An international survey of preferred learning modalities and practice for critical skills in paediatric emergency medicine.


Participating networks include: the Pediatric Emergency Care Applied Research Network (PECARN), the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics (PEMRC), Pediatric Emergency Research Canada (PERC), Paediatric Emergency Research in the United Kingdom and Ireland (PERUKI), Pediatric Research in Emergency Departments International Collaborative (PREDICT), Research in European Pediatric Emergency Medicine (REPEM), and Red de Investigación y Desarrollo de la Emergencia Pediatrónica de Latinoamérica (RIDEPLA)

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3000 words, 6 tables / illustrations, 40 references

Papers must comply with the word count and figure, table and reference limit listed above.

All papers must include a separate title page documenting: authors' full names, academic and professional affiliations and complete addresses; the name and address of the corresponding author; the word count of the paper and the abstract (if applicable).

Original Papers, Reviews and Short Papers must include an abstract of no longer than 250 words. This should be a structured abstract listing the aim of the study (or review), the methods (or 'data sources' for a review), the results and the conclusion. Commentaries must include a brief abstract of no more than 100 words that summarises the key points.

Papers must be written concisely and conform to the style of Resuscitation. They should be clearly divided into sections: Introduction; Methods; Results; Discussion; Conclusions; Conflicts of Interest; Acknowledgments; References; Legends to figures. For review papers and commentaries use appropriate sub-headings instead of methods, results and discussion.

Statistical Methods
* Use nonparametric methods to compare groups when the distribution of the dependent variable is not normal.
* Use measures of uncertainty (e.g. confidence intervals) consistently.
* Report two-sided P values except when one-sided tests are required by study design (e.g., non-inferiority trials). Report P values larger than 0.01 to two decimal places, those between 0.01 and 0.001 to three decimal places; report P values smaller than 0.001 as P<0.001.
Abstract (<250 words) - currently 236 words

Aim: To describe senior paediatric emergency clinician perspectives on the optimal frequency of and preferred modalities for practicing critical paediatric procedures.

Methods: Multi-center multi-country cross-sectional survey of senior paediatric emergency clinicians working in 96 emergency departments (EDs) affiliated with the Pediatric Emergency Research Network (PERN).

Results: 1,332/2,446 (54%) clinicians provided information on suggested frequency of practice and preferred learning modalities for 18 critical procedures. Yearly practice was recommended for six procedures (bag-valve mask ventilation, cardiopulmonary resuscitation (CPR), endotracheal intubation, laryngeal mask airway insertion, defibrillation/DC-cardioversion and intraosseous needle insertion) by at least 80% of respondents. Two procedures (venous cutdown and ED thoracotomy) had yearly practice recommended by less than half of respondents. Simulation was the preferred learning modality for CPR, bag-valve-mask ventilation, DC-cardioversion and transcutaneous pacing. Attending alternative clinical settings (e.g. the operating room) was the preferred learning modality for endotracheal intubation and laryngeal mask insertion. Use of models/mannequins for isolated procedural training was the preferred learning modality for all other invasive procedures. Free text-responses suggested the utility of cadaver labs and animal labs for more invasive procedures (thoracotomy, intercostal catheter insertion, open surgical airways, venous cut-down and pericardiocentesis).

Conclusions: Paediatric ED clinicians suggest that selected paediatric critical procedures should be practiced at least annually. The preferred learning modality depends on the skill practiced; alternative clinical settings are thought to be most useful for standard airway maneuvers, while simulation-based experiential learning is applicable for most other procedures.
Preferred learning and practice for critical skills in PEM

Main text – currently 2916 words (max 3000)

Background

Worldwide, millions of ill and injured children require emergency care each year. In the United States alone, more than 23 million children under 15 years of age visited emergency departments (EDs) in 2013, equating to nearly 39 visits per 100 persons per year.(1) The most critically ill children require timely and effective life-saving interventions to ensure optimal outcomes. There is an expectation that those trained in emergency medicine (EM) are able to perform critical procedures required to treat a range of conditions in children, up to and including complex resuscitation.(2-6)

The existing knowledge, skills, experience and attitudes related to the performance of critical procedures on children by EM physicians has largely been reported from single institutions. There is limited data exploring procedural performance at a national or global level. Critical illness is uncommon in paediatric emergency medicine (PEM) practice.(7) As a result, the exposure of individual clinicians to critical and resuscitative procedures such as endotracheal intubation, central venous access, or advanced life support is infrequent.(8) This raises questions about an emergency physician's ability to maintain skills if relying solely on clinical experience.(9)

Mittiga and colleagues found that 0.22% of presentations to a large paediatric ED required a critical procedure. In their study, PEM fellows performed a median of three critical care procedures annually, with some performing none. During the study year, most attending faculty did not perform any such procedures.(10) Similarly, in an Australian study across three EDs (one tertiary paediatric hospital and two community hospitals), less than 1 in 1000 childhood ED presentations required a critical procedure; 83% of full-time EM physicians regularly exposed to children did not attempt or supervise a single paediatric intubation over the twelve-month study period.(11)

The issue of low exposure to critical paediatric procedures is relevant to all providers who evaluate and treat critically ill children, and may have a direct impact on the clinical outcomes of such patients. Optimal maintenance of skills is unlikely to occur through infrequent exposure to potentially stressful clinical scenarios. However, it is unknown how EM physicians view their educational needs in this context. Understanding providers’ perspectives on the optimal frequency of practice to maintain skills and preferred practice/learning strategies may guide the creation of national and international approaches to skills training and maintenance. Additionally these data could be used to set expectations related to the frequency of practice/performance required for ongoing certification/licensure to practice.
Our objective therefore was to perform an international survey of physicians who regularly care for children in emergency settings to obtain their views on how frequently they need to practice to reinforce the necessary skill set, and their preferred learning modalities for critical procedures in children.

Methods

Study design
This was a multicenter cross-sectional survey of senior EM physicians working in EDs affiliated with Pediatric Emergency Research Networks (PERN).(12) The survey was developed iteratively, through rounds of investigator contribution and refinement, underpinned by a review of relevant literature.(8-11, 13-18)

Survey development
The survey was administered using SurveyMonkey (http://www.surveymonkey.com). The final survey, which took 10-15 minutes to complete, was piloted by the investigators (with representatives from each network), and by ten EM physicians in three hospitals within Melbourne, Australia.

Questions included respondent demographics, training experience, hours of clinical work, and proportion of clinical work in PEM. Specific questions addressing recommended frequency of performance and preferred learning modalities were then asked regarding 18 critical procedures (including 7 airway and 11 non-airway procedures). Suggested frequency of practicing skills was assessed using a 7-point Likert scale (every month, every 3 months, every 6 months, every year, every two years, more than every two years, never). Preferred learning modalities were assessed by asking respondents to select all relevant options from a list including paediatric life support courses, simulated case scenarios / mock codes, use of models / mannequins, and attending alternative clinical settings (such as operating room / anaesthesiology). Free-text responses for preferred learning modalities were optional.

Critical procedures encompassed the following list of interventions: Cardiopulmonary resuscitation (CPR), endotracheal tube insertion, laryngeal mask airway insertion, surgical airway (needle cricothyrotomy, Seldinger technique, and open cricothyrotomy), tracheostomy change, bag-valve-mask, needle thoracocentesis, tube thoracostomy, defibrillation / DC-cardioversion, transcutaneous pacing, intraosseous line insertion, venous cutdown, central venous catheter insertion, arterial line insertion, pericardiocentesis, and ED thoracotomy.

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The final list of critical procedures was based upon the use of the procedure for the stabilization of airway, breathing or circulation, and inclusion in standard reference texts as essential skills in resuscitation.(19, 20). Consensus was achieved on the list of procedures by all investigators.

**Ethics approval**

The survey was approved by the Monash Health Human Research Ethics Committee as low-risk research and given ethical approval in accordance with the National Health and Medical Research Council’s National Statement on Ethical Conduct in Human Research.(21) Where required, additional local or regional institutional review board / ethics approval was obtained prior to distribution at each hospital.

**Setting**

Participating hospitals were affiliated with one of the following research networks: Pediatric Emergency Medicine Collaborative Research Committee (PEM-CRC, USA), Pediatric Emergency Care Applied Research Network (PECARN, USA), Pediatric Emergency Research Canada (PERC, Canada), Paediatric Emergency Research in the United Kingdom & Ireland (PERUKI, UK & Ireland), Paediatric Research in Emergency Departments International Collaborative (PREDICT, Australia and New Zealand), Research in European Pediatric Emergency Medicine (REPEM, 15 countries in Europe and the Middle East), and Red de Investigación y Desarrollo de la Emergencia Pediátrica de Latinoamérica (RIDEPLA, South America).

**Survey distribution and data collection.**

The survey was circulated between April 2015 and March 2016, depending upon the opportunity for distribution within each research network, with two reminders sent at weekly intervals. No incentive was offered for survey participation.

Each of the six networks contributing to PERN had at least one study investigator, who invited hospitals within their network to participate in the study. Information about the study and an invitation to participate was emailed to a nominated site representative at each hospital. If the site was able to participate, this person then distributed a “clinician survey” to eligible staff at their hospital.

The clinician survey was distributed to physicians who would be considered to be working in a supervisory / “senior” capacity in the ED at any time during their usual working week, defined as those who work without direct senior supervision at any point in a 24 hour cycle. It
was expected that this senior role would be fulfilled by different levels of staff in different settings; therefore, distribution occurred via the site representative with local knowledge.

Statistical analysis
Categorical descriptive data are presented as number and percentage. To simplify analysis, the categories for frequency of procedural practice were reduced to four: yearly (or more frequently), every 2 years, more than 2-yearly, and never.

For preferred learning modalities, comparisons were made between respondents who identified 100% of their clinical work as PEM and respondents who did not work all of their clinical time in PEM. Significance was determined using Chi-squared test or Fisher’s exact test as appropriate, with a p value of 0.01 chosen in view of multiple comparisons used. Comparison of preferred learning modalities for each procedure was also conducted between the six geographic regions, with significance determined using the Chi-squared test. Data were analyzed using IBM SPSS Statistics for Mac (version 23, IBM Corporation, Armonk, NY, USA).

Results
The survey was distributed to 2,446 physicians at 101 hospitals; five hospitals were later identified as being unable to participate, and did not contribute data. Of the physicians invited 1,524 (62%) completed at least demographic details, and 1,332 (54%) provided information on suggested frequency of practicing skills and preferred learning modalities for the 18 critical procedures. Table 1 summarizes response rate by region, while table 2 provides an overview of demographic data.

The majority (1,133; 85.1%) of respondents had specialist qualifications, although the specialty varied: the most common was dual qualification in paediatrics and PEM (516; 38.7%), followed by EM alone (221; 16.6%) and pediatrics alone (215; 16.1%). Most respondents (1,286; 96.5%) had been involved in paediatric life support training in the last five years, either as an instructor or a participant.

Figure 1 summarizes the recommended frequency of practice for all 18 critical procedures. Notably, three procedures (bag-valve mask ventilation, CPR and endotracheal intubation) were recommended for yearly practice by over 90% of respondents, while another three (laryngeal mask airway insertion, defibrillation / DC-cardioversion and intraosseous needle insertion) were recommended for yearly practice by 80% of respondents. 16 of 18 procedures were recommended for at least 2-yearly practice by 80% of respondents. Two procedures (venous cutdown and ED thoracotomy) had yearly practice recommended by
43% and 42% of respondents respectively, with more than 20% of respondents recommending that they should never be practiced. Simulated case scenarios / mock codes were the preferred learning modality for CPR, bag-valve-mask ventilation, DC-cardioversion and transcutaneous pacing. Attending alternative clinical settings (such as anesthesiology or the operating room) was the preferred learning modality for endotracheal intubation and laryngeal mask insertion (Figure 2). Use of models / mannequins for isolated procedural training was the preferred learning modality for all other invasive procedures (Figures 3 and 4).

A small proportion (173; 13%) of respondents provided additional free-text comments regarding other learning modalities for specific procedures. Cadaver labs and animal labs were most frequently mentioned for more invasive procedures, including ED thoracotomy, intercostal catheter insertion, open surgical airways, venous cutdown and pericardiocentesis. Three procedures received a number of free-text comments indicating that practicing the procedure in the paediatric ED setting was unnecessary: venous cutdown (38 respondents), ED thoracotomy (24 respondents), and arterial line (7 respondents).

With regards to preferred learning modalities for specific procedures, there was little difference between respondents who identified as working 100% of their clinical time in PEM and those who did not work all of their time in PEM (Appendix 1). Although response patterns were broadly similar between different geographic regions, there was significant variation in preferred learning modalities for some procedures (Appendix 2). For example, respondents from South America and Europe preferred learning modality for surgical airways was attending alternative clinical settings (such as anaesthesia), while respondents from Australia, New Zealand, the United Kingdom and Ireland preferred to attend a course.

**Discussion**

We report the optimal frequency of practice and preferred practice/learning strategies for paediatric critical procedures for 1,322 physicians who treat children in EDs in 96 hospitals, in 14 countries. At least annual practice was recommended by the majority of respondents for 6 of the 18 critical procedures, with at least 2-yearly practice recommended for 16 procedures. Our findings provide important information to guide the prioritization of training, the development of training curricula, the ongoing maintenance of critical procedural skills, and potentially the revalidation or recertification for practicing clinicians.
This is the first large-scale report of the learning needs for individual physicians who see critically unwell children in EDs. Previous work in this area has merely highlighted the infrequency with which individual physicians undertake these critical procedures when working in EDs in the United States(10) and Australia(11) indicating a possible educational need for further practice. These educational needs have now been confirmed.

The current evidence for procedural skills training in medicine supports the use of a “learn, see, practice, prove, do and maintain” framework.(22) After physicians have completed training they must continue to practice skills in order to maintain them. Practice in the clinical setting can be augmented by simulation-based practice. Either model of practice should be grounded in theoretical frameworks such as deliberate practice with feedback, mastery learning and rigorous assessment. Deliberate practice is a regimen of effortful activity described by Ericsson to optimize improvements in skill towards expertise.(23) This requires focused and repetitive practice with precise measurement and ongoing feedback, although this feedback is not often present in the clinical setting.

Simulation is defined by the Society for Simulation in Healthcare as “a technique that creates a situation or environment to allow persons to experience a representation of a real event for the purpose of practice, learning, or evaluation.”(24) Substantive research has been conducted demonstrating the positive impact of simulation-based practice compared to no practice,(25) and simulation training has led to positive clinical outcomes such as reduced neonatal injuries associated with shoulder dystocia,(26) and reduced risk of central-line associated infections.(27-29)

Simulation-based procedural training interventions can be applied to a wide variety of settings. Simulation related to procedures can be divided into integrated procedural training focusing on psychomotor performance (combining a series of discrete tasks to form a complex clinical task) or the whole procedure simulation (that involves role-play with actors to enable communication during performance). The psychomotor tasks are often performed on partial task trainers, which are devices or models representing a specific body part utilized to perform a specific procedure. They may have mechanical interfaces that provide feedback or be limited to a fixed bench-top model. Virtual reality simulations can use a variety of immersive and/or haptic techniques for procedural training on a screen-based interface.
The use of clinical opportunities for planned experiences in locations such as the operating room can be used to provide opportunities for experience and feedback from experts. This was preferred for endotracheal intubation and laryngeal mask insertion. Innovative approaches such as procedural shifts, cadaver labs,(30) and experiences with trauma/ICU services may be used to provide exposure to other procedures.

Our data may guide the development of best practices for skills maintenance, informed by the collective opinion of a large number of senior PEM clinicians. Based upon our results, continuing medical education programs for physicians who see critically unwell children in EDs should aim to provide at least yearly practice in 6, and 2-yearly practice in 16 of the 18 pediatric critical procedures assessed in our study.

Simulation was the preferred learning modality for CPR, bag-valve-mask ventilation, DC-cardioversion and transcutaneous pacing. Attending alternative clinical settings (such as anesthesiology or the operating room) was the preferred learning modality for endotracheal intubation and laryngeal mask insertion, while the use of models and mannequins for isolated procedural training was the preferred learning modality for all other invasive procedures.

Many procedures can be practiced using low cost simulators that are available in local CPR training programs (bag-valve mask ventilation, CPR, endotracheal intubation, defibrillation / DC-cardioversion and intraosseous needle insertion). However, simulation-based experiential learning (through the use of scenarios, models or life support courses) was preferred for a number of procedures.

While the required frequency, dose and intensity of practice are likely specific to each learner and procedure we did not find any meaningful difference with regard to time spent in PEM practice per week. This may reflect a perceived need for practice even from those with mastery of skills. The terms “forgetting curves” and “deskilling” have been applied to the loss of skills over time, with deliberate practice protecting against this process.(31, 32)

Possible explanations for the two procedures with less emphasis on regular practice include the lack of perceived need for venous cut-down with improvements in intraosseous access devices(33, 34), and the infrequent need for a highly skilled and somewhat controversial procedure such as ED thoracotomy.(35, 36)
Similarly, some respondents also expressed the opinion that arterial line and umbilical line placement are procedural skills that physicians who treat children in EDs do not require. These comments likely reflect the heterogeneity of the 96 hospitals who participated in the study, with other clinicians either providing these skills (arterial line placement) or patients who require the procedures not presenting to their institutions (newborns requiring umbilical lines). Despite the heterogeneity of the hospitals included in this study the results were remarkably consistent. However, educational programs should ideally reflect local needs.

Collaborative efforts to develop and share evidence-based and effective training and assessment interventions are important. One example of this work is the International Network for Simulation-based Pediatric Innovation, Research, and Education (INSPIRE), which has developed checklist instruments(37) and assessed the implementation of a point-of-care competency-based infant lumbar puncture program.(38) Although lumbar puncture is often undertaken in a less time-critical manner to the critical procedures listed in our paper, similar methodology may well be able to applied to other, more urgent interventions. Other examples of collaborative training and assessment resources include Open Pediatrics, MedEDPortal and FOAM (Free Open Access Meducation).(39)

Limitations of our work include reporting bias due to physicians self-reporting their experiences and perspectives. There is no gold standard for procedural competence or need for further practice, however, it is likely that physicians are able to self-assess confidence in various procedures. Additionally, it is unknown whether high levels of confidence or recent procedural experience actually translate into fewer procedural complications or better outcomes for critically ill children. Finally, as the survey recruited physicians largely from academic medical centers in the developed world, these data may not represent a true global perspective on this problem.

Physicians who treat children in EDs report that most critical procedural skills should be practiced every two years, with selected resuscitation procedures (endotracheal intubation, laryngeal mask airway insertion, bag-valve-mask ventilation, CPR, defibrillation / DC-cardioversion and intraosseous access) requiring at least yearly practice. The choice of learning modalities for maintenance of critical procedural skills depends on the skills being practiced: alternative clinical settings (such as anesthesiology) are preferred for endotracheal intubation and laryngeal mask insertion; simulated case scenarios are preferred for transcutaneous pacing, defibrillation / DC-cardioversion and CPR, while models / mannequins are preferred for most other invasive procedures, including surgical airways.
and advanced vascular access techniques. This data, from a large population of senior EM physicians, should inform the development of continuing medical educational activities to maintain critical procedural skills for PEM practitioners.
Table 1.
Response rate to survey, by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of responses</th>
<th>Number of invited participants</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia / New Zealand</td>
<td>169</td>
<td>283</td>
<td>60%</td>
</tr>
<tr>
<td>United Kingdom and Ireland</td>
<td>363</td>
<td>573</td>
<td>63%</td>
</tr>
<tr>
<td>United States of America</td>
<td>526</td>
<td>1062</td>
<td>50%</td>
</tr>
<tr>
<td>Canada</td>
<td>138</td>
<td>253</td>
<td>55%</td>
</tr>
<tr>
<td>Europe</td>
<td>106</td>
<td>195</td>
<td>54%</td>
</tr>
<tr>
<td>South America</td>
<td>30</td>
<td>80</td>
<td>38%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,332</td>
<td>2,446</td>
<td>54%</td>
</tr>
</tbody>
</table>
### Table 2. Demographic data of respondents (n=1332).

<table>
<thead>
<tr>
<th></th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>726 (54.5)</td>
</tr>
<tr>
<td><strong>Specialist qualifications</strong></td>
<td></td>
</tr>
<tr>
<td>Pediatrics and PEM</td>
<td>516 (38.7)</td>
</tr>
<tr>
<td>EM alone</td>
<td>221 (16.6)</td>
</tr>
<tr>
<td>Pediatrics alone</td>
<td>215 (16.1)</td>
</tr>
<tr>
<td>None</td>
<td>199 (14.9)</td>
</tr>
<tr>
<td>PEM and EM</td>
<td>72 (5.4)</td>
</tr>
<tr>
<td>PEM alone</td>
<td>70 (5.3)</td>
</tr>
<tr>
<td>Pediatrics and EM</td>
<td>18 (1.4)</td>
</tr>
<tr>
<td>Other specialty</td>
<td>9 (0.7)</td>
</tr>
<tr>
<td>EM and other specialty</td>
<td>5 (0.4)</td>
</tr>
<tr>
<td>Pediatrics and other specialty</td>
<td>5 (0.4)</td>
</tr>
<tr>
<td>PEM and other specialty</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td><strong>Clinical work</strong></td>
<td></td>
</tr>
<tr>
<td>Clinical hours worked per week</td>
<td>25 (18 – 32) †</td>
</tr>
<tr>
<td><strong>Percentage of clinical hours worked in PEM</strong></td>
<td></td>
</tr>
<tr>
<td>0-24%</td>
<td>309 (19.3)</td>
</tr>
<tr>
<td>25-49%</td>
<td>229 (14.3)</td>
</tr>
<tr>
<td>50-74%</td>
<td>97 (6.1)</td>
</tr>
<tr>
<td>75-100%</td>
<td>967 (60.4)</td>
</tr>
<tr>
<td>100% of clinical hours worked in PEM</td>
<td>726 (54.5)</td>
</tr>
<tr>
<td><strong>Life support course participation in last 5 years</strong></td>
<td></td>
</tr>
<tr>
<td>Instructor</td>
<td>806 (60.5)</td>
</tr>
<tr>
<td>Participant</td>
<td>1001 (75.2)</td>
</tr>
<tr>
<td>No participation as either instructor or participant</td>
<td>46 (3.5)</td>
</tr>
</tbody>
</table>

EM = Emergency medicine, PEM = Pediatric emergency medicine.
† median (interquartile range)
Figure 1. Recommended frequency of practice, by procedure (n=1,332)
Preferred learning and practice for critical skills in PEM

Figure 2. Percentage of respondents selecting each learning modality for basic airway and non-invasive chest procedures.
Figure 3. Percentage of respondents selecting each learning modality for invasive airway and chest procedures.
Figure 4. Percentage of respondents selecting each learning modality for advanced vascular access procedures.
References


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