained gp had the highest scores, whereas the ATLS-audit gp had intermediate scores that were higher than the control gp but lower than those of the ATLS-trained gp (p<0.001). Similar findings for the 'overall approach scores - ie ATLS-trained gp had the highest scores, followed by the ATLS-audit gp and then the control (non-ATLS) group. Nil sig diff in non-trauma station scores - but ATLS-trained gp scored most highly. No sig diff between scores of students doing their clerkship in trauma hospitals compared to those in non-trauma hospitals. Overall grades: no failures or borderline passes in either the ATLS-trained gp or ATLS-audit gp - but 9.1% borderline pass and 6.8% fails in the control group.
Conclusion: Supportive of the concept that participating in the ATLS course (ie more hands-on 'realistic' training) improved performance in trauma scenarios using live models more than students who audited the course or had not attended at all. However, it is important to note that 84% of the students not attending or auditing an ATLS course were still given a pass grade in the trauma stations.
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Attia, RR, Miller, EV and Kitz, RJ (1975). "Teaching effectiveness: evaluation of computer-assisted instruction for cardiopulmonary resuscitation." Anesthesia & Analgesia **54**(3): 308-11.

Notes
Attia, 1975, p308
EVIDENCE=Support
LOE= 3
QUALITY=Poor
COMMENTS
27 'first-month' anaesthetic residents. Computer-assisted instruction ('CAI') (plus reading materials and tutor) was used to teach the 1972 (n=13) cohort CPR, whilst the 1973 (n=14) cohort of students were taught only using reading materials and tutor (ie NO computer-assisted instruction). Written knowledge test (10 items) - no measure of psychmotor performance. Test scores in pre-test similar for both groups. Post-intervention test scores significantly higher for the CAI group(9.12 versus 5.82, p<0.001).
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Barsuk, D, Ziv, A, Lin, G*, et al.* (2005). "Using advanced simulation for recognition and correction of gaps in airway and breathing management skills in prehospital trauma care.[see comment]." Anesthesia & Analgesia **100**(3): 803-9.

Notes
Barsuk,2005, p803
EVIDENCE=Support
LOE= 3
QUALITY=Fair
COMMENTS
72 physicians in the first year of their internship and having ocmpleted a formal 2-day ATLS course within the previous year were allocated to either the pre-intervention or intervention groups as described below. (no diff in the participants in either group with respect to time since completing the ATLS course).
Pe-intervention Group (n=36) = simulated training in prehospital trauma scenarios followed basic training in airway and breathing management. Scenarios were (1) severe chest trauma and (2) severe head trauma - both required orotracheal intubation. Intervention group (n=36) = 45 min of simulative training in airway management using the Air-Man simulator were added to the second phase of the study before performing the study scenarios. The content of training was based on common mistakes performed by participants of the Preintervention group. The High Fidelity Patient Simulator (HFPS) (Meti, Sarasota, FL), the Sim-Man simulator (Laerdal, Norway), and AirMan were used. Results: Significant improvement in performance for three items common to both scenarios: use of medication during intubation, cricoid pressure application, and holding of the orotracheal tube during fixation. Administration of O2 improved but not sig (p=0.06).
Conclusions: "The incorporation of the airway and breathing training was followed by changes in performance during advance simulation, mainly a more frequent incidence
of cricoid pressure application and use of medications to facilitate orotracheal intubation." Changes in the ATLS curriculum to include the addition of a specially designed airway management training station had been previously recommended.
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Bruce, SA, Scherer, YK, Curran, CC*, et al.* (2009). "A collaborative exercise between graduate and undergraduate nursing students using a computer-assisted simulator in a mock cardiac arrest." Nursing Education Perspectives **30**(1): 22-7.

Notes
Bruce,2009, p22
EVIDENCE=Knowledge=Support; Confidence=Neutral; Skills=Neutral;
LOE= 4
QUALITY=Poor
COMMENTS
n=11 graduate research students - all BLS trained and 46% ACLS certified. Intervention = Pre and post testing Intervention was (1) Knowledge=10MCQs re AHA(2005) guidelines (2) Confidence = 16items scored1-5 (3) Competence=25-item student competency (performance) scale, testing assessment, diagnosis, treatment and resource management (4) Evaluation=12-items scored 1-5 + 4 open-ended questions. Knowledge scores increased from pre to

post tests (p<0.001) No diff in confidence levels pre and post, p=0.177), Total scores for correct skills performance on the competency scale improved from the first simulation to the second - but no sig diff (p=0.62); positive evaluation of the experience (mean=4.2).

Campbell, DM, Barozzino, T, Farrugia, M*, et al.* (2009). "High-fidelity simulation in neonatal resuscitation." Paediatrics and Child Health **14**(1): 19-23.

Notes
Campbell,2009, p19
EVIDENCE = Neutral (Knowledge); Support(skills assessed on manikin + satisfaction)
LOE= 1 (Pilot study)
QUALITY=Poor
COMMENTS
Small sample size (n=15) makes this an underpowered study - which could explain the lack of statistical significance (type 2 error) for some of the outcomes (eg differences in pre- and post-written evaluation scores). The authors suggest that the statistically significant lower number of redirections from the instructors required in the 'high-fidelity' group during the megacode, "suggests that the computerised visual and auditory provided by the 'hi-fi' mannequin improved learner-response time and seemed to promote independent decision-making during both megacode scenarios." This may be over-interpretation of the results - given the small sample size.

Cavaleiro, A, Guimaraes, H and Calheiros, F (2009). "Training neonatal skills with simulators?" Acta Paediatrica, International Journal of Paediatrics **98**(4): 636-639.

Notes
Cavaleiro,2009, p636
EVIDENCE = Neutral
LOE= 1
QUALITY=Fair
COMMENTS
Large drop-out as the study progressed from an initial 115 eligible students, to 55 randomised, to 45 completed. The manikin was 'intermediate-fidelity' and the 'intervention' was only a 30-minute session. A written test of knowledge is not a reliable method of assessing ACLS skills.
There was no correlation between any test result and the students' 5th year paediatrics grades.
The authors' conclusion that "Simulation-based training of medical students in management of neonatal resuscitation does not lead to significant differences on short-term knowledge comparing with traditional method" is probably over-reaching given that the intervention was a one-off 30min session. .

Cherry, RA, Williams, J, George, J*, et al.* (2007). "The effectiveness of a human patient simulator in the ATLS shock skills station." Journal of Surgical Research **139**(2): 229-35.

Notes
Cherry,2007, p229
EVIDENCE= Knowledge-Neutral; Skills-Neutral
LOE= 1
QUALITY=Good
COMMENTS
Students were randomized into two groups: the control (CTL) group, in which the HPS was not used in the shock skills station and the students were taught in a traditional manner using ATLS approved teaching adjuncts, and the experimental (EXP) group, in which the instructor incorporated the METI (Medical Education Technologies, Inc., Sarasota, FL) Human Patient Simulator (HPS) as the sole teaching adjunct for the shock skills station. (The METI is a computer-controlled mannequin that demonstrates pre-programmed physical findings.) Outcome measures: Knowledge- 20 item MCQ pre and post; Skills- objective structured clinical examinations (OSCEs). The instructors facilitating the shock-related OSCE were blinded as to which students were in the EXP group. A professional actor was hired to serve in the role of patient. No diff between groups in change in MCQ scores pre- and post-test (p=0.807). The relative case scores were equivalent between the CTL (74.5+/- 15.0) and EXP(67.4+/- 15.1) groups (p= 0.124). There was no difference in the distribution of performance ratings between those who had exposure to the HPS and those who did not. The overwhelming majority of students exposed to the HPS (91%) rated the shock skills station as very good to excellent versus those who did not use it in the course(63%).

Christenson, J, Parrish, K, Barabe, S*, et al.* (1998). "A comparison of multimedia and standard advanced cardiac life support learning." Academic Emergency Medicine **5**(7): 702-8.

Notes
Christenson,1998, p702
EVIDENCE=Knowledge-Neutral; Skills on manikin-Support
LOE= 2
QUALITY=Fair
COMMENTS
Non-randomised allocation of final year medical students to either the AHA/Actonics ACLS Multimedia Learning System AHA (n=75 MM) or the ACLS 'standard training' (n= 38 ST). All students BCLS trained within previous year. ST = 2-day course, there were 12 hours of instructional time and 4 hours of formal evaluation combined with independent review. Included theory, demonstration, practice and evaluation. Outcomes measured: (1) knowledge: 50-question multiple-choice examination was administered. (2) Mock arrest performance - 4 domains scored 1-5 with max score 20; (3) blind evaluation of videotape of mock-arrest; (4) %students needing re-evaluation; plus (5)student evaluation of learning. No sig diff in knowledge (MCQ test) or the on-site mock arrest evaluation. In the blinded mock arrest evaluation from the videotapes, the ST group achieved slightly higher and statistically significant scores (p=0.024). Forty-seven percent of students in the MM group vs 24% in the ST group (p < 0.02) required multiple attempts to successfully complete the mock arrest evaluation. The authors suggest that the fact that "the only exposure to an actual defibrillator for MM students was a 30-minute orientation just prior to the evaluation: could explain the increased need for multiple attempts in the MM group. It is recommended that "To reduce the number of re-evaluations and increase student satisfaction, the course must include some hands-on experience with a defibrillator and some experience with managing mock arrests under instructor supervision." Limitations: Non-randomised allocation - possible selection bias. Marking scheme for mock arrest not formally evaluated.
REVIEWER CONCLUSION
The more realistic 'standard training' compared to the multi-media training did not improve knowledge but it did improve skills performance in a mock cardiac arrest.

Curran, VR, Aziz, K, O'Young, S*, et al.* (2004). "Evaluation of the effect of a computerized training simulator (ANAKIN) on the retention of neonatal resuscitation skills." Teaching & Learning in Medicine **16**(2): 157-64.

Notes
Curran,2004, p157
EVIDENCE= Neutral (Knowledge, skills and confidence)
LOE= 1
QUALITY=Poor
COMMENTS
Initial on-site NRP training (using non-intrumental mannikin) and certification. 4-months later 60 3rd year medical students (Newfoundland, Canada) were randomised to either (Exp) the "ANAKIN" system - which encompasses a manikin simulator that is integrated with a computer-based assessment program and videoconferencing technology or (Crl) viewing a NRP training video - then both groups re-assessed at 8-months post NRP. NO explanation of statistical analysis in the Methods Section and only within group results detailed. The main purpose of this study was to evaluate the effectiveness of the ANAKIN system as a means for updating and assessing the neonatal resuscitation skills of neonatal resuscitation providers. Outcome Measures: NRP megacode performance Checklist-131 items= measured initially (post NRP) and at 8-months; Knowledge: 27 item MCQ; Self-rated confidence scale - 15 items rated 1-5; Satisfaction scale - 20 items rated 1-5. Results: Experimental study group did score higher than the control group on Performance Score 2 - but the diff was not significant; Knowledge deteriorated at 4-months and not improved with either 'booster' intervention; students positive about using the ANAKIN system. Confidence scores initially increased (in both groups) from immediately before to immediately after the booster intervention (at 4-months) - but deteriorated by 8 months. No relationship between knowledge and performance scores, not between confidence and performance. Conclusion: Neither the ANAKIN nor the video were effective in maintaining the skill level of the students to the level that they had achieved immediately following the initial NRP course.
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Donoghue, AJ, Durbin, DR, Nadel, FM*, et al.* (2009). "Effect of high-fidelity simulation on Pediatric Advanced Life Support training in pediatric house staff: a randomized trial." Pediatric Emergency Care **25**(3): 139-44.

Notes
Donoghue,2009, p139
EVIDENCE=Support
LOE= 1
QUALITY=Fair
COMMENTS
PGY1-2 paediatric residents at 3 tertiary children's hospitals (n=51). Randomisation within study site and PG level using block-randomisation to high-fidelity (SIM) or standard mannequin groups (MAN). Unblinded RCT. All sessions at all 3 sites were conducted by the same investigator. All 3 phases of the intervention, ie PRE-didactic session- POST, were completed within 90minutes. The only difference between the groups was the 'fidelity' of the manikin used. All sessions were videorecorded by 2 simultaneous webcam feeds, one of which was synchronized to the simulator event log and debriefing software (SimBaby Debrief Viewer, Laerdal). A scoring instrument was designed by investigator consensus that granted a maximum score of 2 points for each critical task. Points could be deducted if tasks were done incorrectly, in the wrong sequence, or after an unacceptable amount of time had elapsed. No significant differences in baseline resuscitation, procedural, or mock code experience between SIM and MAN groups. The PRE phase scores were similar for both groups. The POST phase scores were higher in the SIM group compared with the MAN group, but not statistically sig. The improvement in scores between PRE and POST phases was significantly greater in the SIM group (11.1 [1.8] vs. 4.7 [1.7], P = 0.007). The authors concluded "Our results suggest that residents experiencing high fidelity simulation perform cognitive and decision-making tasks more accurately than those using less realistic models.".

Dunning, J, Nandi, J, Ariffin, S*, et al.* (2006). "The Cardiac Surgery Advanced Life Support Course (CALS): delivering significant improvements in emergency cardiothoracic care." Annals of Thoracic Surgery **81**(5): 1767-72.

Notes
Dunning,2006, p1767
EVIDENCE=Support
LOE= 4
QUALITY=Fair
COMMENTS
Before-after training study. Two courses of 12 participants (11nurse practitioners, 8 senior house officers, 4 registrars, and 1 consultant from a total of 6 UK cardiothoracic
units participated) - to teach management of critically ill (including cardiac arrest) in cardiothoracic surgical patients . Intervention = 'High-fidelity simulation' using mannikin (Resusci Anne, Laerdal Medical Corp)= intubated, central lines, chest drains, urinary catheters and syringe drivers + A laptop computer with an intensive care monitor simulator program was used to present real time clinical data + trainer presented the case, ran the laptop computer, and gave any clinical data if requested. Outcome=Time to successful definitive treament based on (blinded) assessment of videotaped performance in patient scenarios. Four precourse and 4 postcourse cardiac arrest scenarios (VF or asystole) conducted. "Despite the small numbers of scenarios conducted, there was a highly significant difference between the two groups in the time taken to reach all significant objectives after cardiopulmonary resuscitation had been initiated" (Time to CPR not sig diff, p=0.114). "Times to successful chest reopening and internal cardiac massage were also significantly improved in cardiac arrest patients: (451 secs [SD 39 secs] precourse and 228 secs [SD 17 secs] postcourse; p = 0.011)."
Limitation: No control group - so improvements could have been seen even if lower-fidelity intervention used - given that the intensive nature of the course (3 days).

Fabius, DB, Grissom, EL and Fuentes, A (1994). "Recertification in cardiopulmonary resuscitation. A comparison of two teaching methods." Journal of Nursing Staff Development **10**(5): 262-8.

Notes
Fabius,1994, p262
EVIDENCE=Knowledge-Neutral; Skills-Neutral
LOE= 1
QUALITY=Poor
COMMENTS
Difficult to determine the details of the intervention and testing what is written in the paper. ? Text missing on p266 re pass rate.
Results: More time spent using computer method vs traditional method (3.6 vs 2.4hours, p<0.001); Satisfaction higher in the traditional group than the computer group (p<0.05) but instructors more satisfied with the computer method

(p<0.001). Pass rate higher for the computer than the traditional methods group 6% vs 34% (p<0.001) - but no diff in performance scores (not provided in paper); No diff in pre/post test scores between groups (both improved). n=54 re-evaluated at 6-months-no sig diff in retention of skills tested - only one participant in each group passed. No sig diff in skills performance scores between medical-surgical versus critical care nurses.
Conclusion (author): The traditional method of instruction is a more time- and cost-efficient method of recertifying staff in CPR as compared to the computerized interactive videodisc course.
Limitation: Unequal instructor/student ration: 1:3 traditional versus 1:2 computer - should have favoured the computer method

Friedman, Z, You-Ten, KE, Bould, MD*, et al.* (2008). "Teaching lifesaving procedures: the impact of model fidelity on acquisition and transfer of cricothyrotomy skills to performance on cadavers." Anesth Analg **107**(5): 1663-9.

Notes
Friedman, 2008, p1663
EVIDENCE = Neutral (skills)
LOE= 1
QUALITY= Fair
COMMENTS
Aim: The purpose of this study was to compare cricothyrotomy skills acquired on a simple and inexpensive model to those learned on a high fidelity simulator using valid evaluation instruments and the transfer of these skills to human cadavers.
Method: pretest cricothyrotomy on embalmed adult human cadavers videotaped and then followed by 20-min instructional video on the performance of cricothyrotomy and didactic presentation. Subjects then randomised to either the high fidelity group (n= 11): subjects performed two cricothyrotomies on a full-scale Sim-Man (Laerdal) simulator with an anatomically accurate larynx, for airway management and cricothyrotomy. The low fidelity group (n = 11) consisted of subjects performing two cricothyrotomies on a low fidelity model, a 20-cm piece of corrugated anesthesia tubing. Within 2 wk of the training session all subjects performed a second cricothyrotomy post-test on a cadaver. The post-test sessions were videotaped and graded by two blinded examiners (staff anesthesiologists) using a three-point task specific checklist (CL), a global rating scale (GRS) and time taken to perform the cricothyrotomy.
Results: There was no significant difference in the change from pretest to posttest cricothyrotomy performance (primary outcome) between the low-fidelity and high-fidelity model groups as evaluated by the CL, GRS, and time to completion of procedure (all p= NS)
Limitations: Despite a power analysis being provided - the sample size is small and there is a risk of a type II error (fail to reject the null hypothesis when it is false).

Hall, RE, Plant, JR, Bands, CJ*, et al.* (2005). "Human patient simulation is effective for teaching paramedic students endotracheal intubation." Acad Emerg Med **12**(9): 850-5.

Notes
Hall,2005, p850
EVIDENCE=Neutral
LOE=1
QUALITY=Good
COMMENTS
36 paramedic students with no prior experience or training in endotracheal intubation were randomised to one of two methods for the practice of intubation. All students received the same initial didactic and mannequin airway training during their paramedic curriculum. The SIM group received ten hours of instruction on a human patient simulator (version 6.1; Medical Education Technologies Inc., Sarasota, FL) - with an average of 50 intubations performed on the simulator. The control group received the current local standard of 15 training intubations in the OR. Power analysis included. GEE model used to take into account the correlation among outcomes by specifying the cluster unit (each student tested on 15 OR intubations).- with robust estimation to account for the intracluster correlation. The study groups were well matched for demographics and predictors of airway difficulty. All students received a formalized test of 15 patient intubations in the OR. Test intubations were performed on 540 patients. Results: Overall intubation success rate was 87.8% in the SIM group and 84.8% in the OR group, with a difference of 3.0% (95% CI = -4.2% to 10.1%). The success rate on the first attempt was 84.4% in the SIM group and 80.0% in the OR group, with a difference of 4.4% (95% CI = -3.4% to 12.3%). The mean time to successful intubation was 47.2 seconds in the SIM group and 43.0 in the OR group, with a difference of 4.2 (95% CI =-0.5 to 8.8).

Conclusions (Authors) When tested in the OR setting, paramedic students trained to intubate on a human patient simulator are as effective as students trained on human subjects. The results failed to show a significant learning curve, because the success rates were consistent throughout the 15 intubation attempts. This suggests that both simulator and OR training led to sufficient acquisition of ETI skills before OR testing.
Limitations: assessors not blinded to training method. Very few paediatric patients. Translation of skills to prehospital environment not tested - however one assumes that students would be more familiar with the prehospital environment than the OR.

Hoadley, TA (2009). "Learning advanced cardiac life support: a comparison study of the effects of low- and high-fidelity simulation." Nursing Education Perspectives **30**(2): 91-5.

Notes
Hoadley,2009, p91
EVIDENCE = Neutral
LOE= 1 (RCT)
QUALITY= Poor
COMMENTS
Methods: RCT (method of randomisation not stated) of the effect of using a High-Fidelity Simulation Manikin (HFS) (experimental group) versus a Low-Fidelity Simulation Manikin (LFS) (control group) on resuscitation knowledge, skills and student satisfaction/confidence during the teaching of an AHA ACLS course for health care professionals. Total n=53 (HFS=29; LFS=24). No Power calculation. Outcomes: (1) resuscitation knowledge - measured using the AHA ACLS test (?written); (2) ACLS Skills - measured using the AHA ACLS Mega Code Performance Score Sheet; (3) Student preferences regarding simulation - as measured using the National League for Nursing (NLN) Simulation Design Scale; (4) Student satisfaction with learning and Self-confidence in their ability to care for patients - as measured by the NLN Student Satisfaction and Self-Confidence in Learning Scale. No sig diff between HFS and LFS in terms of demographic characteristics, work experience or pre-course knowledge.
Intervention: For students participating in the LFS course, the AHA instructors provided all the information required to resuscitate the manikin: vital signs, heart tones, breath sounds, and a description of the patient's overall condition. Students participating in the HFS course gathered all the same assessment data, but this information came from the manikin and its monitoring devices. (No details are provided about the make or model of the manikin)
Results: No sig diff in ACLS knowledge posttest scores (HFS mean score =90.34 vs LFS mean score 87.67, p=0.26). (A paired t-test would have been more appropriate to use to test the change in knowledge pre-test to post-test - given that an ACLS pre-test had been done.) No sig diff in resuscitation skills; satisfaction with simulation method used, overall student satisfaction or self-confidence.
Conclusion: Small study that failed to demonstrate any difference in student outcomes in an AHA ACLS course that used a computerised high-fidelity manikin compared to a low-fidelity manikin.

Iglesias-Vazquez, JA, Rodriguez-Nunez, A, Penas-Penas, M*, et al.* (2007). "Cost-efficiency assessment of Advanced Life Support (ALS) courses based on the comparison of advanced simulators with conventional manikins." BMC Emerg Med **7**: 18.

Notes
Iglesias-Vazquez, 2007, p18
EVIDENCE = Neutral (skills and knowledge and cost)
LOE= 1
QUALITY= Fair
COMMENTS
Aim: to assess the impact of the introduction in ALS courses of last-generation simulation system in terms of cost-effectiveness.
Method: 250 ALS course participants (nurse and doctors) randomised to low-fidelity (n=125) ALS manikins and (n=125) to high-fidelity (SimMan) mannequins. The duration of the course was 20 hours over four days (5 hours/day) with a ratio of lectures to practical sessions of 1:1 (practical tests not included). Candidates of both groups were similar in terms of age, sex, previous training and employment status. Assessment involved skill stations and test scenarios and written test. Cut-off point to pass written test was 85%.
Results: In group A (conventional training) 98 students (78%) passed and 27 (22%) failed the course. In contrast, in group B (new simulator training) 110 students (88%) passed and 15 (12%) failed the course (p = 0.06). Cost higher for the courses with the high-fidelity mannequins.

Conclusion: (from paper) New medical simulation systems are effective training tools for ALS courses but they are not worthwhile, in terms of cost, when compared to ALS courses based on conventional manikins.
Limitations: Retention of skills not considered.

Kaczorowski, J, Levitt, C, Hammond, M*, et al.* (1998). "Retention of neonatal resuscitation skills and knowledge: a randomized controlled trial." Fam Med **30**(10): 705-11.

Notes
Kaczorowski, 1998, p705
EVIDENCE = Knowledge (Neutral); Skills (Neutral)
LOE= 1 (RCT)
QUALITY= Fair
COMMENTS
N=44 Family Practice Residents who had successfully passed the NRP course were randomised to one of three groups (1) 'video' (n=13) : 3-5 months after NRP viewed a 26-min video review of the NRP course plus unsupervised mannequin practice; (2) 'hands-on' (n=14) : 3-5 months after NRP received supervised hands-on practice booster training sessions with mannequins, including correction of errors by supervisor; (3) control group (n=17): no booster sessions.
Follow-up evaluation at 6-8months post NRP.
Assessment of a) Knowledge (NRP written exam) and b) clinical skills (performance checklists) using 5 scenarios. Skills were identified apriori as either 'life-saving' or 'life-supporting'.
Results: No diff between groups in knowledge scores or performance scores
Knowledge and skill degradation at the time of re-testing for all participants. Some differences in group performance for specific scores in individual scenarios - however such sub-group analyses do not appear to have planned a priori.
Small samples in each group.

Kim, JH, Kim, WO, Min, KT*, et al.* (2002). "Learning by computer simulation does not lead to better test performance than textbook study in the diagnosis and treatment of dysrhythmias." Journal of Clinical Anesthesia **14**(5): 395-400.

Notes
Kim,2002, p395
EVIDENCE=Oppose
LOE= 1
QUALITY=Fair
COMMENTS
RCT (n=57) to compare computer-based simulation with textbook study on ACLS knowledge. Test scores in pretest similar in both groups- both improved immediately after study period (second test) but greatest in the TB group. After one week (third test), scores were lower than second test, and no diff between the two groups .

Knudson, MM, Khaw, L, Bullard, MK*, et al.* (2008). "Trauma training in simulation: translating skills from SIM time to real time." Journal of Trauma-Injury Infection & Critical Care **64**(2): 255-63; discussion 263-4.

Notes
Knudson,2008, p255
EVIDENCE= Knowledge-Neutral; Performance-Neutral (only 'Teamwork' supportive)
LOE= 1
QUALITY=Fair
COMMENTS
One of only a few studies that attempts to measure the effect of simulation training on actual performance in real emergency situations. 18 surgical residents recruited - randomised to receive training management training either a) Experimental group = Trauma curriculum (5 x 2hours = 10 hours total over > 5 weeks) scenario-based delivered with the use of a human performance simulator (SIM) = SimMan (Laerdal) or b) Control group = Trauma curriculum (5 x 2hours = 10 hours total over > 5 weeks) delivered in scenario-based didactic lecture (LEC) - with Q&A session. Outcome measures = (1) Knowledge: Written test; (2) Performance in trauma resuscitations (video-taped in ED - first 4 resuscitations); (3) Evaluation Form. Results only available for 10 residents (4 resuscitation events each). "The vast majority of the residents had positive comments regarding the value of the training in preparing them for their leadership role on the trauma team. Those who were exposed to simulation reported an overall feeling of realism". No diff between groups in a) Written posttraining test 65%(LEC) vs 66% (SIM). For actual performance in trauma resuscitations: a) No sig

diff between SIM vs LEC groups in initial treatment skills (71+/-15 vs 68 +/- 15 - p=0.48) overall - or nor in critical care areas; b) No sig diff overall in crisis management skills (83+/-17 vs 74 +/- 22 - p=0.14 but the SIM group scored consistently higher in all three categories (teamwork, decision making, and situation awareness). The most pronounced difference was in the area of teamwork where SIM residents averaged 15% higher with a p value of 0.04. However, the IRR (Interrater reliability) coefficients between the judges in grading behavioural skills were low (range 0.20 – 0.42). Nil sig diff identified between LEC and SIM on performance scores using multivariate analysis. Non-significant results may be due to small sample size. This appears to be an ongoing study.

Kory, PD, Eisen, LA, Adachi, M*, et al.* (2007). "Initial airway management skills of senior residents: simulation training compared with traditional training." Chest **132**(6): 1927-31.

Notes
Kory,2007, p1927
EVIDENCE = Support
LOE= 3 (non-concurrent and non-active comparison group), prospective cohort study
QUALITY=Fair
COMMENTS
Airway Management Skills ONLY
The comparison groups (ie, ST and TT groups) were from two different calendar years so that contemporaneous skill testing was not possible, since both were undertaken in the PGY3 necessitating testing in two consecutive years.
Sim Man (Laerdal) used for training (ST group only) and assessment (ST and TT groups). Since the simulation-trained (ST) group was trained and assessed on the same manikin - which could potentially contribute to the enhanced performance. No video recording or inter-rater reliability of scoring was undertaken - however in a previous similar study by the same group (Mayo,2004) blinded video-based scoring of resident performance produced identical results as consensus observational scores.

Levitan, RM, Goldman, TS, Bryan, DA*, et al.* (2001). "Training with video imaging improves the initial intubation success rates of paramedic trainees in an operating room setting." Ann Emerg Med **37**(1): 46-50.

Notes
Levitan, 2001, p46
EVIDENCE = Support
LOE= 3
QUALITY= Fair
COMMENTS
The hypothesis of this study was that training with video imaging of 'real life' laryngoscopy, in addition to traditional didactic and mannequin instruction, would improve the success rates of paramedic trainees during their initial operating room intubations. Groups did not differ with respect to age, gender, or level of education.
Comparing the traditional group with the video group, the difference in success rates was statistically significant ($P \leq .0001$; 46.7% versus 88.1%, difference 41.4%, 95% CI 31.1% to 50.7%). The groups also differed in the mean number of laryngoscope insertions per trainee: 6.99 in the traditional group and 2.8 in the video group.
Conclusion: Video imaging, unlike mannequins or line drawings, allowed novices to observe the appearance of critical landmarks on real patients and appears to have enhanced skill acquisition.
Limitations: Retrospective control group; Performance in the OR may not necessarily translate to the pre-hospital emergency scenario.

Marshall, RL, Smith, JS, Gorman, PJ*, et al.* (2001). "Use of a human patient simulator in the development of resident trauma management skills." Journal of Trauma-Injury Infection & Critical Care **51**(1): 17-21.

Notes
Marshall,2001, p17
EVIDENCE=Support (Skills and confidence)
LOE= 4
QUALITY=Fair
COMMENTS
The trauma management skills of 12 surgical interns were tested before and after completing an ATLS course plus exposure to a computerised human patient simulator and compared to senior surgical residents who were ATLS certified. Trauma management skills were evaluated in three areas: critical treatment decisions (CTD), potential for adverse

outcomes (PAO), and team behavior (TB). Performance in each category was scored from 1 (poor) to 5 (excellent). "The interns' CTD performance scores rose 24% after ATLS/HPS (p =0.002). Their PAO performance scores increased 25% after ATLS instruction (p =0.001), and there was a 47% increase in the interns' TB score after ATLS (p =0.001)." The controls, the senior surgical residents, outperformed the surgical interns in all three management areas.
Conclusion: The use of the HPS in conjunction with ATLS improved the development of trauma management skills and self-confidence in surgical interns. It is possible that the skills would have improved with the ATLS course alone. .

Mayo, PH, Hackney, JE, Mueck, JT*, et al.* (2004). "Achieving house staff competence in emergency airway management: results of a teaching program using a computerized patient simulator.[see comment]." Critical Care Medicine **32**(12): 2422-7.

Notes
Mayo,2004,p2422
EVIDENCE = Support
LOE= 1 (Skills performance on manikin): LOE=4 (Skills performance in real arrests)
QUALITY= Fair - Poor
COMMENTS
Airway Management Skills ONLY
SimMan (Laerdal) was used for training and testing (intermediate/high-fidelty simulation),
The immediate training interns (IT) showed a statistically significant difference (improvement) in 6 out of 7 of the essential steps in airway management and 3 out of 4 of the non-essential steps - when compared to the delayed training interns. Significantly more IT interns achieved a perfect total score on second testing than did the IT group on second testing (80% versus 0%, p<0.001). Informal assessment of the interns' clinical performance in real arrests was undertaken in the 10months following their airway training. The authors state: Direct observation of interns in actual initial airway events revealed excellent clinical performance. However - this only involved 41/50 of the interns and since the assessor was actually part of the resuscitation team - the validity of the assessment could be questioned and there was no comparison group.
Small (n=50) single-centre study.

Miotto, HC, Couto, BR, Goulart, EM*, et al.* (2008). "Advanced Cardiac Life Support Courses: live actors do not improve training results compared with conventional manikins." Resuscitation **76**(2): 244-8.

Notes
Miotto, 2008, p244
EVIDENCE = Neutral (knowledge)
LOE= 1
QUALITY= Fair
COMMENTS
Aims:The primary purpose of the present study was to determine whether the use of live actors to create realistic scenarios could improve knowledge retention. The secondary
purpose was to determine if medical specialty, sex, work at hospital facilities, age, and time since graduation from medicine or nursing affected knowledge retention.
Methods: 19 ACLS courses were divided at random into two groups: group A (ACLS courses with conventional manikins plus live actors), and group B (ACLS courses with conventional manikins). Before and immediately after the courses, participants answered 33 multiple choice questions (pre-test and posttest, respectively) to assess their baseline knowledge and their improvement with training. Six months after the course, the participants completed another test with 33 multiple choice questions (final-test) to evaluate their
knowledge retention. 225 participants (51.7%; 111 in group A and 114 in group B)
Results: On univariate analysis, the use of live actors, medical specialties, and sex did not affect pre-test, post-test, and final-test results (p > 0.1). Age and interval since graduation both had a negative correlation with test scores.
Conclusions: The use of live actors to increase scenario realism does not improve knowledge retention.
Limitations: Large drop out in both groups - originally 435 participants. Only knowledge assessed - not skills

Owen, H, Mugford, B, Follows, V*, et al.* (2006). "Comparison of three simulation-based training methods for management of medical emergencies." Resuscitation **71**(2): 204-11.

Notes

Owen,2006,p204
EVIDENCE= Knowledge (Neutral); Confidence (Neutral); Skills on manikin (Support)
LOE= 1
QUALITY=Fair
COMMENTS
The null hypothesis under test was that there was no effect of high fidelity versus lower fidelity technology used during training on student learning outcomes. All participants had a ‘pre-training’ assessment on entering the study, the same total duration of teaching and then a ‘post-training’ (exit) assessment. Assessors blind to group allocation; Post-training assessment scheduled for 3-weeks after last training session. Group 3 showed significantly higher scores (p = 0.047) in the VT-post scenario and performed significantly better than the other groups in the ANAphylaxis scenario (p = 0.012) - which was a 'new challenge'. No difference between the performance of Groups 1 and 2 so the authors conclude that using a whole body manikin is not necessarily better than a smaller, simpler part-task trainer. .

Rodgers, DL, Securro, S, Jr. and Pauley, RD (2009). "The Effect of High-Fidelity Simulation on Educational Outcomes in an Advanced Cardiovascular Life Support Course." Simulation in Healthcare **4**(4): 200-206

Notes
Rodgers, 2009, p200
EVIDENCE= Support
LOE= 2
QUALITY=Fair
COMMENTS
A non-randomised comparative study of the effect of the inclusion of high-fidelity versus low-fidelity mannequins on learning outcomes in nursing students in a 2-day AHA ACLS provider course. Both groups were taught using the same mannequin (SimMan, Laerdal Medical, Stavanger, Norway) but in the high-fidelity group all features of the simulator were activated and accessible to the subjects, with subjects having to acquire all clinical information needed for completion of scenarios from the simulator. In contrast, the low-fidelity group the high-fidelity modality was not activated on the mannequins and subjects were reliant on obtaining a significant portion of the clinical information needed for the scenario by asking questions of the ACLS Instructor (except ECG). After final evaluation scenarios, all subjects had an additional skills performance video recorded. These scenarios were performed with the simulator fully activated for both groups (the low-fidelity group were given an orientation to the high-fidelity components of the mannequin) A panel of three expert raters scored each subject using a modified ACLS Mega Code Performance Score Sheet - modified for use in this study by changing the item responses from yes/no responses to a range response from 1 being not competent to 7 being highly competent. Overall team leader performance and team functioning also assessed. The ACLS Written Examination was used as a written pretest and posttest instrument. The expert raters were blinded to group assignment. No sig diff in drop-out rates in both groups (2 versus 1).
Results: The Mann-Whitney U mean rank score for the low-fidelity mannequin group was 44.34 and for the high-fidelity simulation group was 59.55 (p = 0.010, z =2.592). Neither group performed significantly better than the other on the posttest (p=0.447). However, when comparing the amount of improvement in pretest with that of the posttest scores, the high-fidelity simulation group’s cognitive knowledge improvement was statistically significant over the low-fidelity mannequin group, t(32) =3.348, p= 0.002. Although all 14 items scored higher for the high-fidelity simulation group, nine items indicated statistically significant differences between the groups that favored the high fidelity simulation group.
Conclusions: (from paper) "The results supported the hypothesis that students who use high-fidelity patient simulators achieve better competence as demonstrated in post intervention skills assessments graded by an expert rater, when compared with students who used low fidelity mannequins in an AHAACLS program." At the item level, the data indicate that the use of lower fidelity mannequins maybe as efficacious as higher fidelity mannequins in teaching basic level resuscitation skills. However, as the situation evolved and became more complex, the high-fidelity simulation group was viewed as being significantly more knowledgeable and capable on managing the scenario.
Limitations: The two groups were not equivalent at base-line: mean pre-test score was higher for the low-fidelity mannequin group(72, SD=9.6) than the high-fidelity group (61.5, SD=10.82), p=0.005 - possibly due to lack of random allocation and small sample size. However, despite this the high-fidelity group showed a greater level of improvement than the low-fidelity group in the pre-test to post-test scores. No other significant differences between the groups were identified. Other limitations : single training centre; nursing students only; small sample; high-fidelity group had more practice with the high-fidelity simulator prior to testing; does not address knowledge and skill retention.
OUTCOMES: ACLS Skills assessed on mannequin; Knowledge; Teamwork/Leadership.

Rosenthal, ME, Adachi, M, Ribaudo, V*, et al.* (2006). "Achieving housestaff competence in emergency airway management using scenario based simulation training: Comparison of attending vs housestaff trainers." Chest **129**(6): 1453-1458.

Notes
Rosenthal,2006, p1453
EVIDENCE = Support
LOE= 4
QUALITY=Fair
COMMENTS
Airway Management Skills ONLY
A RCT comparing the a critical care attending (?staff specialist) to a house staff team in training medical interns in initial airway management skills using a computer-controlled patient simulator (CPS) and scenario-based simulation training (SST) on airway management skills. ALL intern participants received computer-controlled patient simulator (CPS) and scenario-based simulation training (SST) - so this study has no comparison/control group to assess the efficacy of simulation. As such it is a LOE=4 (no comparison group) to assess the worksheet question. The authors state that during the 10 months following airway training, intern performance of the essential steps of initial airway management was excellent in actual clinical events involving 79 events performed by a total of 42 different interns. However all assessments were performed by the training physician and no validation of assessment was possible . In addition, no intern was unassisted in their airway management - so 'excellent performance' may have been attributed to working well within a team rather than individual skills.
.

Schwartz, LR, Fernandez, R, Kouyoumjian, SR*, et al.* (2007). "A Randomized Comparison Trial of Case-based Learning versus Human Patient Simulation in Medical Student Education." Academic Emergency Medicine **14**(2): 130-137.

Notes
Schwartz,2007, p130
EVIDENCE = Neutral
LOE= 1
QUALITY= Good
COMMENTS
This was a prospective, randomized study comparing performance on an ACS OSCE between students taught with CBL classroom instruction and HPS. CBL and HPS sessions similar in content. The groups were well balanced in respect to mean age, percent male, specialty training preference, experience with cardiac arrest, or self-rated learning style. No sig diff overall and no sig diff for Cardiac arrest management subscale (8 items) 6.5 (1.3) 7.0 (1.2) -0.5 (-1.0, 0.02). The authors proffer that "Our study offered students an opportunity to practice medicine in a realistic environment with expert feedback but did not allow for repetition or the opportunity to improve their performance. Participants experienced only one ACS-based scenario followed by debriefing. They did not have the opportunity to try different techniques and reinforce learned material." and suggest that "this may explain why our HPS training intervention did not result in superior performance when compared with traditional didactic training."

Schwid, HA, Rooke, GA, Ross, BK*, et al.* (1999). "Use of a computerized advanced cardiac life support simulator improves retention of advanced cardiac life support guidelines better than a textbook review." Critical Care Medicine **27**(4): 821-4.

Notes
Schwid,1999, p821
EVIDENCE = Support
LOE= 1
QUALITY= Good
COMMENTS
RCT comparing the effect of a computer program (ACLS Simulator 3.11) that uses 'photo-realistic' images, animated graphics, and a de-briefing system) with printed ACLS materials (textbook) on the retention of ACLS skills (as measured using a videoed Mega Code mock resuscitation examination - total point score and 'pass/fail') in anaesthetic residents. Assessors blinded to group allocation. No sig diff in characteristics of the groups: in residency clinical skills ratings;

average time spent studying (although 6 in the textbook group did not study at all). Results are still statistically significantly better for the computer simulator group even when these 6 non-studying subjects were excluded.

Tan, GM, Ti, LK, Tan, K*, et al.* (2008). "A comparison of screen-based simulation and conventional lectures for undergraduate teaching of crisis management." Anaesthesia and Intensive Care **36**(4): 565-569.

Notes
Tan,2008, p565
EVIDENCE = Neutral
LOE= 1 (RCT)
QUALITY=Fair
COMMENTS
No power analysis reported (n=64).
A number of potential biases identified in the Discussion section of the paper - reasonably well countered.
The intervention was only one-hour duration - this is possibly not sufficient to effect a significant difference in outcome.
There was no difference in the overall mean performance score for the anaphylaxis scenario but students in the screen-based simulation scored more highly in the sub-scale relating to 'specific treatment'. The authors claim that this reflects superiority of screen-based teaching for clinical skill teaching - however this is possibly over-interpreting the results.
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Wang, XP, Martin, SM, Li, YL*, et al.* (2008). "Effect of emergency care simulator combined with problem-based learning in teaching of cardiopulmonary resuscitation." Chung-Hua i Hsueh Tsa Chih [Chinese Medical Journal] **88**(23): 1651-3.

Notes
Wang, 2008, p1651
EVIDENCE=Psychomotor skills=Neutral; Support= teamwork
LOE= 1
QUALITY=Fair (unable to assess fully)
COMMENTS
Abstract only in English. Details of the intervention or assessment methods are not discernable from the Abstract. The results suggest that there was no sig effect of the addition of the "emergency care simulator" on psychomotor skills of artificial respiration, external cardiac compression, tracheal intubation, and defibrillation, but there were improvements in 'emergency awareness; and team skills.
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Wayne, DB, Butter, J, Siddall, VJ*, et al.* (2005). "Simulation-based training of internal medicine residents in advanced cardiac life support protocols: a randomized trial." Teaching & Learning in Medicine **17**(3): 210-6.

Notes
Wayne,2005,p210
LOE= 1 (RCT - but no active comparison)
QUALITY= Fair
EVIDENCE=Support
COMMENTS
Method (from paper): A randomised crossover trial of 38 2nd year residents (single academic medical centre USA) who were randomly allocated to either receive the intervention (Group A) or serve as wait-list controls (Group B). Both groups underwent baseline testing after randomization. The intervention group then received four 2-hour simulator practice sessions (using a 'high-fidelity' Human Patient Simulator) while the wait-list control group received no intervention (i.e., performed normal clinical duties). After a second round of testing 3 months later, the control group crossed over and received the educational intervention while the intervention group returned to routine duties. A third round of standardized clinical skills testing was then conducted after 3 months for both groups. Teaching sessions gave groups of two to four residents time to practice protocols and procedures and to receive structured education from simulator faculty. Debriefing allowed the residents to ask questions, review algorithms, and receive feedback. Primary outcome measures were checklist scores - scores were computed as percent correct for each of the simulations and summed across the three simulations randomly assigned to each resident. The total scores thus ranged from 0 to 300. A secondary outcome measure was a course assessment survey completed at the end of the 10-month study period.

<u>Results (from paper)</u>: The figure shows that at baseline, the total ACLS checklist scores for Group A and Group B did not differ significantly. However, after the first educational
intervention, the total ACLS checklist performance for Group A (M = 265.6, SD = 9.5) was 38% higher than the total score for the wait-list control Group B (M = 192.5, SD = 35.9), a highly significant difference, t(36) = –8.58, p < .0001. Following crossover, the second educational intervention, and the third round of simulation-based testing, the total ACLS checklist scores for Group A (M= 256.15, SD = 20.28) and Group B (M= 268.98, SD = 12.63) were very similar yet significantly different on statistical grounds, (t(36) = 2.34, p < .05).
Postcourse questionnaire responses were uniformly high and positive endorsing (1–5 Likert scale M and SD) such statements as "Practice with the medical simulator boosts my clinical skill" (4.82, 0.69); "Repetitive practice using the medical simulator is a valuable educational experience" (4.55, 0.76); and "The medical simulator has helped prepare me to be a code leader better than the ACLS course I took" (4.79, 0.70).
<u>Reviewer Conclusion</u>: Simulator training significantly improved performance in ACLS skills - as assessed on a manikin (same manikin as training was undertaken) - however it is possible that similar results could have been achieved using a lower-fidelity manikin.
.

Wayne, DB, Butter, J, Siddall, VJ*, et al.* (2006b). "Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice." <u>Journal of General Internal Medicine</u> **21**(3): 251-6.

<u>Notes</u>
Wayne,2006b, p251
EVIDENCE = Support
LOE= 4
QUALITY= Fair
COMMENTS
Builds on the work reported in the Wayne(2005) RCT and Wayne(2006a) follow-up study - but ? a different cohort of medical registrars at the same medical centre.
<u>Methods (from the paper)</u>: First, all residents underwent baseline pretesting on a random sample of 3 of 6 ACLS scenarios. Second, the residents received a minimum of 4, 2-hour education sessions with deliberate practice of ACLS events and procedures using a medical high-fidelity simulator.
<u>Results (from the paper)</u>: The pretest to posttest contrasts in overall ACLS performance represents a 24% improvement, a highly significant difference (P<.0001). The need for additional deliberate practice for those who failed to reach the overall mastery standard on the posttest was a powerful negative predictor of posttest performance.
Medical knowledge, measured by USMLE Step 1 and 2 scores, had no correlation with ACLS skill posttest results - nor did pretest skill performance also had no correlation
<u>Comment (from paper)</u>: A key question about this and other simulation-based studies is whether performance in a highly controlled simulator environment will generalize to variable clinical practice settings. This is especially the case for critical yet infrequent clinical events like in-hospital ACLS events.
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Wayne, DB, Didwania, A, Feinglass, J*, et al.* (2008). "Simulation-based education improves quality of care during cardiac arrest team responses at an academic teaching hospital: A case-control study." <u>Chest</u> **133**(1): 56-61.

<u>Notes</u>
Wayne,2008, p56
EVIDENCE = Neutral (patient survival); Support (adherence to AHA standards in real arrests)
LOE= 2 (Case control study)
QUALITY= Fair
COMMENTS
Cases = cardiac arrests WITH an 'adherent ACLS response'; Controls = cardiac arrests WITHOUT an 'adherent ACLS response'. The hypothesis under test is that there is no association between adherence to AHA standards during cardiac arrests and prior ACLS simulator-training.
Limitations: Single centre. Retrospective study design - Multivariate analysis allowed for adjustment for some potential confounders but it is possible that other non-measured factors could be confounding the apparent relationship between simulator-training and adherence to AHA guidelines. Inter-rater reliability established - but still possible that there could have been omissions or errors in chart abstraction. No significant difference in the outcome of the arrests ie immediate event survival or survival to hospital discharge.

Wayne, DB, Siddall, VJ, Butter, J*, et al.* (2006a). "A longitudinal study of internal medicine residents' retention of advanced cardiac life support skills." Academic Medicine **81**(10 Suppl): S9-S12.

Notes
Wayne,2006a, pS9
EVIDENCE = Support
LOE= 4 (no comparison group)
QUALITY = Fair
COMMENTS
Methods (from paper): Longitudinal follow-up study of ACLS skills retention in PGY-2 medical residents who had participated in the earlier Wayne,2005 RCT crossover study involving a high-fidelity simulation based educational intervention.
Results (from paper): Mean checklist scores were very stable from baseline (RCT outcome) to follow-up one (6 months) to follow-up two (14 months). ANOVA showed no statistically significant difference in residents' ACLS performance across the three testing occasions ($p > 0.5$)
Conclusion (Reviewer): The lack of ACLS skills decay in this cohort of junior medical residents contrasts with many other studies that have shown rapid ACLS skills decay without re-training. The findings are supportive of the assertion of the authors that their "educational intervention in ACLS skills using deliberate practice and small group teaching that maintains a high level of performance". Limitations of the study include: small sample size (n=38), no comparison group, single centre, possibility of selection bias in the recruitment of residents to the initial RCT.

References

1. Donoghue AJ, Durbin DR, Nadel FM, Stryjewski GR, Kost SI, Nadkarni VM, et al. Effect of high-fidelity simulation on Pediatric Advanced Life Support training in pediatric house staff: a randomized trial. *Pediatric Emergency Care* 2009;25(3):139-44.
2. Schwartz LR, Fernandez R, Kouyoumjian SR, Jones KA, Compton S. A Randomized Comparison Trial of Case-based Learning versus Human Patient Simulation in Medical Student Education. *Academic Emergency Medicine* 2007;14(2):130-137.