Preferred learning modalities and practice for critical skills: a global survey of pediatric emergency medicine clinicians.

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Short title: Critical procedures in pediatric EM

Financial Disclosure The authors have no financial relationships relevant to this article to disclose

Funding source:
Stuart Dalziel's time was part funded by the Health Research Council of New Zealand (HRC13/556). Franz Babl and Ed Oakley are funded by the National Health and Medical Research Council project grant GNT1046727, Centre of Research Excellence for Paediatric Emergency Medicine GNT1058560), Canberra, Australia; and supported by the Victorian Government's Infrastructure Support Program, Melbourne, Australia. Franz Babl's time was part funded by a grant from the Royal Children's Hospital Foundation, Melbourne, Australia, a Melbourne Children's Clinician Scientist Fellowship, Melbourne, Australia; and an NHMRC Practitioner Fellowship, Canberra, Australia.

Potential Conflicts of Interest:
The authors have no conflicts of interest relevant to this article to disclose

Table of contents summary:
This worldwide survey of PEM physicians describes their perceived learning and practice needs for maintenance of skills in lifesaving critical procedures.

What is already known on this subject

Emergency clinicians should be able to perform various paediatric critical procedures, up to and including complex resuscitation. However, individual clinicians are rarely exposed to critically ill children, raising questions about skills maintenance if relying solely on clinical experience.

What this paper adds

Surveyed pediatric emergency physicians report that most critical procedural skills should be practiced at least yearly. The choice of learning modalities - alternative clinical settings (such as anesthesiology), simulated case scenarios and models / mannequins - depends on the skills being practiced.

Word count: 2488 (original submission 2996)

Contributors statement page

Dr. Craig and Dr Auerbach conceptualized and designed the study, collected data, drafted the initial manuscript, and reviewed and revised the manuscript.
All other authors (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, 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

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

Methods: Multi-center multi-country cross-sectional survey of senior pediatric 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. 16 procedures were recommended for yearly practice by at least 50% of respondents. Two procedures (venous cutdown and ED thoracotomy) had yearly practice recommended by less than 40% of respondents.
Simulation was the preferred learning modality for CPR, bag-valve-mask ventilation, DC-cardioversion and transcutaneous pacing. Practice in 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 most 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.

Introduction

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.[1]

In the developed world, critical paediatric illness is uncommon.[2] Mittiga and colleagues found that only 0.22% of presentations to a large pediatric ED in the United States required a critical procedure,[3] while Nguyen et al found the rate of such presentations was less than 0.1% across three Australian EDs.[4] Both studies demonstrated that most senior paediatric emergency medicine (PEM) clinicians did not perform a single critical procedure within a twelve-month period. As a result, individual clinicians' exposure to critical and resuscitative procedures such as endotracheal intubation, central venous access, or advanced life support is infrequent,[5] raising questions about the ability of clinicians to maintain relevant skills.[6] Optimal maintenance of skills is unlikely to occur through infrequent exposure to potentially stressful clinical scenarios.

There is very little evidence, and minimal consensus upon which to base recommendations for frequency of practice for various critical procedures – considerations include the relative task complexity, anticipated frequency of use, ease of practice, and current clinical exposure. 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).[7] The survey was developed iteratively, through rounds of investigator contribution and refinement, underpinned by a review of relevant literature.[4 5 8]

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. A formal content validity ratio was not determined.

Questions included respondent demographics, postgraduate training background (PEM, paediatric, EM), 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, less frequently than

every two years, never). Preferred learning modalities were assessed by asking respondents to select all relevant options from a list including pediatric life support courses, simulated case scenarios / mock codes, use of models / mannequins, and attending alternative clinical settings (such as operating room / anaesthesiology). Additional space for optional free-text responses for preferred learning modalities was provided.

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.[9] Critical procedures encompassed the following: Cardiopulmonary resuscitation (CPR), endotracheal tube insertion, laryngeal mask airway insertion, surgical airway (needle cricothyrotomy, Seldinger technique, and open cricothyrotomy), tracheostomy change, bag-valve-mask ventilation, 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.

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.[10] 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), 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.

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 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 site representatives with knowledge of local circumstances.

Statistical analysis

Categorical descriptive data are presented as number and percentage, with 95% confidence intervals.

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. Comparison of preferred learning modalities for each procedure was also conducted between the six geographic regions. 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 0.00031 comparable to a p value of 0.05 from a single comparison. 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 pediatrics 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 pediatric life support training in the last five years, either as an instructor or a participant.

Figure 1 and Table 3 summarize the recommended frequency of practice for all 18 critical procedures. Notably, four procedures (bag-valve mask ventilation, CPR, endotracheal intubation and laryngeal mask insertion) were recommended for 6-monthly practice by over 50% of respondents. Over 90% of respondents recommended yearly practice for bag-valve mask ventilation, CPR and endotracheal intubation, while another three procedures (laryngeal mask airway insertion, defibrillation / DC-cardioversion and intraosseous needle insertion) were recommended for yearly practice by at least 80% of respondents. 16 of 18 procedures were recommended for yearly practice by at least 50% of respondents. Two procedures (venous cutdown and ED thoracotomy) had yearly practice recommended by 35% and 34% of respondents respectively, with approximately 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. Four procedures received a free-text comments indicating that practicing the procedure was unnecessary: venous cutdown (38 respondents), ED thoracotomy (24 respondents), arterial line (7 respondents), and umbilical venous line (1 respondent).

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 One, supplementary online material). Those working 100% of their time in PEM were more likely to prefer alternative practice settings (such as anesthesia) for endotracheal tube intubation, and less likely to prefer a course for a number of other procedures. Although response patterns were broadly similar between different geographic regions, there was significant variation in preferred learning modalities for some procedures (Appendix Two, supplementary online material). 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

In the absence of a gold standard recommendation, we report the perceived optimal frequency of practice and preferred practice/learning strategies for pediatric 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 16 of the 18 critical procedures.

Previous work in this area has highlighted infrequent performance,[3 4] indicating a possible educational need for further practice. Our study provides some data regarding PEM clinicians' perceived need for this practice.

The current evidence for procedural skills training in medicine supports the use of a "learn, see, practice, prove, do and maintain" framework.[11] After physicians have completed training they must continue to practice skills in order to maintain them. *Deliberate practice* may protect against loss of skills over time,[12] and requires focus, repetition, precise measurement and ongoing feedback,[13] although this feedback is not often present in the clinical setting. Simulation-based experiential learning (through the use of scenarios, models or life support courses) can augment practice in the clinical setting, and was preferred for many of the procedures. Such training has many potential benefits, including improvements in procedural skills, teamwork, and crisis resource management.[14-16]

Published recommendations are mixed regarding optimal frequency of training. For example, the Australian and New Zealand College of Anaesthetists recommend training in "can't intubate, can't ventilate" scenarios once every three years;[17] on the other hand, previous work has identified the benefits of low-dose, high-frequency CPR training for paediatric inhospital providers, with greater skill retention for those experiencing instructor-led training compared to automated feedback training alone.[18]

"Rapid-cycle deliberate practice" which involves repeated supervised attempts at resuscitation procedures with specific feedback and coaching has been shown to improve quality of life support interventions such as rapid defibrillation and early initiation of compression.[19] It is unknown whether this translates to more complex interventions such as intubation, surgical airways, or other invasive procedures. However, this model may be adapted to such procedures to ensure that practitioners are able to practice – under

supervision, and with appropriate feedback - in a simulated setting multiple times until they can demonstrate proficiency.

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.

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[20], and the infrequent need for a highly skilled and somewhat controversial procedure such as ED thoracotomy.[21]

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. For example, the International Network for Simulation-based Pediatric Innovation, Research, and Education (INSPIRE), has developed checklist instruments for infant lumbar punctures;[22 23] this methodology may be applicable to other, more urgent interventions. Other examples of collaborative training and assessment resources include Open Pediatrics, MedEDPortal and FOAM (Free Open Access Meducation).[24]

Based upon both the learning theories presented above and responses from the physicians surveyed, we believe that deliberate practice with appropriate feedback is likely to be a useful

approach. Procedures should be practiced yearly, and the setting should be tailored to the procedure being practiced: the operating theatre may be preferred for non-surgical airway procedures, while simulated settings are appropriate for most other critical procedures.

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, although, it is likely that senior physicians are able to accurately report confidence in various procedures. However, 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.

Another source of reporting bias may relate to the perceived benefits or burdens of frequent procedural skills practice. Conceivably, respondents with a teaching role may derive professional benefit or additional income from increased uptake of procedural skills teaching. Others, however, may be disadvantaged, either through an increased non-reimbursed workload for teaching staff, unpaid time away from clinical work, or financial costs related to paying for procedural skills courses.

Despite this, the consistency of responses from a wide variety of settings – presumably with the inclusion of those who may be advantaged *and* those who may be disadvantaged by any particular recommendation - may indicate that the suggested frequencies are acceptable for our population of PEM clinicians.

It was beyond the scope of our study to document the procedures themselves, how often they are performed, and the outcomes of individual patients undergoing procedures.

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.

Conclusion

Physicians who treat children in EDs report that most critical procedural skills should be practiced at least yearly. The choice of learning modalities - alternative clinical settings (such as anesthesiology), simulated case scenarios and models / mannequins - depends on the skills being practiced. This data should inform the development of continuing medical education activities to maintain critical procedural skills for PEM practitioners.

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Table 1.

Response rate to survey, by region

Region	Number of responses	Number of invited participants	Response rate
Australia / New Zealand	169	283	60%
United Kingdom and Ireland	363	573	63%
United States of America	526	1062	50%
Canada	138	253	55%
Europe	106	195	54%
South America	30	80	38%
TOTAL	1,332	2,446	54%

Table 2. Demographic data of respondents (n=1332).

	n (%)
Female	726 (54.5)
Specialist qualifications	
No specialist qualification	199 (14.9)
Pediatrics and PEM	516 (38.7)
EM alone	221 (16.6)
Pediatrics alone	215 (16.1)
PEM and EM	72 (5.3)
PEM alone	70 (5.3)
Pediatrics and EM	18 (1.4)
Other specialty†	9 (0.7)
EM and other specialty	5 (0.4)
Pediatrics and other specialty†	5 (0.4)
PEM and other specialty†	2 (0.2)
Clinical work	
Clinical hours worked per week	25 (18 – 32)‡
Percentage of clinical hours worked in PEM	
0-24%	251 (18.8)
25-49%	185 (13.9)
50-74%	85 (6.4)
75-10%	85 (6.4)
100% of clinical hours worked in PEM	726 (54.5)
Life support course participation in last 5 years	
Instructor only	285 (21.4)
Participant only	491 (36.9)
Both instructor or participant	510 (38.3)
Neither instructor nor participant	46 (3.5)

EM = Emergency medicine, PEM = Pediatric emergency medicine.

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

‡ median (interquartile range)

Table 3. Percentage of respondents recommending1-monthly, 3-monthly, 6-monthly and yearly frequency of practice for all 18 critical procedures.

	Every month % (95% CI)	Every 3 months % (95% CI)	Every 6 months % (95% CI)	Every year % (95% CI)
CPR	16 (14 - 18)	20 (18 - 22)	25 (23 - 28)	30 (27 - 32)
Bag-valve-mask	18 (16 - 21)	22 (20 - 24)	25 (22 - 27)	27 (25 - 29)
Endotracheal tube	13 (12 - 15)	23 (21 - 25)	28 (25 - 30)	28 (25 - 30)
LMA insertion	10 (9 - 12)	19 (17 - 21)	26 (24 - 28)	31 (28 - 33)
Surgical airway - needle	2 (1 - 3)	8 (6 - 9)	16 (14 - 18)	43 (41 - 46)
Surgical airway - Seldinger	2 (1 - 3)	6 (5 - 7)	13 (12 - 15)	39 (37 - 42)
Surgical airway - open	2 (1 - 3)	6 (5 - 7)	13 (11 - 15)	37 (35 - 40)
Tracheostomy change	3 (2 - 4)	8 (7 - 10)	18 (16 - 20)	41 (38 - 43)
Chest - needle thoracocentesis	3 (2 - 4)	9 (7 - 10)	20 (18 - 22)	44 (42 - 47)
Chest - intercostal catheter	3 (2 - 4)	8 (7 - 10)	19 (17 - 22)	44 (42 - 47)
Chest - defibrillation / DCR	10 (8 - 11)	16 (14 - 17)	26 (23 - 28)	36 (33 - 38)
Chest - pacing	4 (3 - 5)	8 (7 - 10)	17 (15 - 19)	38 (35 - 40)
Intraosseous line	9 (7 - 10)	16 (14 - 17)	24 (22 - 26)	37 (34 - 40)
Venous cutdown	1 (1 - 2)	3 (2 - 4)	8 (7 - 10)	22 (20 - 24)
Central venous line	2 (2 - 3)	8 (6 - 9)	18 (16 - 20)	38 (35 - 40)
Arterial line	2 (1 - 3)	6 (5 - 8)	17 (15 - 19)	31 (28 - 33)
Pericardiocentesis	1 (1 - 2)	4 (3 - 5)	12 (10 - 13)	35 (33 - 38)
ED thoracotomy	1 (0 - 2)	2 (1 - 3)	9 (8 - 11)	22 (20 - 24)

Figure 1. Recommended frequency of practice, by procedure (n=1,332)

Figure 2. Percentage of respondents selecting each learning modality for non-invasive chest procedures and basic airway 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.

Acknowledgements.
When the study was approved, the members of the executive of PERN (Pediatric Emergency Research Networks) were:
Nathan Kuppermann, Chair of PERN Executive Committee (PECARN, USA)
Stuart Dalziel, Vice-Chair of PERN Executive Committee (PREDICT, NZ)
David Johnson (PERC, Canada)
Martin Osmond (PERC, Canada)
Jim Chamberlain (PECARN, USA)
Charles Macias (PEMCRC, USA)
Anupam Kharbanda (PEMCRC, USA)
Franz Babl (PREDICT, Australia)
Ed Oakley (PREDICT, Australia)
Patrick Van de Voord (REPEM, Belgium)
Santi Mintegi (REPEM, Spain)
Mark D Lyttle (PERUKI, England)
Ronan O'Sullivan (PERUKI, Ireland)

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Cincinnati Children's Hospital, Ohio: Matt Mittiga
Nationwide Children's Hospital (Columbus), Ohio: Rachel Stanley
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Maimonodes Medical Centre (NYC), New York: Hector Vazquez
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Children's Hospital of Eastern Ontario: Sarah Reid
CHU-Sainte Justine: Jocelyn Gravel
IWK Health Centre: Eleanor Fitzpatrick
McMaster Children's Hospital: Mohamed Eltorki
Sick Kids: Tania Principi
Stollery Children's Hospital: Andrew Dixon
Winnipeg Children's Hospital: Scott Sawyer

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Bristol Royal Hospital for Children, Bristol: Holly Lavigne-Smith
Chelsea and Westminster Hospital, London: Felicity Taylor
County Durham and Darlington NHS Foundation Practice: Amanda Cowton
Derriford Hospital, Plymouth: Tom Dougherty
Evelina Hospital, London: John Criddle
King's College Hospital, London: Fleur Cantle, Darren Darby
Leeds General Infirmary, Leeds: Abi Hoyle
Leicester Royal Infirmary, Leicester: Damian Roland
Northumbria Specialist Emergency Care Hospital: Stephen Owens
Nottingham Children's Hospital, Nottingham: Chris Gough
Royal Alexandra Children's Hospital, Brighton: Catherine Bevan
Royal Derby Hospital, Derby: Gisela Robinson
Royal Devon and Exeter Hospital, Exeter: Elizabeth Florey
Royal Manchester Children's Hospital, Manchester: Katherine Potier
Sheffield Children's Hospital, Sheffield: Derek Burke
Sunderland Royal Hospital, Sunderland: Niall Mullen
University Hospital, Southampton, Southampton: Jane Bayreuther
Watford General Hospital (West Herts NHS Trust), Watford: Michelle Jacobs
Royal Victoria Infirmary, Newcastle upon Tyne: Mark Anderson

IRELAND
Our Lady's Children's Hospital, Crumlin, Dublin: Carol Blackburn

Tallaght Children's Hospital, Tallaght, Dublin: Turlough Bolger
Temple Street Children's University Hospital, Dublin: Roisin Mc Namara

NORTHERN IRELAND
Royal Belfast Hospital for Sick Children, Belfast: Julie-Ann Maney

SCOTLAND
Aberdeen Royal Infirmary, Aberdeen: Gareth Patton
Crosshouse Hospital, Kilmarnock: Joanne Mulligan
Forth Valley Royal Hospital, Larbert: Roger Alcock
Royal Hospital for Sick Children (Yorkhill), Glasgow: Steven Foster
Royal Hospital for Sick Children, Edinburgh: Jen Browning

WALES
Children's Hospital for Wales, Cardiff: Colin Powell, Zoe Roberts
Morriston Hospital, Swansea: Kirsty Dickson-Jardine

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The Children's Hospital at Westmead: Sarah Dalton, Mary McCaskill
Lady Cilento Children's Hospital: Natalie Phillips
The Gold Coast Hospital and Health Service: Shane George
The Townsville Hospital: Jeremy Furyk
Women & Children's Hospital, Adelaide: DR AMIT KOCHAR
Monash Children's Hospital: Simon Craig
Royal Children's Hospital, Melbourne: Franz Babl
Princess Margaret Hospital, Perth: Meredith Borland

Research in European Pediatric Emergency Medicine (REPEM):
BELGIUM:
University Hospital Ghent: Patrick Van de Voorde

FRANCE:
Necker Enfants Malades H. Paris: Gérard Cheron

SPAIN:
Cruces University Hospital, Bilbao, Basque Country: Santiago Mintegi, Jimena de Pedro
Rio Hortega's Hospital, Valladolid: Roberto Velasco
Gregorio Maranon University Hospital, Madrid: Rafael Marañón

Red de Investigación y Desarrollo de la Emergencia Pediátrica de Latinoamérica (RIDEPLA):

ARGENTINA:
Hospital de Pediatría Prof Dr Juan P Garrahan, Buenos Aires: Guillermo Kohn Loncarica and Pedro Rino

PARAGUAY:
Hospital Pediátrico Niños de Acosta Ñu, San Lorenzo: Viviana Pavlicich