KeyLime Simulation

Arguably The 10 “best” papers of the last 12 months

Farhan Bhanji & Glenn Posner
Sep 27, 2019
We do not have an affiliation (financial or otherwise) with a pharmaceutical, medical device or communications organization, but we are on the payroll at the Royal College

Nous n’avons aucune affiliation (financière ou autre) avec une entreprise pharmaceutique, un fabricant d’appareils médicaux ou un cabinet de communication, mais nous travaillons pour le Collège Royal.
‘There shouldn’t be anything wrong with not knowing’: epistemologies in simulation

Stella L Ng,1 Emilia Kangasjarvi,1 Gianni R Lorello,2,3 Lori Nemoy4 & Ryan Brydges4,5

Goal: “to uncover the epistemological* beliefs of students experiencing SBE” because of possible misalignment between key features of sim (i.e. safety, learning from mistakes) and real life.

*Epistemological: epistemic culture is a social group sharing a particular set of beliefs and values: what knowledge is, acceptable methods for generating it, the criteria by which it is judged, how one can come to know
• Methods: Qualitative - interviewed 24 pre-clerkship medical students following participation in a technical skills training study. Cardiac auscultation

• Results:
  > Knowledge = concrete facts from external sources
  > Learning from experience is not a priority
  > Experts are the ultimate knowledge validators, presence & feedback
  > Faculty could counter medicine’s pressures to perform with certainty and confidence all the time by embodying and modelling an authentic appreciation of learning through experiences, errors and discovery

• Conclusion:
  > idealize the objective pursuit of truth may compromise the purported culture of SBE
  > Try to bridge the beliefs of medicine and SBE
Analysis

• Safety!
  > For theatre-based = psychological safety
    » Uncertainty is embraced where uncertainty or “frames” exist
    » We still use directive feedback in the face of egregious errors
  > For technical skills = patient safety
    » Opportunity for deliberate practice and feedback away from patient

• Opportunity for questions are important, but the social order of a medical school class will not go away, not a failing of SBE
Comparing the Learning Effectiveness of Healthcare Simulation in the Observer Versus Active Role: Systematic Review and Meta-analysis

Megan Delisle, MD;
Mellissa A. R. Ward, MD;
Jason C. Pradarelli, MD, MS;
Nikhil Panda, MD;
Jeffery D. Howard, MD;
Alexander A. Hannenberg, MD

**Summary Statement:** The benefits of observation in simulation-based education in healthcare are increasingly recognized. However, how it compares with active participation remains unclear. We aimed to compare effectiveness of observation versus active participation through a systematic review and meta-analysis. Effectiveness was defined using Kirkpatrick’s 4-level model, namely, participants’ reactions, learning outcomes, behavior changes, and patient outcomes. The peer-reviewed search strategy included 8 major databases and gray literature. Only randomized controlled trials were included. A total of 13 trials were included (426 active participants and 374 observers). There was no significant difference in reactions (Kirkpatrick level 1) to training between groups, but active participants learned (Kirkpatrick level 2) significantly better than observers (standardized mean difference = −0.2; 95% confidence interval = −0.37 to −0.02, \( P = 0.03 \)). Only one study reported behavior change (Kirkpatrick level 3) and found no significant difference. No studies reported effects on patient outcomes (Kirkpatrick level 4). Further research is needed to understand how to effectively integrate and leverage the benefits of observation in simulation-based education in healthcare.

*(Sim Healthcare 00:00–00, 2019)*

**Key Words:** Simulation, education, observed simulation, systematic review, meta-analysis.
Primary Outcome

No studies reported Kirkpatrick level 4 outcomes.
<table>
<thead>
<tr>
<th>Study</th>
<th>ES (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bong 2017</td>
<td>0.89 (0.21, 1.57)</td>
<td>100.00</td>
</tr>
<tr>
<td>Subtotal (I-squared = .%, p = .)</td>
<td>0.89 (0.21, 1.57)</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brydges 2012</td>
<td>-0.45 (-1.06, 0.16)</td>
<td>52.76</td>
</tr>
<tr>
<td>VanderWeien 2014</td>
<td>-0.06 (-0.71, 0.59)</td>
<td>47.24</td>
</tr>
<tr>
<td>Subtotal (I-squared = 0.0%, p = 0.393)</td>
<td>-0.27 (-0.71, 0.18)</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blanie 2018</td>
<td>-0.41 (-0.80, -0.02)</td>
<td>71.15</td>
</tr>
<tr>
<td>Semler 2015</td>
<td>0.07 (-0.60, 0.74)</td>
<td>32.85</td>
</tr>
<tr>
<td>Subtotal (I-squared = 31.3%, p = 0.228)</td>
<td>-0.25 (-0.69, 0.19)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**NOTE:** Weights are from random effects analysis

**FIGURE 3.** Kirkpatrick level 1 subgroup analysis – technical versus nontechnical skills training. ES, effect size.
FIGURE 6. Kirkpatrick level 2 – funnel plot.
### Study

<table>
<thead>
<tr>
<th>Study</th>
<th>ES (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baxter 2012</td>
<td>-0.41 (−1.28, 0.46)</td>
<td>5.94</td>
</tr>
<tr>
<td>Blarie 2018</td>
<td>-0.09 (−0.63, 0.45)</td>
<td>15.14</td>
</tr>
<tr>
<td>Boncyk 2016</td>
<td>0.36 (−0.57, 1.29)</td>
<td>5.20</td>
</tr>
<tr>
<td>Bong 2017</td>
<td>-0.13 (−0.77, 0.51)</td>
<td>10.81</td>
</tr>
<tr>
<td>Hobgood 2010a</td>
<td>-0.26 (−0.82, 0.30)</td>
<td>14.09</td>
</tr>
<tr>
<td>Hobgood 2010b</td>
<td>-0.34 (−0.79, 0.11)</td>
<td>21.72</td>
</tr>
<tr>
<td>Lai 2016</td>
<td>-0.49 (−1.12, 0.14)</td>
<td>11.15</td>
</tr>
<tr>
<td>Semler 2015</td>
<td>0.26 (−0.88, 1.40)</td>
<td>3.46</td>
</tr>
<tr>
<td>Weiler 2018</td>
<td>0.00 (−0.60, 0.60)</td>
<td>12.48</td>
</tr>
<tr>
<td>Subtotal (I^2 = 90%, p = 0.851)</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Technical

<table>
<thead>
<tr>
<th>Study</th>
<th>ES (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blarie 2018</td>
<td>-0.44 (−1.00, 0.12)</td>
<td>30.12</td>
</tr>
<tr>
<td>Boncyk 2016</td>
<td>0.18 (−0.74, 1.10)</td>
<td>11.04</td>
</tr>
<tr>
<td>Brydges 2012</td>
<td>-0.49 (−1.11, 0.13)</td>
<td>24.57</td>
</tr>
<tr>
<td>Semler 2015</td>
<td>0.28 (−0.57, 1.13)</td>
<td>12.92</td>
</tr>
<tr>
<td>VanderWielen 2014</td>
<td>-0.06 (−0.72, 0.60)</td>
<td>21.36</td>
</tr>
<tr>
<td>Subtotal (I^2 = 0.0%, p = 0.467)</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

**NOTE:** Weights are from random effects analysis.

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**E 7.** Kirkpatrick level 2 subgroup analysis – technical versus nontechnical skills training. ES, effect size.
<table>
<thead>
<tr>
<th>Study</th>
<th>ES (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baxter 2012</td>
<td>-0.41 (-1.28, 0.46)</td>
<td>6.24</td>
</tr>
<tr>
<td>Boncyk 2016</td>
<td>0.36 (-0.57, 1.29)</td>
<td>5.49</td>
</tr>
<tr>
<td>Bong 2017</td>
<td>-0.13 (-0.77, 0.51)</td>
<td>10.96</td>
</tr>
<tr>
<td>Brydges 2012</td>
<td>-0.49 (-1.11, 0.13)</td>
<td>11.78</td>
</tr>
<tr>
<td>Hobgood 2010a</td>
<td>-0.53 (-1.65, 0.59)</td>
<td>3.80</td>
</tr>
<tr>
<td>Hobgood 2010b</td>
<td>-0.70 (-1.19, -0.21)</td>
<td>17.66</td>
</tr>
<tr>
<td>Lai 2016</td>
<td>-0.49 (-1.12, 0.14)</td>
<td>11.28</td>
</tr>
<tr>
<td>Serlere 2015</td>
<td>0.27 (-0.41, 0.95)</td>
<td>9.93</td>
</tr>
<tr>
<td>Vander Wielen 2014</td>
<td>-0.06 (-0.72, 0.60)</td>
<td>10.35</td>
</tr>
<tr>
<td>Weiler 2018</td>
<td>0.00 (-0.50, 0.60)</td>
<td>12.51</td>
</tr>
<tr>
<td>Subtotal (I^2 = 6.9%, p = 0.378)</td>
<td>-0.26 (-0.48, -0.03)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Knowledge:

<table>
<thead>
<tr>
<th>Study</th>
<th>ES (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanie 2018</td>
<td>-0.26 (-0.65, 0.13)</td>
<td>38.00</td>
</tr>
<tr>
<td>Boncyk 2016</td>
<td>0.18 (-0.74, 1.10)</td>
<td>6.76</td>
</tr>
<tr>
<td>Hobgood 2010a</td>
<td>0.01 (-0.45, 0.47)</td>
<td>27.32</td>
</tr>
<tr>
<td>Hobgood 2010b</td>
<td>0.01 (-0.44, 0.46)</td>
<td>27.82</td>
</tr>
<tr>
<td>Subtotal (I^2 = 0.0%, p = 0.701)</td>
<td>-0.08 (-0.32, 0.16)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

NOTE: Weights are from random effects analysis

Kirkpatrick Level 3 – Behavior Change

Blanie et al.\textsuperscript{34} defined perceived learning transfer as a Kirkpatrick level 3 outcome. They found no significant different between the 2 cohorts.
**Ethnography:** the scientific description of the customs of individual peoples and cultures

Goal: “to identify key aspect of EM culture that were made more obvious through simulation and examine how those values, beliefs, and practices were transmitted to MS in the exercise”
• **Methods:** Qualitative
  > 98 3\textsuperscript{rd}-year MS in simulated emergency dept in Australia;
  > Participant observation, interviews, document review.

• **Results:** 20 staff and 92 MS
  > 7 CORE values with 27 related beliefs:
    » Identifying and treating dangerous pathology;
    » Managing uncertainty;
    » Patients & families at centre of care;
    » Balancing needs and resources at the system level;
    » Value of the team approach;
    » Education as integral;
    » EM as part of self-identity

• “We observed that culture was transmitted during the simulation exercise”
Ideas

• Simulation as a tool of ‘Cultural Compression’: transmission of culture in an expedited fashion;
• Enculturation; Indoctrination;
• Using sim to elucidate the culture of the ED and the specialty of EM;
• Reflection on cultural transmission may help sim designers consider the messages that are being shared – the hidden curriculum, opportunities for caricature
Original Investigation  |  Medical Education

Machine Learning Identification of Surgical and Operative Factors Associated With Surgical Expertise in Virtual Reality Simulation

Alexander Winkler-Schwartz, MD; Recai Yilmaz, MD; Nykan Mirchi, BSc; Vincent Bissonnette, MD; Nicole Ledwos, BA; Samaneh Siyar, MSc; Hamed Azarnoush, PhD; Bekir Karlik, PhD; Rolando Del Maestro, PhD
Figure 1. The Process of Generating a Final Optimized Machine Learning Algorithm With a Set of Selected Metrics

For algorithm optimization, each machine learning algorithm has a defined set of parameters by which it functions, the adjustment of which will modify its overall performance. An analogy for these parameters is the statistical methods that underlie P value adjustments (e.g., Bonferroni and Benjamini-Hochberg). MATLAB, release 2018a (MathWorks Inc) was used to modify the intrinsic properties of 4 machine learning algorithms (K-nearest neighbor, naive Bayes, discriminant analysis, and support vector machine).
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Staff Neurosurgeons (n = 14)</th>
<th>Fellows or Senior Residents (n = 14)</th>
<th>Junior Residents (n = 10)</th>
<th>Medical Students (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (range), y</td>
<td>45 (33-59)</td>
<td>33 (29-35)</td>
<td>30 (27-38)</td>
<td>23 (23-26)</td>
</tr>
<tr>
<td>Sex, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14 (100)</td>
<td>13 (93)</td>
<td>8 (80)</td>
<td>6 (50)</td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
<td>1 (7)</td>
<td>2 (20)</td>
<td>6 (50)</td>
</tr>
<tr>
<td>Total No. of years of practice, median (range)</td>
<td>12.5 (1-25)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Neurosurgical subspecialty, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spine</td>
<td>5 (36)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Oncology and epilepsy</td>
<td>4 (29)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Skull base</td>
<td>2 (14)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>2 (14)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cerebrovascular</td>
<td>1 (7)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Matrix demonstrating actual vs estimated group memberships by 4 different machine learning algorithms. Percentages reflect the total among rows.
Figure 3. Number of Performance Metrics Selected for By 4 Different Machine Learning Algorithms

Performance metrics are categorized as those involving movements of 1 or both instruments, force applied to the underlying structures and damage to underlying brain, blood loss, and quantity of tumor removed.
Goal: “to assess whether the implementation of an intrapartum training package (PROMPT) across a health service reduced the proportion of term babies born with Apgar score <7 and 5 mins”
Effect of hands-on interprofessional simulation training for local emergencies in Scotland: the THISTLE stepped-wedge design randomised controlled trial

Erik Lenguerrand,¹ Cathy Winter,² Dimitrios Siassakos,³ Graeme MacLennan,⁴ Karen Innes,⁴ Pauline Lynch,⁵ Alan Cameron,⁶ Joanna Crofts,² Alison McDonald,⁴ Kirsty McCormack,⁴ Mark Forrest,⁴ John Norrie,⁷ Siladitya Bhattacharya,⁸ Tim Draycott¹,²

THISTLE: Trial of Hands-on Interprofessional Simulation Training for Local Emergencies
PROMPT: PRactical Obstetric Multi-Professional Training
• Methods:
  > 12 randomized maternity units with >900 births/yr in Scotland, March 2014 – Sep 2016 (87K births);
  > Exposed to PROMPT training and implementation;

• Results:
  > Moderate but non-significant reduction in the rate of term babies with Apgar score <7 following PROMPT training, essentially no effect.

• Conclusion:
  > “local implementation at scale was found to be more difficult than anticipated”
<table>
<thead>
<tr>
<th>Table 1</th>
<th>Prevalence rate of Apgar score $&lt;7$ mins during the study period*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>Period</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td></td>
</tr>
<tr>
<td>Apgar $&lt;7$ mins (n)</td>
<td>189</td>
</tr>
<tr>
<td>Births (n)</td>
<td>14 342</td>
</tr>
<tr>
<td>Prevalence, 95% CI</td>
<td>1.32 (1.14 to 1.52)</td>
</tr>
<tr>
<td>Intention-to-treat: Intervention as per randomisation</td>
<td></td>
</tr>
<tr>
<td>Unexposed</td>
<td></td>
</tr>
<tr>
<td>Apgar $&lt;7$ mins (n)</td>
<td>189</td>
</tr>
<tr>
<td>Births (n)</td>
<td>14 342</td>
</tr>
<tr>
<td>Prevalence, 95% CI</td>
<td>1.32 (1.14 to 1.52)</td>
</tr>
<tr>
<td>Exposed</td>
<td></td>
</tr>
<tr>
<td>Apgar $&lt;7$ mins (n)</td>
<td>68</td>
</tr>
<tr>
<td>Births (n)</td>
<td>4806</td>
</tr>
<tr>
<td>Prevalence, 95% CI</td>
<td>–</td>
</tr>
<tr>
<td>‘As-implemented’: Intervention as per first training</td>
<td></td>
</tr>
<tr>
<td>Unexposed</td>
<td></td>
</tr>
<tr>
<td>Apgar $&lt;7$ mins (n)</td>
<td>189</td>
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<tr>
<td>Exposed</td>
<td></td>
</tr>
<tr>
<td>Apgar $&lt;7$ mins (n)</td>
<td>31</td>
</tr>
<tr>
<td>Births (n)</td>
<td>1 132</td>
</tr>
<tr>
<td>Prevalence, 95% CI</td>
<td>2.74 (1.93 to 3.87)</td>
</tr>
</tbody>
</table>

*Based on the 86 514 births with an assigned Apgar score observed in the 12 maternity units which had attended the THISTLE Study Train the Trainer (T3) programme and had not implemented the intervention prior to the study (two units declined to participate during the study period).
Analysis

• Is this a metric on which we cannot move the needle?
• How did the UK do it?
  > Mandatory
  > Annual
  > Interprofessional
  > Protocol-based
  > In-situ/on-site
  > With hands-on training for shoulder dystocia
• No secondary outcomes? Experience? Morbidity?
Simulation-Based Event Analysis Improves Error Discovery and Generates Improved Strategies for Error Prevention

Anna-Theresa Lobos, MD; Natalie Ward, PhD, CE; Ken J. Farion, MD; David Creery, MSc, MD; Colleen Fitzgibbons, RN; Christa Ramsay, RRT; Melanie Hogue, RN; Mélissa Langevin, MD

**Introduction:** An adverse event (AE) is a negative consequence of health care that results in unintended injury or illness. The study investigates whether simulation-based event analysis is different from traditional event analysis in uncovering root causes and generating recommendations when analyzing AEs in hospitalized children.

**Methods:** Two simulation scenarios were created based on real-life AEs identified through the hospital's Safety Reporting System. Scenario A involved an error of commission (inpatient drug error) and scenario B involved detecting an error that already occurred (drug infusion error). Each scenario was repeated 5 times with different, voluntary clinicians. Content analysis, using deductive and inductive approaches to coding, was used to analyze debriefing data. Causes and recommendations were compiled and compared with the traditional event analysis.

**Results:** Errors were reproduced in 60% (3/5) of scenario A. In scenario B, participants identified the error in 100% (5/5) of simulations (average time to error detection = 15 minutes). Debriefings identified reasons for errors including product labeling, memory aid interpretation, and lack of standard work for patient handover. To prevent error, participants suggested improved drug labeling, specialized drug kits, alert signs, and handoff checklists. Compared with traditional event analysis, simulation-based event analysis revealed unique causes for error and new recommendations.

**Conclusions:** Using simulation to analyze AEs increased unique error discovery and generated new recommendations. This method is different from traditional event analysis because of the immediate clinician debriefings in the clinical environment. Hospitals should consider simulation-based event analysis as an important addition to the traditional process. *(Sim Healthcare 14:209–216, 2019)*
Simulation reaches data saturation → Debriefing Data:
- Notes
- Transcripts

→ Team Theme Analysis

→ Final Study Recommendations

Expert Video Review Recommendations → Final Study Recommendations

Traditional RCA findings
<table>
<thead>
<tr>
<th>Cause of Error</th>
<th>Quote</th>
</tr>
</thead>
</table>
| Confusion about route                | Physician:  
“I focused on the IV because it’s a quick access”  
Physician and nurse:  
“Didn’t want to poke the kid if we already had an IV”  |
| Confusion about memory aids          | Physician:  
“On the PALS card, I looked at 1:1000 to give IV... but didn’t notice that was for hypotension only after multiple doses of IM epinephrine”  
“I saw dose in mg/kg on cards which was confusing.”  |
| Confusion about hospital resuscitation sheets | Physician and nurse:  
“Surprised to find anaphylaxis section on these on sheets... didn’t know it was there”  
“Too much text”  
“Why is Epi IM not with other Epi doses?”  |
| Confusion about medication labeling  | Physician:  
“I can’t find 1:1000 on the vial, that’s how I’m used to ordering it”  
“The vial – 1 mg/mL – says you can give it IV.”  |
<table>
<thead>
<tr>
<th>Preprinted order policy development</th>
<th>Scenario A: Simulation-Based Event Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop and implement a PPO set for use on inpatient units for patients with a primary admitting diagnosis of anaphylaxis with education for nurses and residents</td>
<td>Medication labeling</td>
</tr>
<tr>
<td></td>
<td>1. Creation of specialized drug kits for anaphylaxis: small bag containing IM needle, IM epinephrine with label on bag reading “IM EPINEPHRINE 1 mg/mL (1:1000), DOSE: 0.01 mg/kg IM (max dose 0.5 mg IM). DO NOT GIVE IV”</td>
</tr>
<tr>
<td></td>
<td>2. Adding indication on the epinephrine vials and boxes; adding “DO NOT give IV, IM ONLY” to 1 mg/mL vials of epinephrine</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Guarding against harm</th>
<th>Guarding against harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pharmacy to review the number of vials of epinephrine ward stock available in the cabinet and determine whether it can be safely reduced</td>
<td>1. Alert signs with clear messaging in patient rooms</td>
</tr>
<tr>
<td></td>
<td>2. Removal of vials of 1 mg/mL of epinephrine as ward stock; this concentration to only be available in anaphylaxis kits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education</th>
<th>Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Anaphylaxis education for nurses and residents</td>
<td>1. Session of the common 5 mistakes</td>
</tr>
<tr>
<td>2. Education for staff regarding hospital resuscitation medication sheets on how to use and where it should be kept re-education for unit and nursing staff to ensure allergy status is updated in the health record</td>
<td>2. Standardized common emergencies training/laminated management card</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transfer of knowledge and protocols:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Edited hospital resuscitation medication sheets:</td>
</tr>
<tr>
<td>- List medications alphabetically</td>
</tr>
<tr>
<td>- Bold IM epinephrine dose</td>
</tr>
<tr>
<td>- List indication first</td>
</tr>
</tbody>
</table>
**TABLE 4.** Recommendation Comparison: Traditional Event Analysis Versus Simulation-Based Event Analysis for Scenario B

<table>
<thead>
<tr>
<th>Scenario B: Traditional Event Analysis</th>
<th>Scenario B: Simulation-Based Event Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Product labeling</td>
</tr>
<tr>
<td>1. Clarifying the D1 guideline in the PICU with respect to the use of Vasopressin</td>
<td>Matching colors between syringe and pump for each concentrations/doses and PPO, ie, yellow for vasopressin used for D1; red for vasopressin used for shock</td>
</tr>
<tr>
<td>2. Updating the resident protocol binder and creating an online reference site for PICU protocols</td>
<td>Guarding against harm</td>
</tr>
<tr>
<td>3. Clarify the dosing and preparation of vasopressin in the PICU</td>
<td>Alert signs on infusion pumps for high-alert medications; ie, sign hanging on pump that reads “Vasopressin for DI U/kg/HR” or “Vasopressin for Shock U/kg/MIN”</td>
</tr>
<tr>
<td></td>
<td>Transfer of knowledge</td>
</tr>
<tr>
<td></td>
<td>Creating checklists for handoff; use of a brief, standard checklist for change of care provider. Create a physician checklist for assessing acute physiological changes in patients</td>
</tr>
</tbody>
</table>
Goal: “to review the effect of in situ simulation training in a hospital setting on morbidity or mortality”
ABSTRACT

Background The use of in situ simulation has previously been shown to increase confidence, teamwork and practical skills of trained professionals. However, a direct benefit to patient outcomes has not been sufficiently explored. This review focuses on the effect of in situ simulation training in a hospital setting on morbidity or mortality.

Methods A combined search was conducted in PUBMED, OVID, WEB OF SCIENCE, CINAHL, SCOPUS and EMBASE. 478 studies were screened with nine articles published between 2011 and 2017 meeting the inclusion criteria for analysis.

Results This review selected eight prospective studies and one prospective-retrospective study. Three studies isolated in situ simulation as an experimental variable while the remaining studies implemented in situ programmes as a component of larger quality improvement initiatives. Seven studies demonstrated a significant improvement in morbidity and/or mortality outcomes following integrated in situ simulation training.

Conclusion Existing literature, albeit limited, demonstrates that in situ training improves patient outcomes either in isolation or within a larger quality improvement programme. However, existing evidence contains difficulties such as isolating the impact of in situ training from various potential confounding factors and potential for publication bias.

- 9 articles
- 3 studies of ISS, 6 QI
- 7 demonstrated an effect
- Publication bias?
<table>
<thead>
<tr>
<th>Study</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andreas et al.</td>
<td>Investigated the role of mock codes in paediatric cardiopulmonary arrest (CPA) survival rates. Mock codes were held monthly at random times during Monday through Friday day shifts, increasing in number as the study progressed. All regular code team members were involved including medical residents, paediatric intensive care unit nurses, medical students, hospitalists and pharmacists. High-fidelity manikins were used in either the clinical simulation centre or a functional paediatric patient room. Scenarios ranged from sepsis, respiratory distress, increased intracranial pressure/hemorrhage, anaphylactic shock and cardiogenic shock. Each code encompassed one or more scenarios with initial emphasis on pulseless rhythms in year 1, followed by rhythms with a pulse in year 2 and a composite in years 3 and 4. Debriefing events led by trained clinical faculty followed the mock codes where video recordings were used. The chosen outcome of interest was survival rates, defined as a patient survival-to-discharge percentage. CPA survival rates increased significantly over the last 2 years of the study.</td>
</tr>
<tr>
<td>Steinmann et al.</td>
<td>Examined the effect of a novel 4-hour team training curriculum, consisting of online teaching, multiple in situ simulation exercises and simulation debriefs. Participants consisted of all healthcare professionals involved in an acute resuscitation, including staff physicians, residents, nurses, respiratory therapists and emergency department technicians. Outcomes of interest were primarily skills based; however, this study also evaluated the effect of the simulation-based training curriculum on patient survivability after intervention, reporting a non-significant impact.</td>
</tr>
<tr>
<td>Riley et al.</td>
<td>Investigated the effects of didactic training alone or in combination with in situ simulation on adverse perinatal outcomes. Three hospitals were randomly assigned to either have no intervention (control), TeamSTEPPS didactic training, or in situ simulation integrated with TeamSTEPPS training (full intervention). Participants included all the labour and delivery staff. Eleven in situ simulations were conducted across a half a year after didactic training in the third hospital. Outcomes included: the Weighted Adverse Outcome Score which decreased in the full intervention hospital, stayed the same in the didactic-only hospital and increased in the control hospital.</td>
</tr>
<tr>
<td>Knight et al.</td>
<td>Examined the clinical effects of a composite resuscitation team training programme. The training included in situ simulation along with other interventions. The preintervention baseline period was 4 years with an intervention period of 1 year. The study demonstrated an improvement in the primary outcome which was survival-to-discharge following a CPA. Exclusion criteria included events which used extracorporeal membrane oxygenation (ECMO) at code initiation.</td>
</tr>
<tr>
<td>Baddock et al.</td>
<td>Investigated the effect of a multifaceted patient safety programme on clinical outcomes. Baseline measurements were conducted over 1 year followed by a 1-year intervention period and a 6-month sustainability period. The intervention comprised in situ simulation training. Patients involved in other interventions, in situ simulations were conducted four times per month during the intervention period and monthly during the sustainability period on both day and night shifts. Scenarios were designed to mimic clinical states preceding arrest where both technical and non-technical skills were emphasised. Measured outcomes included hospital-acquired severe sepsis/septic shock, acute respiratory failure, rate of unplanned transfers to higher level of care (HLOC) and weight risk adjusted observed to expected mortality ratio. All outcomes except for the rate of unplanned transfers to HLOC improved significantly when compared with both the baseline period and to control hospital units which did not receive the training programme.</td>
</tr>
<tr>
<td>Sodhi et al.</td>
<td>Investigated cardiopulmonary resuscitation outcomes with interventions including mock codes along with other optimisation protocols. The mock codes were conducted at least twice a year in different departments around the hospital. The study demonstrated improvement in the rate of return of spontaneous circulation (ROSC) as well as survival-to-discharge.</td>
</tr>
<tr>
<td>Riley et al.</td>
<td>Examined the effect of introducing a paediatric medical emergency team (PMEET) coupled with weekly in situ simulation training on hospital outcomes. This initiative included a 2-year baseline followed by a 5-year intervention period which encompassed three primary interventions: a standardised care process, teamwork training through in situ simulation, and education and performance feedback. Phase 1 introduced education and performance feedback as well as a standardised care process over 3 years. It was followed by phase 2 which occurred during the last 2 years of the study and included in situ training. This study demonstrated a decrease in the adverse outcome index after intervention.</td>
</tr>
<tr>
<td>Theilen et al.</td>
<td>Examined the effect of introducing a paediatric medical emergency team (PMEET) coupled with weekly in situ simulation training on hospital outcomes. This initiative included a 2-year baseline followed by a 5-year intervention period which encompassed three primary interventions: a standardised care process, teamwork training through in situ simulation, and education and performance feedback. Phase 1 introduced education and performance feedback as well as a standardised care process over 3 years. It was followed by phase 2 which occurred during the last 2 years of the study and included in situ training. This study demonstrated a decrease in the adverse outcome index after intervention.</td>
</tr>
<tr>
<td>Gibbs et al.</td>
<td>Implemented and investigated the effect of an in situ simulation programme to combat a methicillin resistant Staphylococcus aureus (MRSA) outbreak in a level-4 neonatal intensive care unit. Physicians, nurses, respiratory therapists, and environmental service workers completed the training programme, which incorporated 30 min in situ simulations along with debriefing. The main educational principles of interest were proper techniques of personal protective equipment, hand hygiene, handling potentially contaminated materials and entering/exiting infected rooms. This study demonstrated a significant decrease in the number of infections.</td>
</tr>
</tbody>
</table>
Effects of a Multimodal Program Including Simulation on Job Strain Among Nurses Working in Intensive Care Units: A Randomized Clinical Trial

Radia El Khamali, RN; Atika Mouaci, RN; Sabine Valera, RN; Marion Cano-Chavel, RN; Camille Pingis, RN; Céline Sanz, RN; Amel Allal, RN; Valérie Attard, RN; Julie Malardier, RN; Magali Delfino, RN; Fifina D’Anna, RN; Pierre Rostini, MD; Stéphan Aguilard, RN; Karine Berthias, RN; Béatrice Cresta, RN; Frédéric Iride, RN; Valérie Reynaud, RN; Jérémie Suard, RN; Wlady Syja, RN; Cécile Vankiersbilck, RN; Nicole Chevalier, RN; Karen Inthavong, RN; Jean-Marie Forel, MD; Karine Baumstarck, MD, PhD; Laurent Papazian, MD, PhD; for the SISTRESSREA Study Group
Figure. Flow of Intensive Care Unit (ICU) Nurses Through the Trial

437 Nurses assessed for eligibility

239 Excluded
128 Not enrolled before study stopped
67 Did not meet inclusion criteria
0 Refused to participate
22 On maternity leave
12 Planned to leave the ICU
10 Had already completed the simulation intervention

198 Randomized

101 Randomized to receive intervention
101 Received intervention as randomized
4 Stopped working in ICU and unavailable for 6-month assessment
0 Lost to follow-up

97 Randomized to receive control
97 Received control as randomized
12 Stopped working in ICU and unavailable for 6-month assessment
0 Lost to follow-up

97 Included in primary analysis
4 Excluded from primary analysis (stopped working in ICU)
101 Included in analysis on absenteeism and turnover

85 Included in primary analysis
12 Excluded from primary analysis (stopped working in ICU)
97 Included in analysis on absenteeism and turnover
<table>
<thead>
<tr>
<th>Table 1. Baseline Characteristics of the Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Age group, y</strong></td>
</tr>
<tr>
<td>≤30</td>
</tr>
<tr>
<td>31-40</td>
</tr>
<tr>
<td>≥41</td>
</tr>
<tr>
<td><strong>Women</strong></td>
</tr>
<tr>
<td><strong>Men</strong></td>
</tr>
<tr>
<td><strong>Single, not married</strong></td>
</tr>
<tr>
<td><strong>No. of children</strong></td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>&gt;2</td>
</tr>
<tr>
<td><strong>Length of commute, min</strong></td>
</tr>
<tr>
<td>&lt;15</td>
</tr>
<tr>
<td>15-30</td>
</tr>
<tr>
<td>&gt;30</td>
</tr>
<tr>
<td><strong>Work status</strong></td>
</tr>
<tr>
<td>Full time</td>
</tr>
<tr>
<td>Day shift</td>
</tr>
<tr>
<td>12-h shift</td>
</tr>
<tr>
<td>ICU rotation as part of nursing school</td>
</tr>
</tbody>
</table>
Table 2. Main Outcome Measures

<table>
<thead>
<tr>
<th></th>
<th>No. of Observations/Total No. (%)</th>
<th>Between-Group Difference, % (95% CI)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention Group</td>
<td>Control Group</td>
<td></td>
</tr>
<tr>
<td><strong>Primary Outcome</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job strain at 6 mo(^b)</td>
<td>13/97 (13)</td>
<td>57/85 (67)</td>
<td>54 (40-64)</td>
</tr>
<tr>
<td><strong>Secondary Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isostrain at 6 mo(^c)</td>
<td>7/97 (7)</td>
<td>47/85 (55)</td>
<td>48 (35-59)</td>
</tr>
<tr>
<td>High psychological demand at 6 mo</td>
<td>26/97 (27)</td>
<td>61/85 (72)</td>
<td>45 (31-56)</td>
</tr>
<tr>
<td>Low social support at 6 mo</td>
<td>49/97 (51)</td>
<td>65/85 (76)</td>
<td>26 (12-38)</td>
</tr>
<tr>
<td>Low decision latitude at 6 mo</td>
<td>15/97 (15)</td>
<td>58/85 (68)</td>
<td>53 (39-63)</td>
</tr>
<tr>
<td>Absenteeism during 6-mo follow-up</td>
<td>1/101 (1)</td>
<td>8/97 (8)</td>
<td>7 (1-15)</td>
</tr>
<tr>
<td>Left ICU during 6-mo follow-up(^d)</td>
<td>4/101 (4)</td>
<td>12/97 (12)</td>
<td>8 (0-17)</td>
</tr>
<tr>
<td>Job strain at 12 mo(^b)</td>
<td>21/57 (37)</td>
<td>26/36 (72)</td>
<td>35 (15-52)</td>
</tr>
<tr>
<td>Isostrain at 12 mo(^c)</td>
<td>8/57 (14)</td>
<td>24/36 (67)</td>
<td>53 (33-67)</td>
</tr>
</tbody>
</table>
Simulation and education

Hospitals with more-active participation in conducting standardized in-situ mock codes have improved survival after in-hospital cardiopulmonary arrest

Karen Josey\textsuperscript{a}, Marshall L. Smith\textsuperscript{a}, Arooj S. Kayani\textsuperscript{b}, Geoff Young\textsuperscript{a}, Michael D. Kasperski\textsuperscript{a}, Patrick Farrer\textsuperscript{a}, Richard Gerkin\textsuperscript{a}, Andreas Theodorou\textsuperscript{a}, Robert A. Raschke\textsuperscript{a,c,*}

Goal: “to determine if more-active hospital participation in standardized in-situ mock code training is associated with increased in-hospital cardiopulmonary arrest survival”
• Methods:
  > ecological study – 26 hospitals
  > ISMC performance vs. IHCA discharge survival rates

• Results:
  > Hospitals with “more active ISMC participation = 17.6 ISMC/100 beds/year; less active = 3.2 ISMC/100 beds/year;
  > Mean survival 42.8% vs 31.8%, 0.62 OR for IHCA mortality;

*Ecological study: observational study defined by the level at which data are analysed, namely at the population or group level, rather than individual level.
### Mock Code Debriefing Sheet

#### Pulseless V-Fib

<table>
<thead>
<tr>
<th>Time of Pulseless Recognition</th>
<th>Compressions Initiated</th>
<th>Arrival of Code Cart</th>
<th>Initial Rhythm Recognized</th>
<th>Time of Initial Defibrillation</th>
<th>Backboard Placed</th>
<th>Time of 1st Drug</th>
<th>Time of 2nd Defibrillation</th>
</tr>
</thead>
</table>

#### Intervention Timeline

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Time from start</th>
<th>Time Success Criteria Met or Missed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Pulseless Recognition</td>
<td>00:16</td>
<td>Completed Successfully</td>
</tr>
<tr>
<td>Compressions Initiated</td>
<td>00:20</td>
<td>Completed Successfully</td>
</tr>
<tr>
<td>Arrival of Code Cart</td>
<td>00:27</td>
<td>Completed Successfully</td>
</tr>
<tr>
<td>Initial Rhythm Recognized</td>
<td>00:50</td>
<td>Completed Successfully</td>
</tr>
<tr>
<td>Time of Initial Defibrillation</td>
<td>01:51</td>
<td>Late: More than 15 seconds from rhythm recognition</td>
</tr>
<tr>
<td>Backboard Placed</td>
<td>02:15</td>
<td>Completed Successfully</td>
</tr>
<tr>
<td>Time of 1st Drug</td>
<td>03:27</td>
<td>Late: More than 120 seconds from rhythm recognition</td>
</tr>
<tr>
<td>Time of 2nd Defibrillation</td>
<td>04:30</td>
<td>Late: More than 135 seconds from first defibrillation</td>
</tr>
</tbody>
</table>

#### CPR by Cycle

<table>
<thead>
<tr>
<th>Cycle One</th>
<th>Cycle Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (2&quot;) <em>100% rule</em></td>
<td>Depth (2&quot;) <em>100% rule</em></td>
</tr>
<tr>
<td>Rate (100/min) <em>100% rule</em></td>
<td>Rate (100/min) <em>100% rule</em></td>
</tr>
<tr>
<td>Compression : Breath Ratio (30:2) <em>100% rule</em></td>
<td>Compression : Breath Ratio (30:2) <em>100% rule</em></td>
</tr>
<tr>
<td>New Compressor this cycle</td>
<td>New Compressor this cycle</td>
</tr>
<tr>
<td>Time without compressions &lt;10 sec intervals</td>
<td>Time without compressions &lt;10 sec intervals</td>
</tr>
<tr>
<td>Pulse CHECK with compressions</td>
<td>Pulse CHECK with compressions</td>
</tr>
<tr>
<td>Adequate BVM Ventilation <em>80% rule</em></td>
<td>Adequate BVM Ventilation <em>80% rule</em></td>
</tr>
</tbody>
</table>

#### Interventions:

- Pulse Ox

#### Critical Errors:

On the first Defib did not identify rhythm correctly

#### Debriefing Notes:

- Remediation Methods used: Return Demand CPR

- Commonly remediated items:
  - Compression Depth
  - Compression Technique
  - Hand position
  - 30/2 Ratio
  - Counting aloud
  - 2 full minutes on chest
  - Off chest time < 15 sec
  - Pulse check with compressions

- AED/Defib equipment usage
  - Hands free pads
  - Connection problems
  - Pads versus 3-5 lead
  - ALS algorithm

- Facilitator "In Charge"

- Team Roles Filled:
  - Defib/Code Cart
  - Breathing
  - CPR
  - Facilitator "In Charge"
  - Emergency Meds
  - Recorder
  - Away
  - Closed Loop Communication
Table 2
Comparison of hospitals with more-active versus less-active ISMC participation: ISMC performance, survival to discharge and possible confounders.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Hospitals with more-active ISMC participation (n = 12)</th>
<th>Hospitals with less-active ISMC participation (n = 14)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median ISMCs/100 beds/year</td>
<td>17.6</td>
<td>3.2</td>
<td>0.001</td>
</tr>
<tr>
<td>ISMC Defibrillation within 2 min</td>
<td>35.0%</td>
<td>25.9%</td>
<td>0.05</td>
</tr>
<tr>
<td>ISMC CPR quality composite score</td>
<td>70.8%</td>
<td>70.8%</td>
<td>0.99</td>
</tr>
<tr>
<td>ISMC Teamwork composite score</td>
<td>39.5%</td>
<td>36.2%</td>
<td>0.50</td>
</tr>
<tr>
<td>Survival to discharge s/p IHCA</td>
<td>42.8%</td>
<td>31.8%</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

**Potential confounders:**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Hospitals with more-active ISMC participation (n = 12)</th>
<th>Hospitals with less-active ISMC participation (n = 14)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median number of licensed beds</td>
<td>93</td>
<td>70</td>
<td>0.92</td>
</tr>
<tr>
<td>Median number of admissions/year</td>
<td>3709</td>
<td>2675</td>
<td>0.86</td>
</tr>
<tr>
<td>Median number of IHCAs per year</td>
<td>92</td>
<td>55</td>
<td>0.86</td>
</tr>
<tr>
<td>Proportion of pediatric IHCAs</td>
<td>3.9%</td>
<td>3.7%</td>
<td>0.77</td>
</tr>
<tr>
<td>Hospital observed mortality</td>
<td>1.80%</td>
<td>1.78%</td>
<td>0.78</td>
</tr>
<tr>
<td>Hospital expected mortality</td>
<td>1.89%</td>
<td>1.79%</td>
<td>0.07</td>
</tr>
<tr>
<td>Proportion of admissions to ICU</td>
<td>12.4%</td>
<td>19.5%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Mean APACHE score</td>
<td>54.3</td>
<td>52.4</td>
<td>0.001</td>
</tr>
<tr>
<td>ICU observed mortality</td>
<td>6.5%</td>
<td>6.2%</td>
<td>0.23</td>
</tr>
<tr>
<td>ICU expected mortality</td>
<td>6.90%</td>
<td>6.41%</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Analysis

- How many beds do these hospitals have?
- My hospital has 1200 beds, would require multiple codes per day to be considered “more active” in this study;
- Implementation is important (see Thistle/PROMPT);
- Debriefing points/goals are important;
- Causality is obviously an issue
“Congratulations on your fantastic publication in Resuscitation, I finally had a chance to read it with a fine tooth comb. I run a similar program for a hospital with 1200 beds (The Ottawa Hospital Simulation Patient Safety Program), so I am disheartened by the 17.6 ISMCs per 100 beds per year that I would need to run in order to be considered a more-active user. Digging down into your numbers, I'm happy to see that you stratified by size of hospital. Could you please share your median number of sessions at the >200 bed hospitals, especially at the large (708-bed) hospital so that I can see where my program fits in to this? Thanks so much, and congrats again on a really important publication, Glenn”
“Hi Glenn,
I think your question is very good – that number is definitely influenced by the large number of small hospitals in our system. Weirdly, our largest (708 bed) hospital was not a more-active user. We have so many real codes, that most of the staff there don’t feel the need for mock codes. I don’t have the data right in front of me, but let me look at the files I have at home to answer your question more specifically. However, I would not feel confined to participate at a level that was determined by an observational study such as ours. I’m sure we would agree that any reasonable increase in training is likely to benefit patient outcomes.

Kind regards,
Bob Raschke”
Simulation and education

A randomized education trial of spaced versus massed instruction to improve acquisition and retention of paediatric resuscitation skills in emergency medical service (EMS) providers

Catherine Patocka\textsuperscript{a,\*}, Adam Cheng\textsuperscript{b}, Matthew Sibbald\textsuperscript{c}, Jonathan P. Duff\textsuperscript{d}, Anita Lai\textsuperscript{a}, Patricia Lee-Nobbee\textsuperscript{a}, Helen Levin\textsuperscript{e}, Terry Varshney\textsuperscript{f}, Bryan Weber\textsuperscript{a}, Farhan Bhanji\textsuperscript{g}
Fig. 1 – Study outline.
Fig. 2 - Overview of participants enrolment (BLS denotes basic life support).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Massed group (n = 22)</th>
<th>Spaced group (n = 26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of EMS service</td>
<td>9.6 (±4.1)</td>
<td>9.1 (±4.9)</td>
</tr>
<tr>
<td>Female gender (%)</td>
<td>10 (46)</td>
<td>13 (50)</td>
</tr>
<tr>
<td>Provider type (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced care paramedic (EMT-P)</td>
<td>16 (73)</td>
<td>21 (81)</td>
</tr>
<tr>
<td>Primary care paramedic (EMT-A)</td>
<td>6 (27)</td>
<td>5 (19)</td>
</tr>
<tr>
<td>Previously completed PALS (%)</td>
<td>17 (77)</td>
<td>22 (85)</td>
</tr>
<tr>
<td>Timing of previous pediatric resuscitation (months)</td>
<td>47 ± 43</td>
<td>46 ± 43</td>
</tr>
<tr>
<td>Motivation to learn pediatric resuscitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Not at all motivated</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Slightly motivated</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(3) Moderately motivated</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(4) Very motivated</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>(5) Extremely motivated</td>
<td>11</td>
<td>15</td>
</tr>
</tbody>
</table>

EMS — Emergency Medical Services, EMT — Emergency Medical Technician, PALS — Pediatric Advanced Life Support.
**Infant chest compressions**

- **Global rating scale score**
  - Pre-course
  - Post-course
  - 3 months post-course

**Adult chest compressions**

- **Global rating scale score**
  - Pre-course
  - Post-course
  - 3 months post-course

**Bag valve mask ventilation**

- **Global rating scale score**
  - Pre-course
  - Post-course
  - 3 months post-course

**Intraosseous insertion**

- **Global rating scale score**
  - Pre-course
  - Post-course
  - 3 months post-course
### Table 2 - Differences in quantitative skills assessment scores between (1) pre-course to post-course (2) pre-course to 3 months post-course.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Massed (n=22)</th>
<th>Spaced (n=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-course</td>
<td>Post-course</td>
</tr>
<tr>
<td>Infant chest compressions</td>
<td>35.7 ± 27.9</td>
<td>90 ± 13.5</td>
</tr>
<tr>
<td>Adult chest compressions</td>
<td>40.3 ± 30.5</td>
<td>93 ± 6.6</td>
</tr>
<tr>
<td>Bag mask ventilation</td>
<td>48 ± 30.5</td>
<td>61.2 ± 27.7</td>
</tr>
<tr>
<td></td>
<td>Pre-course</td>
<td>3 months post-course</td>
</tr>
<tr>
<td>Infant chest compressions</td>
<td>35.7 ± 27.9</td>
<td>77.3 ± 25.7</td>
</tr>
<tr>
<td>Adult chest compressions</td>
<td>40.3 ± 30.5</td>
<td>90 ± 8.6</td>
</tr>
<tr>
<td>Bag mask ventilation</td>
<td>48 ± 30.5</td>
<td>48.1 ± 30.8</td>
</tr>
</tbody>
</table>
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