Exposure and confidence with critical non-airway procedures: a global survey of paediatric emergency medicine physicians

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Contributors statement page

Dr. Craig conceptualized and designed the study, collected data, drafted the initial manuscript, and reviewed and revised the manuscript.
All other authors (Dr Auerbach, Dr Cheek, Dr Babl, Dr Oakley, Dr Nguyen, Dr Rao, Dr Dalton, Dr Lyttle, Dr Mintegi, Dr Nagler, Dr Mistry, Dr Dixon, Dr Rino, Dr Kohn Loncarica and Dr Dalziel) designed the study, collected data, and reviewed and revised the manuscript.
All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Abstract

Background:

Children rarely experience critical illness, resulting in low exposure of emergency physicians (EPs) to critical procedures. Our primary objective was to describe senior EP confidence, most recent performance and/or supervision of critical non-airway procedures. Secondary objectives were to compare responses between those who work exclusively in PEM and those who do not, and to determine whether confidence changed for selected procedures according to increasing patient age.

Methods:

Survey of senior EPs working in 96 emergency departments (EDs) affiliated with the Pediatric Emergency Research Networks (PERN). Questions assessed training, performance, supervision, and confidence in 11 non-airway critical procedures, including CPR, vascular access, chest decompression and cardiac procedures.

Results:

Of 2,446 physicians, 1,503 (61%) responded to the survey. Within the previous year, only CPR and insertion of an intraosseous needle (IO) had been performed by at least 50% of respondents: over 20% had performed defibrillation / DC cardioversion. More than 50% of respondents had never performed or supervised ED thoracotomy, pericardiocentesis, venous cutdown or transcutaneous pacing. Self-reported confidence was high for all patient age groups for CPR, needle thoracocentesis, tube thoracostomy, IO insertion and defibrillation / DC-cardioversion. Confidence levels increased with increasing patient age for central venous and arterial line insertion. Respondents working exclusively in PEM were more likely to report being at least somewhat confident in defibrillation / DC cardioversion, IO insertion, and central venous line insertion in particular age groups; however, they were less likely to be at least somewhat confident in ED thoracotomy and transcutaneous pacing.

Conclusions: CPR and IO insertion were the only critical non-airway procedures performed by at least half of EPs within the previous year. Confidence was higher for these procedures, and needle and tube thoracostomy. These data may inform the development of continuing medical education activities to maintain pediatric procedural skills for emergency physicians.

Introduction

Worldwide, millions of ill and injured children require emergency care each year. In the United States alone, more than 27 million children visited emergency departments (EDs) in 2014.[1] Critically ill children require timely and effective life-saving interventions to ensure optimal outcomes. Those trained in emergency medicine (EM) should be able to perform critical procedures required to treat a range of conditions in children, up to and including complex resuscitation.[2]

ED presentations for critical illness are uncommon in children living in high-income countries.[3] As a result, individual EM or pediatric EM (PEM) clinicians' exposure to critical and resuscitative procedures such as endotracheal intubation, central venous access, or advanced life support is infrequent.[4] Mittiga and colleagues found that only 0.22% of visits to a single large pediatric ED required a critical procedure. In their study, senior trainees (PEM fellows) performed a median of three critical care procedures annually with orotracheal intubation comprising 56% of all procedures.[5] Some senior trainees, and most attending physicians, did not perform any such procedures in a given year.[5] Similarly, in an Australian study across three EDs (one tertiary pediatric hospital and two community hospitals), less than 0.1% of pediatric presentations required a critical procedure over the twelve-month study period, with endotracheal intubation accounting for 73% of all such procedures.[6] This rarity of experience with critical procedures raises questions about the ability of individual emergency physicians to maintain skills if relying solely on clinical exposure.[7]

Significant attention has been paid to assessment and improvement of PEM physicians' airway procedural skills, particularly endotracheal intubation.[8-15] However, there has been much less emphasis on skills maintenance for critical *non-airway* procedures. Competency with non-airway procedures is relevant to all providers who evaluate and treat critically ill children, and may directly impact the clinical outcomes of patients. However, it is unknown how frequently EM physicians globally perform these critical procedural skills. Understanding physicians' frequency of performance of these procedures may guide the creation of national and international approaches to skills training and maintenance.

Our primary objective was to perform an international survey of physicians who regularly care for children in emergency settings to assess their recent performance or supervision, and confidence in undertaking various non-airway critical procedures. Secondary objectives were to compare responses between emergency physicians who exclusively care for children and those who do not; to determine whether confidence varied according to patient age group for selected procedures; and to make comparisons across different geographic regions.

Methods

Study design

This was a multicenter, international cross-sectional survey of senior physicians working in EDs affiliated with Pediatric Emergency Research Networks (PERN),[16] and is presented according to the STROBE statement on reporting of observational studies.[17]

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.

The survey was developed iteratively, through rounds of investigator contribution and refinement, underpinned by a review of relevant literature.[4,6,18] Questions included respondent demographics, postgraduate training background (PEM, pediatric, EM), hours of clinical work, and proportion of clinical work in PEM. Specific questions addressed most recent performance, supervision, and confidence in performing various critical procedures, including 11 non-airway procedures.

The final consensus 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] Critical non-airway procedures encompassed the following interventions: Cardiopulmonary resuscitation (CPR), needle thoracocentesis, tube thoracostomy, defibrillation / DC-cardioversion, transcutaneous pacing, intraosseous needle insertion, venous cutdown, central venous catheter insertion, arterial line insertion, pericardiocentesis, and ED thoracotomy.

Respondents were asked to categorize their most recent performance and supervision of each procedure by selecting the most appropriate choice from within the last 3 months, within the last 6 months, within the last year, within the last 5 years, more than 5 years ago, or never. Procedural confidence was ranked on a 5-point Likert scale which was labeled as 1=not at all confident, 3=somewhat confident, and 5=very confident. For vascular access procedures, respondents were asked to rate their confidence for five different age groups: <3 months, 4-12 months, 1-5 years, 6-11 years, and 12 or more years.

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.[20] 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 pediatric emergency medicine 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), Pediatric Emergency Research in the United Kingdom & Ireland (PERUKI, UK & Ireland), Pediatric 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.

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. A nominated site representative at each hospital distributed the survey to eligible staff. 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.
The 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 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, and due to the infrequency of responses for the categories of within the last 3 months, within the last 6 months, and within the last year, it was decided to combine these categories into "within the last year". Also, confidence was dichotomized into "confident" (with a ranking of at least 3 on the 5-point Likert scale) and "not confident" (a ranking of 1 or 2).

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; a Bonferroni correction was applied to account for the multiple comparisons undertaken, with a p-value of 0.002 comparable to a p value of 0.05 from a single comparison. Similar analyses were performed when comparing responses between each research network and all other networks combined. 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 1,602 (65%) completed at least demographic details, and 1,503 (61%) provided information on most recent performance and supervision, and self-rated confidence for the 11 non-airway critical procedures (Table 1)

The majority (1,271; 84.6%) of respondents had specialist qualifications, although the specialty varied: the most common was dual qualification in pediatrics and PEM (574; 38.3%), followed by EM alone (257; 17.1%) and pediatrics alone (242; 16.1%). Most respondents (1,450; 96.5%) had been involved in pediatric life support training in the last five years, either as an instructor or a participant (Table 2).

The non-airway critical procedural experience for the study population is summarized in figures 1 (performance) and 2 (performance or supervision). Only two procedures (CPR and insertion of an intraosseous needle) had been performed by at least 50% of respondents within the previous year. The only other procedure performed by at least 20% of respondents was defibrillation / DC cardioversion. More than 50% of respondents had never performed or supervised ED thoracotomy, pericardiocentesis, venous cutdown or transcutaneous pacing. Self-reported confidence was high for CPR, a frequently performed procedure, but was also high for needle thoracocentesis and tube thoracostomy (Figure 3). Confidence appeared to increase with increasing patient age for central venous line and arterial line insertion (Figure 4), but was high in all age groups for insertion of an intraosseous needle and DC-cardioversion / defibrillation (Figure 5).

Those working exclusively in PEM, as compared to those also caring for adults, were more likely to report being at least somewhat confident in defibrillation / DC cardioversion of children aged 11 years or less, for intraosseous needle in children aged 4-12 months, and central venous line insertion in children aged 4 months to five years. They were also less likely to report never having done many of the procedures listed. Self-reported confidence was higher in ED thoracotomy and transcutaneous pacing for those not working exclusively in PEM. Comparisons between each research network and all other research networks are presented within the appendix.

Discussion

Successful completion of rarely performed procedures may make the difference between life and death for pediatric emergencies. However, when a critical non-airway procedure is required – apart from CPR and intraosseous needle insertion - our findings suggest that most PEM physicians are unlikely to have recent hands-on experience. Most respondents had never performed or supervised ED thoracotomy, pericardiocentesis, venous cutdown or transcutaneous pacing. These findings provide important information to guide continuing medical education activities for emergency physicians who care for children.

Our results suggest that a practicing PEM physician can reasonably expect to insert an intraosseous needle, or perform CPR within the next twelve months. Both these procedures were associated with high levels of self-assessed confidence. In addition, both procedures require a limited number of reproducible steps, and are likely to be amenable to "rapid-cycle deliberate practice" – a process of repeated supervised attempts at resuscitation procedures with specific feedback and coaching, which has been shown to improve quality of life-support interventions.[21]

The successful use and familiarity with powered intraosseous needle systems may be partially responsible for the limited exposure of PEM physicians to central venous line insertion. In addition, arterial and central venous lines are used more often in the PICU setting. As these interventions are rarely time-critical, it may be reasonable to defer these procedures to more experienced intensive care or anesthesiology colleagues, who can undertake the procedure in more controlled conditions. However, for uncommon time-critical conditions such as cardiac tamponade, cardiac arrest from penetrating trauma, and tension pneumothorax, there will be occurrences when a child requires an emergent but life-saving procedure, and the only person available is an inexperienced proceduralist.

How should the wider health-care system respond to the likelihood that an inexperienced proceduralist may be the only option for a child requiring a critical intervention? We recommend that each emergency department determines a strategy to ensure that emergency physicians have either the training or the ready availability of external expert personnel to perform *all* necessary critical procedures.

In an environment where such critical procedures are very infrequent, how can individual PEM physicians maintain their skills? Current evidence supports the use of a “learn, see, practice, prove, do and maintain” framework.[25] After physicians have completed training they must continue to practice skills in order to maintain them. Deliberate practice is a regimen of effortful activity described by Ericsson to optimize improvements in skill towards expertise.[26] This requires focused and repetitive practice with precise measurement and ongoing feedback, although this feedback is not often present in the clinical setting. Simulation-based training with deliberate practice has been shown to be effective for achieving skill acquisition,[27] and to identify areas for improvement in resuscitation.[28,29] Recently, tools have been developed to assess specific procedural skills in the simulated setting.[30] Alternatives to traditional simulation training include live animal models[31,32], and the increasingly popular use of cadaver training labs.[33-35] Both methods appear to be highly rated by learners and provide superior fidelity, however, there are concerns regarding the use of live animal models including modulating effects of general anesthesia on the physiologic response to procedures, and concerns regarding animal welfare.[36] Understanding the relative frequency of – and provider confidence in - non-airway critical procedures highlights educational needs for emergency physicians, which may be met by the development of targeted educational programs. These programs should be designed to ensure regular deliberate practice to improve confidence and procedural competency.

Another challenge in evaluating the success of procedural education is the determination of the clinical effects of such training. 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. A study of pediatric residents found that after a workshop on procedural skills, the largest increases in self-reported confidence and competence were for those procedures with which they were least experienced.[22]

Complications may also be more likely in patients with an inexperienced proceduralist; a study of tube thoracostomies at an adult trauma center found a higher rate of complications when chest drain insertion was rated as 'difficult'.[23] Although the optimal approach is yet to be determined, recommendations for senior emergency physicians to perform such procedures appears reasonable, while suggestions for specialized staff (such as thoracic surgeons) to be available appears impractical.[24]

Limitations

Limitations of our work include bias due to physicians self-reporting their experience and confidence, and the possibility of sampling bias. As self-report, it is possible that our results either overestimate or underestimate actual practice and procedure performance. The responses gained from a survey circulated throughout global pediatric emergency medicine networks may not be representative of the wider general emergency medicine community, as most children presenting for emergency care do not attend specialized pediatric emergency departments.[4] However, it is a strength of our study that a large number of emergency physicians were not in exclusive PEM practice, increasing the external validity of our findings.

Finally, as the survey recruited physicians largely from academic medical centers in high-income countries, these data may not represent a true global perspective. The mortality rate and incidence of critical illness in children is much higher in low- and middle-income countries, therefore, clinicians practicing in these settings are expected to have different experiences and confidence in the range of critical procedures studied.

Conclusion

Our study provides unique data on senior ED physician experience and confidence in non-airway procedures. These findings indicate that few physicians performed procedures beyond CPR and intraosseous insertion. Confidence was high for CPR, chest decompression, and intraosseous needle insertion, and there was little difference in confidence levels between those practicing exclusively in PEM, and those working with a mixture of adults and children. These data should inform the development of continuing medical education activities to maintain critical procedural skills for PEM practitioners.

Table 1. Response rate to survey, according to region, or country, of clinical practice.

Region	Number of invited participants	Number of responses (%)
United States of America	1,062	613 (58)
Canada	253	151 (60)
South America	80	34 (43)
Australia / New Zealand	283	184 (65)
United Kingdom and Ireland	573	407 (71)
Europe	195	114 (58)
TOTAL	2,446	1,503 (61)

Table 2. Demographic data of respondents (n=1,503).

	n (%)
Female*	831 (55.6)
Specialist qualifications	
No specialist qualification	232 (15.4)
Pediatrics and PEM	574 (38.3)
EM alone	257 (17.1)
Pediatrics alone	242 (16.1)
PEM and EM	80 (5.3)
PEM alone	75 (5.0)
Pediatrics and EM	19 (1.3)
Other specialty† (combined with EM, PEM or Pediatrics)	10 (0.6)
Other specialty† alone	14 (1.0)
Clinical hours worked per week (mean, range)	25 (18 – 32) ‡
Percentage of clinical time devoted to pediatric emergency care	
0-24%	292 (19.4)
25-49%	214 (14.2)
50-74%	92 (6.1)
75-99%	101 (6.7)
100%	804 (53.5)
Life support course participation in last 5 years	
Instructor	311 (20.7)
Participant only	570 (37.9)
Both instructor or participant	569 (37.9)
Neither instructor nor participant	53 (3.5)

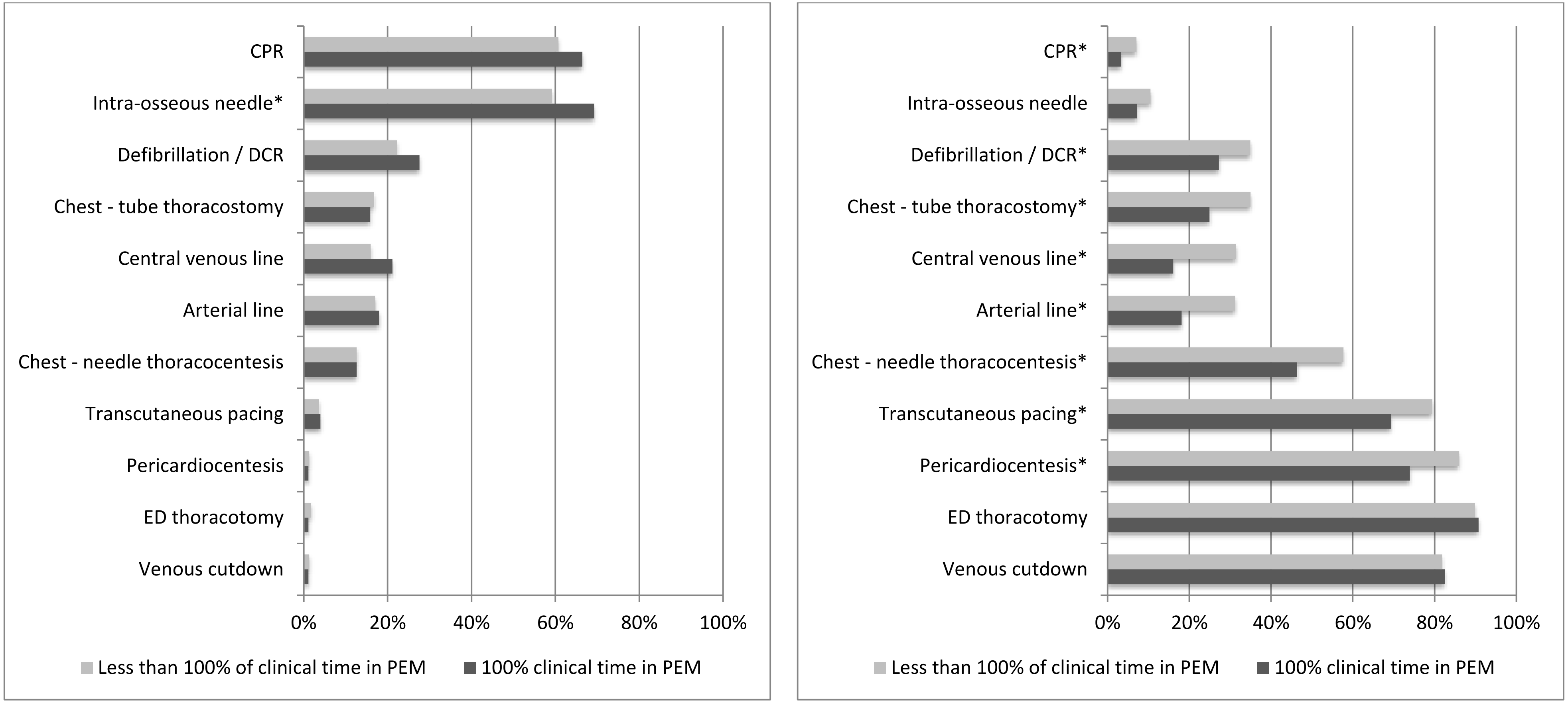
EM = Emergency medicine, PEM = Pediatric emergency medicine.

* missing data for 8 respondents

† other specialties included anesthesiology, intensive care, and general practice

‡ median (interquartile range)

Figure 1. Percentage of respondents who had performed each procedure: comparison of those working exclusively in PEM to those working less than 100% of clinical time in PEM. (a) Performed or supervised within the last 12 months, and (b) never performed or supervised (* denotes significant difference at p<0.002).



a

b

Figure 2. Percentage of respondents who had performed or supervised each procedure: comparison of those working exclusively in PEM to those working less than 100% of clinical time in PEM. (a) Performed or supervised within the last 12 months, and (b) never performed or supervised (* denotes significant difference at p<0.002).

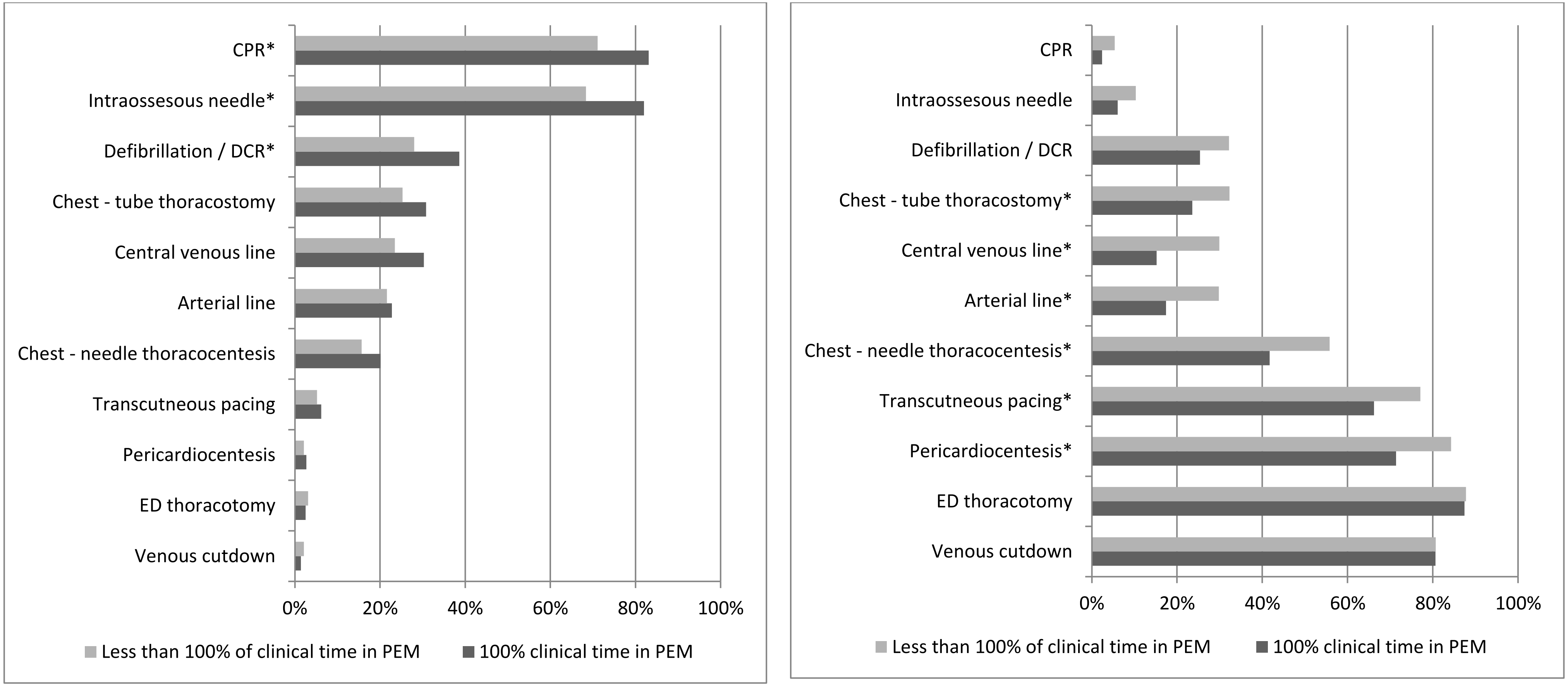


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Figure 3. Percentage of respondents reporting "at least somewhat confident" for non-airway critical procedures: comparison of those working exclusively in PEM to those working less than 100% of clinical time in PEM (* denotes significant difference at p<0.002).

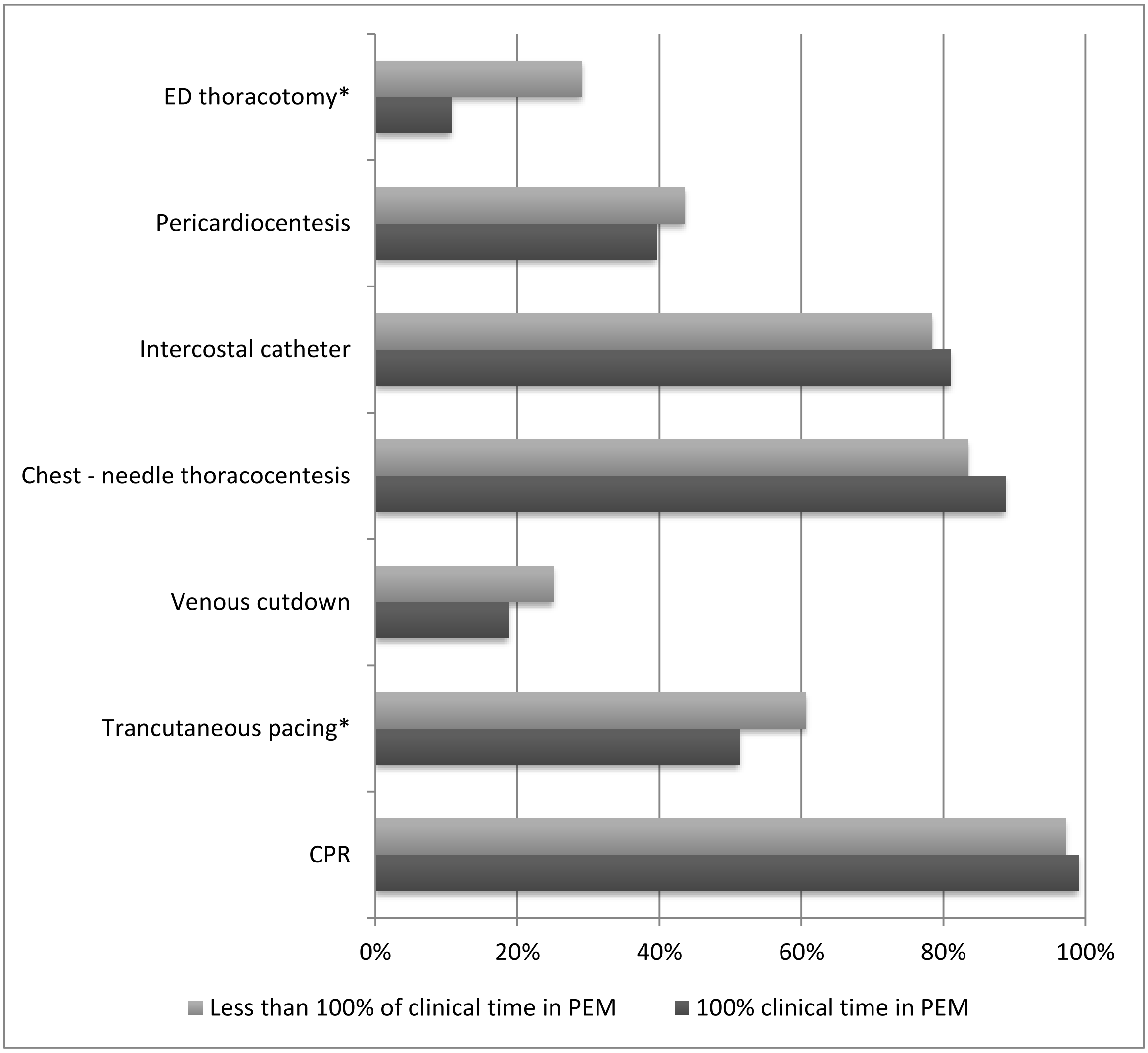


Figure 4. Percentage of respondents reporting “at least somewhat confident” for central venous line and arterial line insertion according to patient age group, comparing those with exclusive PEM clinical practice to those with less than 100% PEM clinical practice (* denotes significant difference at p<0.002).

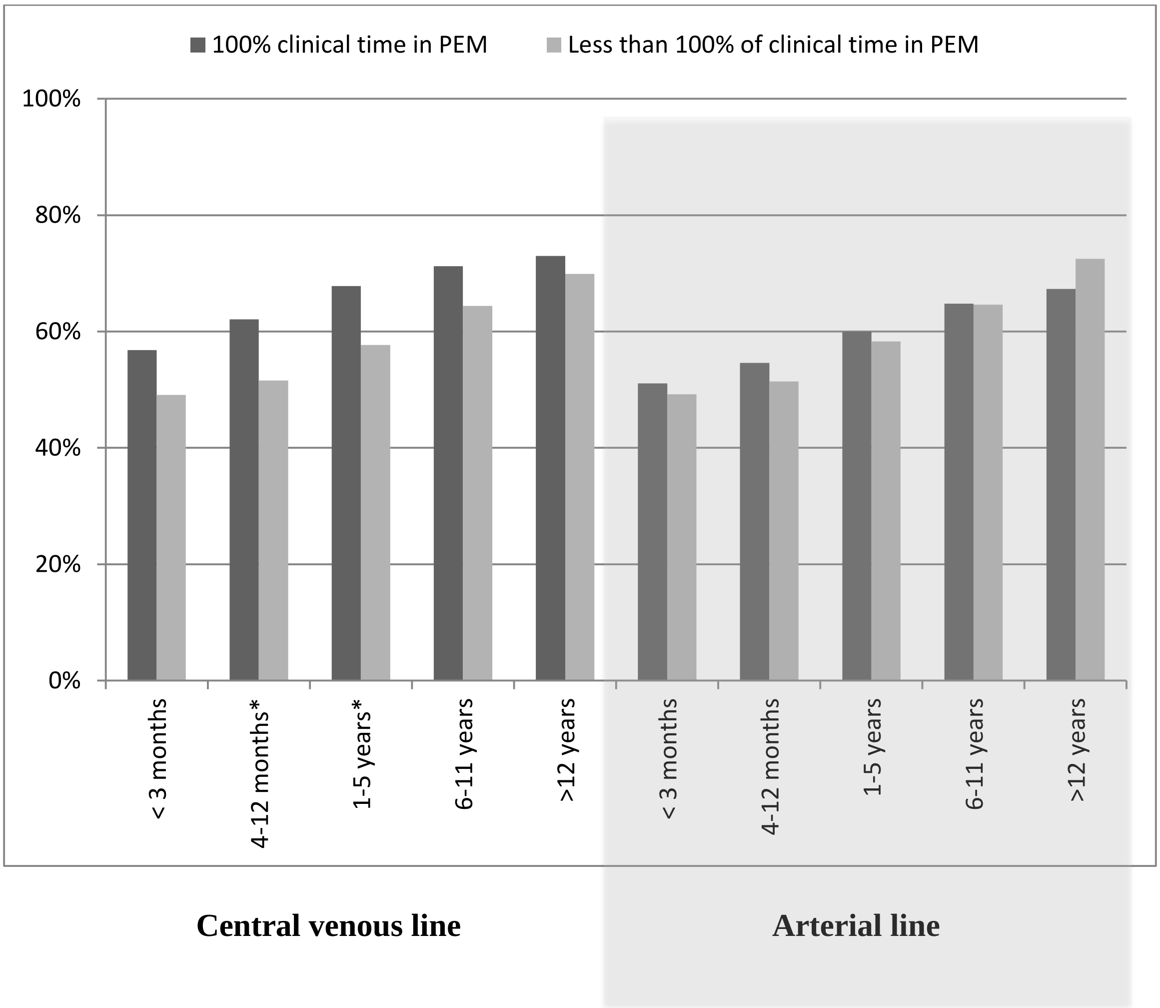
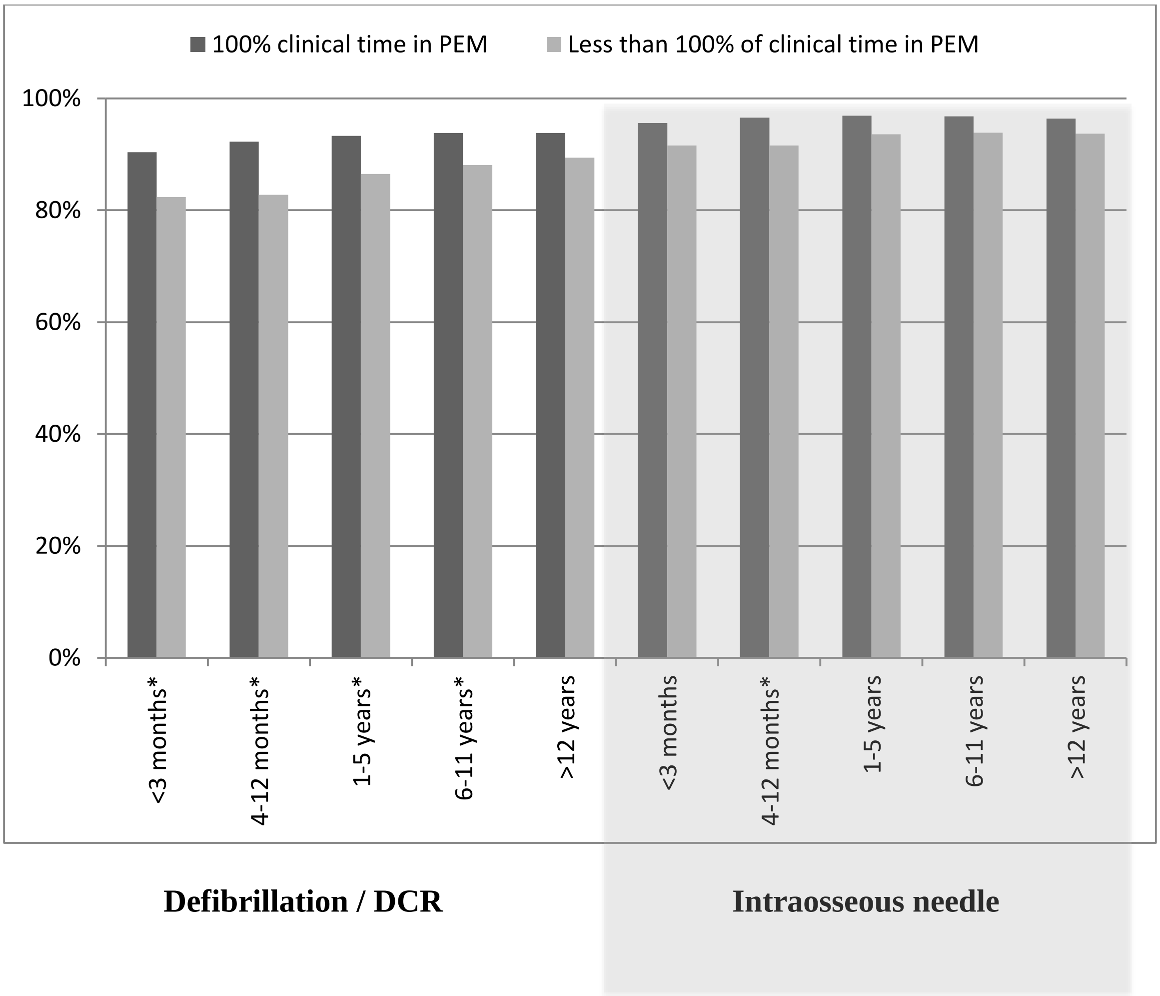


Figure 5. Percentage of respondents reporting “at least somewhat confident” for defibrillation / DC cardioversion and interosseous needle insertion according to patient age group, comparing those with exclusive PEM clinical practice to those with less than 100% PEM clinical practice (* denotes significant difference at p<0.002).



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Supplementary online material: Comparison between each research network and all other respondents.

PREDICT Network (Australia and New Zealand), n=184 vs all other respondents (n=1319).

Table A1: Performance or supervisión of each critical procedure within the last year: PREDICT vs non-PREDICT responses

	PREDICT network n (%)	Non-PREDICT network n (%)	P value*
CPR	129 (70.1)	1040 (78.8)	0.008
Chest needle	22 (12)	250 (19)	0.021
Tube thoracostomy	60 (32.6)	365 (27.7)	0.164
Defibrillation / DCR	42 (22.8)	464 (35.2)	0.001
Transcutneous pacing	6 (3.3)	80 (6.1)	0.125
Intraossesous needle	129 (70.1)	1008 (76.4)	0.062
Venous cutdown	1 (0.5)	25 (1.9)	0.188
Central venous line	39 (21.2)	369 (28)	0.053
Arterial line	55 (29.9)	279 (21.2)	0.008
Pericardiocentesis	2 (1.1)	35 (2.7)	0.199
ED thoracotomy	3 (1.6)	39 (3)	0.306

* Calculated using Chi-square test

Table A2: Never performed or supervised each critical procedure: PREDICT vs non-PREDICT responses

	PREDICT network n (%)	Non-PREDICT network n (%)	P value*
CPR	3 (1.6)	54 (4.1)	0.145
Chest needle	89 (48.4)	636 (48.2)	0.969
Tube thoracostomy	39 (21.2)	377 (28.6)	0.036
Defibrillation / DCR	56 (30.4)	373 (28.3)	0.543
Transcutneous pacing	136 (73.9)	935 (70.9)	0.396
Intraossesous needle	9 (4.9)	112 (8.5)	0.093
Venous cutdown	153 (83.2)	1059 (80.3)	0.425
Central venous line	32 (17.4)	299 (22.7)	0.128
Arterial line	24 (13)	324 (24.6)	0.001
Pericardiocentesis	156 (84.8)	1007 (76.3)	0.01
ED thoracotomy	170 (92.4)	1147 (87)	0.036

* Calculated using Chi-square test

Table A3: Proportion of PREDICT and non-PREDICT respondents reporting “at least somewhat confident” for each procedure.

	PREDICT network n (%)	Non-PREDICT network n (%)	P value*
CPR	183 (100)	1263 (97.9)	0.048
Pacing	124 (67.8)	692 (53.9)	<0.001
Venous cutdown	61 (33.3)	258 (20.1)	<0.001
Chest needle	174 (95.6)	1092 (85)	<0.001
Tube thoracostomy	171 (93.4)	999 (77.9)	<0.001
Pericardiocentesis	82 (45.1)	525 (40.9)	0.289
ED thoracotomy	43 (23.6)	240 (18.7)	0.112
Defibrillation / DCR <3 months	171 (94.5)	1076 (85.5)	0.001
Intraosseous needle <3 months	177 (97.8)	1173 (93.2)	0.016
CVC <3 months	110 (61.1)	657 (52.1)	0.023
Arterial line <3 months	121 (66.9)	602 (47.8)	<0.001
Defibrillation / DCR 4-12 months	169 (93.9)	1097 (87.1)	0.009
Intraosseous needle 4-12 months	180 (99.4)	1179 (93.6)	0.001
CVC 4-12 months	116 (64.1)	709 (56.2)	0.046
Arterial line 4-12 months	134 (74)	631 (50.1)	<0.001
Defibrillation / DCR 1-5 years	174 (96.1)	1126 (89.2)	0.004
Intraosseous needle 1-5 years	179 (98.9)	1193 (94.8)	0.015
CVC 1-5 years	133 (73.9)	775 (61.5)	0.001
Arterial line 1-5 years	148 (82.2)	702 (55.9)	<0.001
Defibrillation / DCR 6-11 years	175 (96.7)	1137 (90.3)	0.005
Intraosseous needle 6-11 years	179 (98.9)	1195 (94.9)	0.017
CVC 6-11 years	146 (80.7)	834 (66.2)	<0.001
Arterial line 6-11 years	163 (91.1)	766 (60.9)	<0.001
Defibrillation / DCR 12 or more years	174 (96.7)	1148 (91)	0.01
Intraosseous needle 12 or more years	180 (99.4)	1189 (94.5)	0.004
CVC 12 or more years	154 (85.1)	877 (69.6)	<0.001
Arterial line 12 or more years	169 (93.4)	835 (66.3)	<0.001

* Calculated using Chi-square test

PERUKI Network (United Kingdom and Ireland), n=407 vs all other respondents (n=1096).

Table A4: Performance or supervisión of each critical procedure within the last year: PERUKI vs non-PERUKI responses

	PERUKI network n (%)	Non-PERUKI network n (%)	P value*
CPR	301 (74)	868 (79.2)	0.03
Chest needle	59 (14.5)	213 (19.4)	0.027
Tube thoracostomy	79 (19.4)	346 (31.6)	<0.001
Defibrillation / DCR	88 (21.6)	418 (38.1)	<0.001
Transcutneous pacing	9 (2.2)	77 (7)	<0.001
Intraossesous needle	307 (75.4)	830 (75.7)	0.904
Venous cutdown	6 (1.5)	20 (1.8)	0.643
Central venous line	82 (20.1)	326 (29.7)	<0.001
Arterial line	105 (25.8)	229 (20.9)	0.042
Pericardiocentesis	11 (2.7)	26 (2.4)	0.713
ED thoracotomy	11 (2.7)	31 (2.8)	0.895

* Calculated using Chi-square test

Table A5: Never performed or supervised each critical procedure: PERUKI vs non-PERUKI responses

	PERUKI network n (%)	Non-PERUKI network n (%)	P value*
CPR	22 (5.4)	35 (3.2)	0.046
Chest needle	222 (54.5)	503 (45.9)	0.003
Tube thoracostomy	162 (39.8)	254 (23.2)	<0.001
Defibrillation / DCR	154 (37.8)	275 (25.1)	<0.001
Transcutneous pacing	340 (83.5)	731 (66.7)	<0.001
Intraossesous needle	30 (7.4)	91 (8.3)	0.555
Venous cutdown	333 (81.8)	879 (80.2)	0.481
Central venous line	163 (40)	168 (15.3)	<0.001
Arterial line	142 (32.9)	206 (18.8)	<0.001
Pericardiocentesis	345 (84.8)	818 (74.6)	<0.001
ED thoracotomy	365 (89.7)	952 (86.9)	0.14

* Calculated using Chi-square test

Table A6: Proportion of PERUKI and non-PERUKI respondents reporting "at least somewhat confident" for each procedure.

	PERUKI network n (%)	Non-PERUKI network n (%)	P value*
CPR	396 (99.2)	1050 (97.8)	0.059
Pacing	217 (54.5)	599 (56)	0.604
Venous cutdown	118 (29.6)	201 (18.8)	<0.001
Chest needle	355 (89.4)	911 (85.1)	0.034
Tube thoracostomy	334 (84.3)	836 (78.1)	0.009
Pericardiocentesis	173 (43.5)	434 (40.7)	0.334
ED thoracotomy	131 (32.8)	152 (14.2)	<0.001
Defibrillation / DCR <3 months	318 (81.5)	929 (88.6)	<0.001
Intraosseous needle <3 months	375 (95.9)	975 (92.9)	0.039
CVC <3 months	179 (45.8)	588 (55.9)	0.001
Arterial line <3 months	208 (53.2)	515 (41.9)	0.166
Defibrillation / DCR 4-12 months	325 (83.3)	941 (89.6)	0.001
Intraosseous needle 4-12 months	374 (95.9)	985 (93.7)	0.113
CVC 4-12 months	190 (48.7)	635 (60.4)	<0.001
Arterial line 4-12 months	212 (54.2)	553 (52.7)	0.611
Defibrillation / DCR 1-5 years	343 (87.7)	957 (91)	0.067
Intraosseous needle 1-5 years	378 (97.2)	994 (94.7)	0.045
CVC 1-5 years	212 (54.2)	696 (66.3)	<0.001
Arterial line 1-5 years	232 (59.6)	618 (59)	0.833
Defibrillation / DCR 6-11 years	350 (90)	962 (91.5)	0.356
Intraosseous needle 6-11 years	379 (97.2)	995 (94.8)	0.051
CVC 6-11 years	246 (62.9)	734 (69.9)	0.011
Arterial line 6-11 years	263 (67.3)	666 (63.7)	0.213
Defibrillation / DCR 12 or more years	359 (91.8)	963 (91.7)	0.95
Intraosseous needle 12 or more years	380 (97.4)	989 (94.3)	0.013
CVC 12 or more years	279 (71.4)	752 (71.6)	0.921
Arterial line 12 or more years	308 (78.8)	696 (66.3)	<0.001

* Calculated using Chi-square test

United States of America (PEM-CRC and PECARN networks), n=613 vs all other respondents (n=890).

Table A7: Performance or supervisión of each critical procedure within the last year: USA vs non-USA responses

	USA network n (%)	Non-USA network n (%)	P value*
CPR	301 (74)	868 (79.2)	0.03
Chest needle	59 (14.5)	213 (19.4)	0.027
Tube thoracostomy	79 (19.4)	346 (31.6)	<0.001
Defibrillation / DCR	88 (21.6)	418 (38.1)	<0.001
Transcutneous pacing	9 (2.2)	77 (7)	<0.001
Intraossesous needle	307 (75.4)	830 (75.7)	0.904
Venous cutdown	6 (1.5)	20 (1.8)	0.643
Central venous line	82 (20.1)	326 (29.7)	<0.001
Arterial line	105 (25.8)	229 (20.9)	0.042
Pericardiocentesis	11 (2.7)	26 (2.4)	0.713
ED thoracotomy	11 (2.7)	31 (2.8)	0.895

* Calculated using Chi-square test

Table A8: Never performed or supervised each critical procedure: USA vs non-USA responses

	USA network n (%)	Non-USA network n (%)	P value*
CPR	5 (0.8)	52 (5.8)	<0.001
Chest needle	243 (39.6)	482 (54.2)	<0.001
Tube thoracostomy	108 (17.6)	308 (34.6)	<0.001
Defibrillation / DCR	107 (17.5)	322 (36.2)	<0.001
Transcutneous pacing	377 (61.5)	694 (78)	<0.001
Intraossesous needle	22 (3.6)	99 (11.1)	<0.001
Venous cutdown	478 (78)	734 (82.5)	0.03
Central venous line	53 (8.6)	278 (31.2)	<0.001
Arterial line	75 (12.2)	273 (30.7)	<0.001
Pericardiocentesis	417 (68)	746 (83.8)	<0.001
ED thoracotomy	505 (82.4)	812 (91.2)	<0.001

* Calculated using Chi-square test

Table A9: Proportion of USA and non-USA respondents reporting “at least somewhat confident” for each procedure.

	USA network n (%)	Non-USA network n (%)	P value*
CPR	592 (99.3)	854 (97.4)	0.006
Pacing	361 (60.9)	455 (52.1)	0.001
Venous cutdown	110 (18.5)	209 (23.9)	0.014
Chest needle	539 (90.7)	727 (83.3)	<0.001
Tube thoracostomy	489 (82.3)	681 (78.1)	0.048
Pericardiocentesis	277 (46.7)	330 (37.8)	0.001
ED thoracotomy	84 (14.1)	199 (22.8)	<0.001
Defibrillation / DCR <3 months	538 (93.1)	709 (82.3)	<0.001
Intraosseous needle <3 months	564 (97.4)	786 (91.3)	<0.001
CVC <3 months	364 (62.9)	403 (46.7)	<0.001
Arterial line <3 months	297 (51.3)	426 (49.5)	0.499
Defibrillation / DCR 4-12 months	545 (94.3)	721 (83.6)	<0.001
Intraosseous needle 4-12 months	565 (97.6)	794 (92.1)	<0.001
CVC 4-12 months	392 (67.7)	433 (50.2)	<0.001
Arterial line 4-12 months	318 (55)	447 (51.9)	0.239
Defibrillation / DCR 1-5 years	549 (94.8)	751 (86.9)	<0.001
Intraosseous needle 1-5 years	569 (98.3)	803 (93.4)	<0.001
CVC 1-5 years	425 (73.5)	483 (56)	<0.001
Arterial line 1-5 years	354 (61.2)	496 (57.8)	0.194
Defibrillation / DCR 6-11 years	551 (95.2)	761 (88.4)	<0.001
Intraosseous needle 6-11 years	567 (97.9)	807 (93.7)	<0.001
CVC 6-11 years	438 (75.8)	542 (62.8)	<0.001
Arterial line 6-11 years	378 (65.5)	551 (64.1)	0.595
Defibrillation / DCR 12 or more years	549 (95)	773 (89.6)	<0.001
Intraosseous needle 12 or more years	561 (97.1)	808 (93.8)	0.005
CVC 12 or more years	446 (77.2)	585 (67.8)	<0.001
Arterial line 12 or more years	394 (68.2)	610 (70.8)	0.293

* Calculated using Chi-square test

Canada (PERC network) , n=151 vs all other respondents (n=1352).

Table A10: Performance or supervisión of each critical procedure within the last year: PERC vs non-PERC responses

	PERC network n (%)	Non-PERC network n (%)	P value*
CPR	118 (78.1)	1051 (77.7)	0.909
Chest needle	26 (17.2)	246 (18.2)	0.767
Tube thoracostomy	49 (32.5)	376 (27.8)	0.23
Defibrillation / DCR	54 (35.8)	452 (33.4)	0.566
Transcutneous pacing	8 (5.3)	78 (5.8)	0.813
Intraossesous needle	121 (80.1)	1016 (75.1)	0.176
Venous cutdown	1 (0.7)	25 (1.8)	0.289
Central venous line	31 (20.5)	377 (27.9)	0.054
Arterial line	16 (10.6)	318 (23.5)	<0.001
Pericardiocentesis	2 (1.3)	35 (2.6)	0.342
ED thoracotomy	3 (2)	39 (2.9)	0.525

* Calculated using Chi-square test

Table A11: Never performed or supervised each critical procedure: PERC vs non-PERC responses

	PERC network n (%)	Non-PERC network n (%)	P value*
CPR	1 (0.7)	56 (4.1)	0.039
Chest needle	65 (43)	660 (48.8)	0.178
Tube thoracostomy	19 (12.6)	397 (29.4)	<0.001
Defibrillation / DCR	26 (17.2)	403 (29.8)	0.001
Transcutneous pacing	96 (63.6)	975 (72.1)	0.028
Intraossesous needle	3 (2)	118 (8.7)	0.002
Venous cutdown	123 (81.5)	1089 (80.5)	0.788
Central venous line	16 (10.6)	315 (23.3)	<0.001
Arterial line	32 (21.2)	316 (23.4)	0.547
Pericardiocentesis	114 (75.5)	1049 (77.6)	0.56
ED thoracotomy	138 (91.4)	1179 (87.2)	0.138

* Calculated using Chi-square test

Table A12: Proportion of PERC and non-PERC respondents reporting "at least somewhat confident" for each procedure.

	PERC network n (%)	Non-PERC network n (%)	P value*
CPR	150 (100)	1296 (98)	1
Pacing	85 (56.7)	731 (55.5)	0.786
Venous cutdown	22 (14.8)	297 (22.5)	0.03
Chest needle	143 (95.3)	1123 (85.3)	0.001
Tube thoracostomy	131 (87.9)	1039 (78.9)	0.009
Pericardiocentesis	61 (40.7)	546 (41.5)	0.841
ED thoracotomy	19 (12.7)	264 (20)	0.03
Defibrillation / DCR <3 months	138 (95.2)	1109 (85.7)	0.001
Intraosseous needle <3 months	144 (98.6)	1206 (93.2)	0.01
CVC <3 months	70 (47.6)	697 (53.8)	0.153
Arterial line <3 months	57 (39)	666 (51.5)	0.004
Defibrillation / DCR 4-12 months	143 (97.3)	1123 (86.9)	<0.001
Intraosseous needle 4-12 months	145 (98.6)	1214 (93.8)	0.017
CVC 4-12 months	81 (55.1)	744 (57.5)	0.585
Arterial line 4-12 months	58 (39.7)	707 (54.6)	0.001
Defibrillation / DCR 1-5 years	142 (96.6)	1158 (89.4)	0.005
Intraosseous needle 1-5 years	145 (99.3)	1227 (94.9)	0.016
CVC 1-5 years	94 (63.9)	814 (63)	0.813
Arterial line 1-5 years	71 (48.6)	779 (60.4)	0.006
Defibrillation / DCR 6-11 years	142 (97.3)	1170 (90.4)	0.006
Intraosseous needle 6-11 years	144 (98.6)	1230 (95.1)	0.05
CVC 6-11 years	104 (71.2)	876 (67.6)	0.378
Arterial line 6-11 years	78 (53.8)	851 (65.9)	0.004
Defibrillation / DCR 12 or more years	143 (97.3)	1179 (91.1)	0.01
Intraosseous needle 12 or more years	143 (97.9)	1226 (94.8)	0.096
CVC 12 or more years	103 (70.5)	928 (71.7)	0.778
Arterial line 12 or more years	81 (55.5)	923 (71.3)	<0.001

* Calculated using Chi-square test

Europe (REPEM network) , n=114 vs all other respondents (n=1389).

Table A13: Performance or supervisión of each critical procedure within the last year: REPEM vs non-REPEM responses

	REPEM network n (%)	Non-REPEM network n (%)	P value*
CPR	44 (38.6)	1125 (81)	<0.001
Chest needle	14 (12.3)	258 (18.6)	0.093
Tube thoracostomy	10 (8.8)	415 (29.9)	<0.001
Defibrillation / DCR	14 (12.3)	492 (35.4)	<0.001
Transcutneous pacing	7 (6.1)	79 (5.7)	0.841
Intraossesous needle	34 (29.8)	1103 (79.4)	<0.001
Venous cutdown	3 (2.6)	23 (1.7)	0.442
Central venous line	15 (13.2)	393 (28.3)	<0.001
Arterial line	19 (16.7)	315 (22.7)	0.138
Pericardiocentesis	3 (2.6)	34 (2.4)	0.903
ED thoracotomy	1 (0.9)	41 (3)	0.196

* Calculated using Chi-square test

Table A14: Never performed or supervised each critical procedure: REPEM vs non-REPEM responses

	REPEM network n (%)	Non-REPEM network n (%)	P value*
CPR	26 (22.8)	31 (2.2)	<0.001
Chest needle	84 (73.3)	641 (46.1)	<0.001
Tube thoracostomy	69 (60.5)	347 (25)	<0.001
Defibrillation / DCR	75 (65.8)	354 (25.5)	<0.001
Transcutneous pacing	97 (85.1)	974 (70.1)	0.001
Intraossesous needle	51 (44.7)	70 (5)	<0.001
Venous cutdown	97 (85.1)	1115 (80.3)	0.211
Central venous line	52 (45.6)	279 (20.1)	<0.001
Arterial line	59 (51.8)	289 (20.8)	<0.001
Pericardiocentesis	100 (87.7)	1063 (76.5)	0.006

ED thoracotomy	108 (94.7)	1209 (87)	0.016

* Calculated using Chi-square test

Table A15: Proportion of REPEM and non-REPEM respondents reporting "at least somewhat confident" for each procedure.

	REPEM network n (%)	Non-REPEM network n (%)	P value*
CPR	93 (83)	1353 (99.4)	<0.001
Pacing	24 (21.8)	792 (58.4)	<0.001
Venous cutdown	5 (4.5)	314 (23.1)	<0.001
Chest needle	44 (39.6)	1222 (90.1)	<0.001
Tube thoracostomy	33 (29.7)	1137 (83.9)	<0.001
Pericardiocentesis	10 (9.1)	597 (44.1)	<0.001
ED thoracotomy	4 (3.6)	279 (20.6)	<0.001
Defibrillation / DCR <3 months	55 (49.1)	1192 (89.8)	<0.001
Intraosseous needle <3 months	64 (57.7)	1286 (96.8)	<0.001
CVC <3 months	30 (26.8)	737 (55.4)	<0.001
Arterial line <3 months	29 (26.4)	694 (52.2)	<0.001
Defibrillation / DCR 4-12 months	59 (52.7)	1207 (90.9)	<0.001
Intraosseous needle 4-12 months	71 (64)	1288 (96.8)	<0.001
CVC 4-12 months	32 (28.6)	793 (59.6)	<0.001
Arterial line 4-12 months	30 (27)	735 (55.3)	<0.001
Defibrillation / DCR 1-5 years	67 (59.8)	1233 (92.6)	<0.001
Intraosseous needle 1-5 years	76 (68.5)	1296 (97.6)	<0.001
CVC 1-5 years	32 (28.6)	876 (66)	<0.001
Arterial line 1-5 years	32 (28.8)	818 (61.7)	<0.001
Defibrillation / DCR 6-11 years	69 (61.6)	1243 (93.6)	<0.001
Intraosseous needle 6-11 years	79 (71.2)	1295 (97.4)	<0.001
CVC 6-11 years	34 (30.4)	946 (71.2)	<0.001
Arterial line 6-11 years	35 (31.5)	894 (67.5)	<0.001
Defibrillation / DCR 12 or more years	72 (64.3)	1250 (94.1)	<0.001
Intraosseous needle 12 or more years	79 (71.2)	1290 (97.1)	<0.001
CVC 12 or more years	36 (32.1)	995 (74.9)	<0.001
Arterial line 12 or more years	39 (35.1)	965 (72.6)	<0.001

* Calculated using Chi-square test

South / Central America (RIDEPLA network) , n=34 vs all other respondents (n=1469).

Table A16: Performance or supervisión of each critical procedure within the last year: RIDEPLA vs non-RIDEPLA responses

	RIDEPLA network n (%)	Non-RIDEPLA network n (%)	P value*
CPR	34 (100)	1135 (77.3)	0.002
Chest needle	8 (23.5)	264 (18)	0.405
Tube thoracostomy	8 (23.5)	417 (28.4)	0.534
Defibrillation / DCR	18 (52.9)	488 (33.2)	0.016
Transcutneous pacing	4 (11.8)	82 (5.6)	0.125
Intraossesous needle	20 (58.8)	1117 (76)	0.021
Venous cutdown	3 (8.8)	23 (1.6)	0.001
Central venous line	11 (32.4)	397 (27)	0.49
Arterial line	11 (32.4)	323 (22)	0.151
Pericardiocentesis	1 (2.9)	36 (2.5)	0.855
ED thoracotomy	2 (2.9)	41 (2.8)	0.958

* Calculated using Chi-square test

Table A17: Never performed or supervised each critical procedure: RIDEPLA vs non-RIDEPLA responses

	RIDEPLA network n (%)	Non-RIDEPLA network n (%)	P value*
CPR	0 (0)	57 (3.9)	0.637
Chest needle	22 (64.7)	703 (47.9)	0.052
Tube thoracostomy	19 (55.9)	397 (27)	<0.001
Defibrillation / DCR	11 (32.4)	418 (28.5)	0.619
Transcutneous pacing	25 (73.5)	1046 (71.2)	0.767
Intraossesous needle	6 (17.6)	115 (7.8)	0.037
Venous cutdown	28 (82.4)	1184 (80.6)	0.798

Central venous line	15 (44.1)	316 (21.5)	0.002
Arterial line	16 (47.1)	332 (22.6)	0.001
Pericardiocentesis	31 (91.2)	1132 (77.1)	0.052
ED thoracotomy	31 (91.2)	1286 (87.5)	0.525

* Calculated using Chi-square test

Table A18: Proportion of RIDEPLA and non-RIDEPLA respondents reporting "at least somewhat confident" for each procedure.

	RIDEPLA network n (%)	Non-RIDEPLA network n (%)	P value*
CPR	32 (97)	1414 (98.2)	0.604
Pacing	5 (15.2)	811 (56.6)	<0.001
Venous cutdown	3 (9.1)	316 (22)	0.075
Chest needle	11 (33.3)	1255 (87.5)	<0.001
Tube thoracostomy	12 (36.4)	1158 (80.8)	<0.001
Pericardiocentesis	4 (12.5)	603 (42.1)	0.001
ED thoracotomy	2 (6.3)	281 (19.6)	0.059
Defibrillation / DCR <3 months	27 (81.8)	1220 (86.8)	0.408
Intraosseous needle <3 months	26 (81.3)	1324 (94)	0.003
CVC <3 months	14 (42.4)	753 (53.4)	0.21
Arterial line <3 months	11 (33.3)	712 (50.6)	0.05
Defibrillation / DCR 4-12 months	25 (75.8)	1241 (88.2)	0.03
Intraosseous needle 4-12 months	24 (72.7)	1335 (94.8)	<0.001
CVC 4-12 months	14 (42.4)	811 (57.6)	0.082
Arterial line 4-12 months	13 (39.4)	752 (53.4)	0.11
Defibrillation / DCR 1-5 years	25 (75.8)	1275 (90.4)	0.005
Intraosseous needle 1-5 years	25 (75.8)	1347 (95.8)	<0.001
CVC 1-5 years	12 (37.5)	896 (63.6)	0.002
Arterial line 1-5 years	13 (40.6)	837 (59.6)	0.031
Defibrillation / DCR 6-11 years	25 (75.8)	1287 (91.5)	0.002
Intraosseous needle 6-11 years	26 (78.8)	1348 (95.8)	<0.001
CVC 6-11 years	12 (36.4)	968 (68.8)	<0.001
Arterial line 6-11 years	12 (36.4)	917 (65.4)	0.001
Defibrillation / DCR 12 or more years	25 (75.8)	1297 (92.1)	0.001
Intraosseous needle 12 or more years	26 (78.8)	1343 (95.5)	<0.001
CVC 12 or more years	13 (39.4)	1018 (72.3)	<0.001
Arterial line 12 or more years	13 (39.4)	991 (70.4)	<0.001

* Calculated using Chi-square test