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

**Worksheet author(s)**

| Halamek, Louis Patrick | Date Submitted for review: 12 October 2009 |

**Clinical question:** For healthcare professionals (P), do simulation based learning methodologies (I), when compared to traditional (lectures) training (C), improve the acquisition of content knowledge, technical skills, and behavioral skills required for effective and safe resuscitation (O)?

**Is this question addressing an intervention/therapy, prognosis or diagnosis?** intervention (target population = healthcare professionals)

**State if this is a proposed new topic or revision of existing worksheet.** new topic

**Conflict of interest specific to this question.** I am a: 1) consultant to Laerdal Medical, Inc., and Advanced Medical Simulation, Inc., and a 2) grant recipient of the Laerdal Foundation and the U.S. Agency for Healthcare Research and Quality

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? See above.

**Search strategy (including electronic databases searched).**

**Databases explored:**
- the Cochrane Library for Systematic Reviews
- Medline via PubMed
- AHA Endnote database
- Google Scholar

In addition a manual search of pertinent non-healthcare sources likely to contain seminal works (such as those describing human factors and human performance in high-risk domains such as aerospace, aviation, nuclear power, the military and emergency rescue fields such as rescue swimming, fire fighting, and law enforcement) was conducted to provide appropriate context.

**Keywords (followed by database searched and number of “hits”):**
- simulation AND resuscitation (Cochrane 2, Medline 454, Google Scholar 12,600)
- medical simulation AND resuscitation (Cochrane 2, Medline 14,958, Google Scholar 9,850)
- surgical simulation AND resuscitation (Cochrane 2, Medline 7345, Google Scholar 7,150)
- healthcare simulation AND resuscitation (Cochrane 2, Medline 2753, Google Scholar 8,940)

**State inclusion and exclusion criteria.**

**Inclusion Criteria:**
- Intervention: simulation
- Subjects: all healthcare professionals or trainees in adult or pediatric domains
- Outcome: performance during resuscitation of humans or simulated humans in real or simulated clinical environments

**Exclusion Criteria:**
- Studies of training or learning interventions where simulation is not specifically mentioned
- Descriptive (non-experimental) studies
- Animal studies
- Non-English manuscripts
- Non-peer reviewed publications/presentations

**Number of articles/sources meeting criteria for further review.**

Extensive review of the literature produced 24 studies examining the effects of simulation-based training on the acquisition of skills by healthcare professionals.
# Summary of evidence

## Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
<th>Study 4</th>
<th>Study 5</th>
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<tbody>
<tr>
<td>Fair</td>
<td>Mayo, Hackney et al. 2004; Draycott, Sibanda et al. 2006; Draycott, Crofts et al. 2008; Edelson, Litzinger et al. 2008</td>
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**Level of evidence**

- **A** = Return of spontaneous circulation
- **B** = Survival of event
- **C** = Survival to hospital discharge
- **D** = Intact neurological survival
- **E** = Other endpoint

\[Italics = Animal studies\]
### Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td><strong>Good</strong></td>
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<td>Hall, Plant et al. 2005</td>
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<tr>
<td><strong>Fair</strong></td>
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<td>Nielsen, Goldman et al. 2007</td>
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A = Return of spontaneous circulation  
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C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  
*Italics = Animal studies*

### Evidence Opposing Clinical Question

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A = Return of spontaneous circulation  
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D = Intact neurological survival  
E = Other endpoint  
*Italics = Animal studies*
Simulation-based training in its broadest sense encompasses any training exercise where a representation (mental/virtual or physical) of reality is generated and trainees are allowed to perform actual or simulated activities to interact with that representation. Simulation-based training is grounded in sound adult learning theory, supported by rational conjecture, and felt to be essential for achieving expert performance. It has been used for decades in other domains where the risk to human life is high and is a core component of maintenance of certification/competency programs in those domains. While objective data exists in some of those domains to support the use of simulation it is far from being definitive in nature or comprehensive across all domains. Despite the paucity of objective evidence the use of simulation-based training remains standard operating procedure in commercial aviation, aerospace, the military, etc. and no one working in those domains would consider conducting a prospective, randomized, controlled trial where subjects (and those whose safety they bear responsibility) are randomized to the “no simulation” group.

The use of simulation-based training in healthcare began at a few pioneering sites several decades ago but its widespread deployment is a relatively recent phenomenon. The literature has very few actual studies of its use and utility; the vast majority of the literature consists of either discussion of the theoretical soundness of simulation based on principles of adult learning or “how to” descriptions. Nevertheless twenty-four studies were identified with four (Hall 2005, Knudson 2008, Kory 2007, Mayo 2004) rated as LOE 1 and twenty rated as LOE 3 through LOE 5; twenty-two revealed results supportive of the use of simulation, two were rated as neutral and none were rated as opposing. Especially intriguing are the results of:

Draycott (2006 LOE 3, 2008 LOE 3): Simulation-based training in the management of difficult deliveries reduced the incidence of hypoxic-ischemic encephalopathy in a large population compared with historical controls.

Hall (2005 LOE 1): Trainees who practiced intubation on human patient simulators developed the same degree of proficiency as those trainees who practiced on real living human patients. While technically a neutral study, this result (practice on a patient simulator producing the same degree of technical expertise as practice on real humans) should be viewed as supportive of the use of simulation.

Knudsen (2008 LOE 1): Simulation-based immersive learning produced better behavioral (crew resource management) skills in residents than didactic training.

Kory (2007 LOE 1): The authors suggest that a single focused simulation-based experience provided better training in emergency airway management than two years of clinical experience obtained during residency training.

Wayne (2008 LOE 3): This is a very intriguing study with all subjects receiving ACLS training at baseline followed by randomization to either simulation-based training + clinical experience (second year of residency) or clinical experience only (third year of residency). The second year residents adhered to ACLS guidelines better than the third year residents, arguably indicating that at least for this particular outcome measure (adherence to ACLS guidelines) a single simulation-based experience provided better training than an additional full year of residency experience.

So what can be said about the effectiveness of simulation-based training in healthcare where the emphasis is clearly on evidence-based practice and historically the gold standard of evidence has consisted of the prospective, randomized, controlled, sufficiently powered clinical trial where the outcomes focus on patients? In some ways this situation is similar to the debate that is currently taking place regarding the extent of evidence necessary to accept quality assurance/improvement work. At one end of the spectrum are authors who insist that quality initiatives must be subject to the same rigorous testing that precedes the introduction of new pharmacologic therapies and medical instrumentation in order to prove that they actually improve quality and ensure patient safety. Alternatively, others note that requiring randomized controlled trials to assess the safety of innovations with high face validity may unduly place humans at risk and therefore prove impossible to conduct. In fact some authors are of the opinion that to not use simulation-based training methodologies, relying instead solely on practice on real patients, is ethically indefensible. Thus we are left with a situation where the need for more definitive evidence, while desirable, is felt by at least some members of the healthcare education and training community to not be necessary nor practical.

Acknowledgements:
Citation List


Comment: LOE 4, Quality Fair, Supporting. Simulation-based training clearly produced short-term improvements in behavioral skills in this study of experienced ECMO specialists. This trial did not directly compare simulation-based training with traditional (didactic) training.


Comment: LOE 4, Quality Fair, Supporting. Simulation-based training resulted in enhanced technical skills and fewer errors in trainees (all of whom had previously received ATLS training) during simulated crises compared with trainees who did not receive such training prior to the simulated crises.


Comment: LOE 4, Quality Fair, Supporting. This study actually compared two different types of birthing simulators and does not represent a trial of "simulation vs traditional (didactic)" training and thus for the purposes of this review is LOE 4.


Comment: LOE 4, Quality Fair, Supporting. Method of training was not evaluated in this study.


Comment: LOE 4, Quality Fair, Supporting. All 4 training programs contained elements of simulation; the differences in the training programs included location and type of simulator technology but not methodology.


Comment: LOE 4, Quality Fair, Supporting. Simulation-based training produced short-term improvements in the technical skills required for safe singleton breech vaginal delivery but does not compare simulation with other training modalities.


Comment: LOE 4, Quality Fair, Supporting. Simulation-based training produced short-term improvements in the technical skills required for the management of shoulder dystocia; this trial essentially compares simulation-based training with no training.

Comment: LOE 4, Quality Fair, Supporting. In this observational study (pre/post intervention, no controls) repeated simulated emergency situations followed by debriefings resulted in sequentially improved performance in technical and behavioral skills during simulated resuscitations and improved simulated patient outcomes.


Comment: LOE 4, Quality Fair, Supporting. This study indicates that the combination of objective information regarding performance (feedback) and facilitated debriefing is superior to either alone in producing improvement in human performance. Simulation was not directly compared to traditional (didactic) training methodologies.


Comment: LOE 3, Quality Fair, Supporting. Even though this study uses historical controls the decrease in the incidence of hypoxic-ischemic encephalopathy, a significant neonatal problem and tremendous medicolegal issue, seen after simulation-based training is impressive and highly clinically relevant. This is a wonderful example of how studies rated as something other than LOE 1 can nevertheless have a high degree of clinical relevance.


Comment: LOE 3, Quality Fair, Supporting. Even though this study uses historical controls the decrease in the incidence of hypoxic-ischemic encephalopathy, a significant neonatal problem and tremendous medicolegal issue, seen after simulation-based training is impressive and highly clinically relevant. This is a wonderful example of how studies rated as something other than LOE 1 can nevertheless have a high degree of clinical relevance.


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Comment: LOE 4, Quality Fair, Supporting. In this observational study repeated simulated emergency situations followed by debriefings resulted in sequentially improved performance.

Comment: LOE 4, Quality Fair, Supporting. In this observational study repeated simulated obstetric emergency situations followed by debriefings resulted in sequentially improved performance in technical and behavioral skills.


Comment: LOE 1, Quality Good, Supporting. While at first glance this may seem to be a "Neutral" study as there was no difference detected between groups, this should be considered as supportive of simulation as trainees who practiced intubation on human patient simulators developed the same degree of proficiency as those trainees who practiced on real living human patients. Certainly it is a tremendous advantage to be able to practice a skill without the requirement that it be performed on a living human being (especially if that human is a child or is critically ill).


Comment: LOE 1, Quality Good, Supporting. This study is one of only a few that directly compares traditional lecture-based training with simulation-based immersive learning. While both groups achieved similar scores in assessment of content knowledge, the group experiencing simulation scored higher in behavioral (crew resource management) skills, a result not unexpected given the nature of simulation.


Comment: LOE 1, Quality Good, Supporting. This is a very intriguing study comparing simulation-based training in airway management with clinical experience gained during two years of residency. Residents who received simulation-based airway management training during their first year of residency performed this technical skill with better proficiency than fellow third year residents who did not receive simulation-based training. This arguably indicates that at least for this particular outcome measure (airway management) a single simulation-based experience provided better training than two years of residency training.


Comment: LOE 1, Quality Fair, Supporting. This study nicely shows that focused simulation and debriefing around airway management results in improved performance in intubation skill (in simulated patients) compared to completion of ACLS.


Comment: LOE 4, Quality Fair, Supporting. Simulated emergencies followed by facilitated debriefings produced improvements in content knowledge and confidence. Perhaps most importantly it also
increased self-awareness of areas of weakness; this is an important, yet often underappreciated, aspect of debriefing.


Comment: LOE 1, Quality Good, Supporting. While at first glance it appears to be a neutral study, the fact that there was substantial improvement (33 minutes to 21 minutes) in "decision to incision" time makes this tremendously clinically relevant.


Comment: LOE 5, Quality Fair, Supporting. This case report simply associates recent simulation-based training in a specific clinical intervention with a favorable real-life outcome.


Comment: LOE 4, Quality Fair, Supporting. Simulation-based training clearly produced short-term improvements in the behavioral skill of effective communications in difficult clinical situations; each subject acts as their own control and no comparisons between training methodologies are made.


Comment: LOE 4, Quality Fair, Supporting. Simulated emergencies followed by facilitated debriefings produced improvements in content knowledge and confidence.


Comment: LOE 3, Quality Good, Supporting. This is a very intriguing study with all subjects receiving ACLS training at baseline followed by randomization to either simulation-based training + clinical experience (second year of residency) or clinical experience only (third year of residency). The second year residents actually adhered to ACLS guidelines better than the third year residents, arguably indicating that at least for this particular outcome measure (ACLS adherence) a single simulation-based experience provided better training than a year of residency training.

References