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A Modified Delphi Study to Prioritize Content for a Simulation-based Pediatric Curriculum for Emergency Medicine Residency Training Programs

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ABSTRACT

Objectives: Pediatric training is an essential component of emergency medicine (EM) residency. The heterogeneity of pediatric experiences poses a significant challenge to training programs. A national simulation curriculum can assist in providing a standardized foundation of pediatric training experience to all EM trainees. Previously, a consensus-derived set of content for a pediatric curriculum for EM was published. This study aimed to prioritize that content to establish a pediatric simulation-based curriculum for all EM residency programs.

Methods: Seventy-three participants were recruited to participate in a three-round modified Delphi project from 10 stakeholder organizations. In round 1, participants ranked 275 content items from a published set of pediatric curricular items for EM residents into one of four categories: definitely must, probably should, possibly could, or should not be taught using simulation in all residency programs. Additionally, in round 1 participants were asked to contribute additional items. These items were then added to the survey in round 2. In round 2, participants were provided the ratings of the entire panel and asked to rerank the items. Round 3 involved participants dichotomously rating the items.

Results: A total of 73 participants participated and 98% completed all three rounds. Round 1 resulted in 61 items rated as definitely must, 72 as probably should, 56 as possibly could, 17 as should not, and 99 new items were suggested. Round 2 resulted in 52 items rated as definitely must, 91 as probably should, 120 as possibly could, and 42 as should not. Round 3 resulted in 56 items rated as definitely must be taught using simulation in all programs.

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Conclusions: The completed modified Delphi process developed a consensus on 56 pediatric items that definitely must be taught using simulation in all EM residency programs (20 resuscitation, nine nonresuscitation, and 26 skills). These data will serve as a targeted needs assessment to inform the development of a standard pediatric simulation curriculum for all EM residency programs.

There are an average of 35 million pediatric visits to emergency departments (ED) in the United States each year.[1] In an emergency, children typically access emergency care at the nearest ED, which are usually staffed by emergency medicine (EM) physicians who concurrently care for both children and adults. Consequently, over 85% of pediatric visits are to general EDs instead of dedicated pediatric EDs.[2] Very few EM physicians will complete subspecialty training in pediatric emergency medicine (PEM). The majority of PEM-trained physicians will work in a dedicated pediatric ED.[3] In the "typical" general ED, pediatric patients are approximately 20% of the total daily patient volume and many EDs care for less than five pediatric patients per day.[1] Higher mortality rates for pediatric cardiac and respiratory arrest have been reported in EDs with lower annual pediatric patient visits.[1,4,5] These lower-volume EDs are less likely to comply with evidence-based treatment guidelines for high-acuity conditions.[6–10] These studies may represent opportunities to improve the existing pediatric training of EM residents and attending physicians.

Currently, the Accreditation Council for Graduate Medical Education (ACGME) requires EM residency programs to allocate 20% of patient encounters to patients < 18 years of age, including the critical care of infants and children, but provides limited guidance as to specific requirements regarding these experiences.[11] The EM Model Review Task Force of the American Board of Emergency Medicine regularly publishes a more specific and extensive list of pediatric content for EM residency programs.[12] A study by Mitzman et al.[13] reported a consensus of core items for a pediatric emergency care curriculum in residency programs. It is difficult for programs to cover all of the content items described in this curriculum because of the heterogeneity of pediatric clinical and educational experiences available.[14,15] The majority of EM residents' clinical experiences occur during rotations in dedicated pediatric EDs with high pediatric volumes.[14,15] However, studies have reported that even very busy academic pediatric EDs treat small percentages of critically ill children, making it challenging for trainees, including EM residents, to have sufficient opportunities to care for high-acuity cases and perform critical care procedures during their pediatric ED rotations.[16–21]

Simulation-based training can be used to mitigate the EM residents' lack of opportunity to master the important skills and knowledge required for the safe and effective delivery of care to children. Simulation is an effective instructional method, particularly for learning critical skills and procedures. Systematic reviews and meta-analyses have clearly established that simulation is an effective method for healthcare provider training under the right conditions,[22–24] with some of this literature demonstrating improvements in downstream patient outcomes.[25] The objective of this study was to prioritize the content for a national pediatric simulation-based training curriculum for all EM residency programs. The findings from this study will serve as the targeted needs assessment to inform the development of a standardized, high-quality, pediatric simulation curriculum that is open access for all EM training programs.

METHODS

Study Setting and Population

The first step in this project was to form a Pediatric Simulation Collaborative composed of diverse stakeholder organizations in pediatrics, EM, and simulation. The formation of this group was facilitated by the American College of Emergency Physician president inviting 10 relevant stakeholder organizations to appoint a representative to the Collaborative (see Table 1). Each stakeholder representative was asked to recruit additional experts to serve as participants (see Data Supplement S1, Table S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1002/aet2.10412/full) in the Delphi process described here (see Figure 1).

Study Design

This project was developed by this group in consultation with an expert in the Delphi process between August and October 2018. We modeled our project on Delphi projects conducted by Mitzman et al.[13] for designing a pediatric curriculum for EM residents and

Table 1
Roles and Responsibilities of 73 Physicians Who Served as Delphi Panelists During this Project and the Organizations They Represented

Roles of in simulation/residency (selected all that applied)	No.	%
Leadership role in simulation center	30	42.9
Lead or develop pediatric simulation curricula	42	60.0
Lead or develop adult simulation curricula	30	42.9
Facilitate pediatric simulations	49	70.0
Facilitate adult simulations	33	47.1
Residency program director/ associate director	4	5.6
Organizations represented on panel		
1. American Academy of Emergency Medicine		
2. American Academy of Pediatrics		
3. American College of Emergency Physicians		
4. Council of Emergency Medicine Residency Directors		
5. Emergency Medicine Residents' Association		
6. International Network for Simulation-based Pediatric Innovation, Research, & Education		
7. International Pediatric Simulation Society		
8. Pediatric Trauma Society		
9. Society for Academic Emergency Medicine		
10. Society for Simulation in Healthcare		

Bank et al.,[26] to determine the simulation-based curriculum for PEM fellowship training in Canada. Established data collection and processing methods for Delphi were used.[27–29] However, unlike the traditional Delphi, which starts with "an exploration of the subject" through open-ended questions or in-person brainstorming,[27] the first round of our Delphi was developed using pediatric curriculum content material previously established by a panel of experts in 2017.[13] For our first round, we developed an electronic survey composed of the 206 content items: 133 knowledge and 73 skills and experiences from the list of "must teach" or "may teach" curriculum topics generated by Mitzman et al.[13] Panelists were also offered the opportunity to contribute additional de novo content. This project remained true to the remaining features of the Delphi including the engagement of experts with specialized knowledge as participants, up to four iterative rounds, anonymity of the participants' contributions, and feedback to the participants on their collective performance after each round. This study was determined to be exempt research by Yale University School of Medicine.

Study Protocol/Key Outcome Measures

The instructions for completion of the Delphi study were carefully designed to ensure a clear understanding from all participants. This was achieved by asking participants to complete each round of the survey with the mindset of best educational practice for each topic presented. Participants were asked, for the purposes of the study, to assume unlimited resources, expertise, and time. Simulation was defined as "educational experiences designed to teach clinical care that did not involve actual patients" using published definitions from the Association for Healthcare Research and Quality and the Society for Simulation in Healthcare.[30] Examples of simulation modalities were also

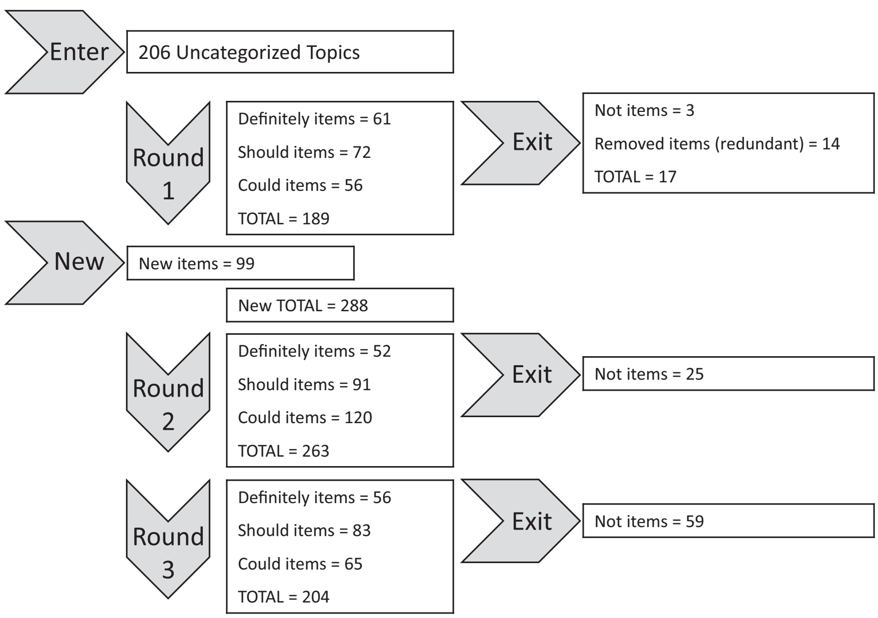

Figure 1. Categorization of topics across the three rounds of the Delphi.

provided and included task trainers, manikins, high-fidelity simulators, actors/simulated patients, augmented/virtual reality, and role-playing. The curriculum components related to core knowledge were presented in sets representing organ systems in a cephalocaudal sequence starting with those related to the head (neurology items) and ending with those related to the limbs (musculoskeletal, atraumatic orthopedics items). Knowledge components that did not fit into organ-based classification were presented next (e.g., signs and symptom items). Finally, core procedural skills were presented in three groups of approximately 20 items each (see Data Supplement S1, Appendix S1, with first round survey). In each of the above sections, participants were provided a free-text option to add additional content items that were not identified in Mitzman's work. Unlike the traditional Delphi, our Delphi study was conducted using electronic survey software (SurveyMonkey Inc.).

During the first round, Delphi participants were asked to rate the "appropriateness" of teaching a curriculum component through simulation using a 4-point scale in which scale options were labeled: definitely must, probably should, possibly could, or should not be taught with simulation in all programs.[26] Items from the first round were scored using a method described by Altschuld and Thomas[31] by which the ratings for each item were multiplied by the number of participants selecting that rating and then summed. For example, 36 participants rated Ultrasound FAST Scan as "definitely must," which is worth a value of 4 ($36 \times 4 = 144$); 20 rated it "probably should" ($20 \times 3 = 60$); 12 rated it "possibly could" ($12 \times 2 = 24$); and three rated it "should not" ($3 \times 1 = 3$). The summary score for this item would be $144 + 60 + 24 + 3 = 231$. Items were sorted by the summary score and presented to a core group of researchers to make decisions about categorizing items. The group looked for gaps in the summary scores to determine where to separate the items into summary categories: definitely must, probably should, possibly could, and should not.

During round 2, we presented the topics in sets by how they were categorized as a result of the first round: "definitely must teach with simulation"; "probably should use simulation"; "possibly could use simulation"; or "should not use simulation." Panelists were asked to rerate these items using the same 4-point scale. All new items suggested by the participants during the first round were presented separately during the second round. The participants also rated these new items using the 4-point rating scale. In round 2, participants did not have the ability to add new items via free text. Items in round 2 were scored and summarized using the methods described for the first round. After round 2, we calculated a weighted composite average score by adding the summary scores from the first round to the summary score from the second round and then dividing by the total number of panelists across both rounds. Using the example for Ultrasound FAST Scan from above, we added the summary score of 231 from the first round to the summary score of 222 from the second round to get a combined summary score of 453. We then converted this summary score to an weighted composite average rating by dividing it by the total number of panelists across both rounds ($453/144 = 3.15$). For the new items that were not rated during round 1, we used two methods to estimate a summary rating to substitute for the missing rating from round 1. In method A, we calculated the mean ratings for each of the four categories from round 1 and then substituted that mean rating for the missing value from round 1, based on the item's category assignment from round 2. In method B, we simply used the rating of the new items received in round 2 for both rounds. Items that did not fall into the same categories using both methods A and B, were considered discrepant and became the content for round 3. Participants were asked to make final recommendations making a final rating for the discrepant items.

Across all three Delphi rounds, missing values resulting from skipped items were negligible (486 missing values out of 38,846 ratings expected from panelists = 0.13%). Since there were such low numbers of missing values, which we felt would have minimal impact on results, we used a mean replacement strategy for all missing data point in the data set.

RESULTS

The participants represented a geographically diverse group of 73 physicians as noted in Data Supplement S1, Figure S1. Participants were purposefully recruited with diverse training backgrounds including completion of EM residency ($n = 32$; 41%), EM residency then PEM fellowship ($n = 17$; 25%) and pediatrics residency then PEM fellowship ($n = 24$; 34%). Table 1 describes the participants' role(s) in simulation, residency leadership, and stakeholder organizations.

Figure 1 displays the number of content items and their categorization over the three rounds.

Round 1 was completed between October 26, 2018, and November 20, 2018. In round 1, 97.3% (71 of 73) of the Delphi panelists categorized the original 206 content items and added an additional 99 items. The participants identified 14 items as redundant and rated 3 as should not be taught using simulation. Round 2 was completed between December 21, 2018, and January 25, 2019, and involved all 73 panelists (100%). In round 2, most of the new items were categorized; however, a few were among the 25 which were rated "should not be taught using simulation." This resulted in 263 items that were categorized during round 2, including 38 that were inconsistently categorized across the first two rounds. The two methods described above for evaluating the additional items yielded consistent results for all but 38 items (12.5%), three of which were split between the "definitely must" and "probably should" categories and 35 that were split between the "probably should" and "possibly could" categories. These became the content for round 3. Round 3 was completed between February 11, 2019, and March 10, 2019, and included 71 of 73 panelists (97.3%). In round 3, the final 38 items that straddled the definitely must/probably should and probably should/possibly could categories were dichotomously rated. Items rated as should not be taught using simulation in either round 1 or round 2 were removed.

The 56 items rated as must be taught using simulation in all programs included 20 resuscitation items (Table 2), 10 nonresuscitation items (Table 3) and 26 skills (Table 4). Each of these tables includes columns referencing each of the items to their respective coding by Mitzman and the EM Model Codes.[12,13]

DISCUSSION

Emergency medicine physicians are required to be competent in the care of the pediatric patient. Yet, the opportunity to manage unwell pediatric patients and

Table 2
Pediatric Resuscitation Items That All Programs Must Teach Using Simulation

	Mitzman code	EM model code
Airway/breathing		
1. Diagnosis and management of respiratory failure	AR15	19.2.3
2. Diagnosis and management of upper airway obstruction*	AR25	16.1.2
3. Diagnosis and management of respiratory distress	P05	19.2.3
4. Diagnosis and management of severe asthma*	P08	16.4.1
5. Diagnosis and management of pneumothorax	P11	16.2.6
Signs and symptoms		
6. Recognize a sick infant or child	SSO1	19.2.3
Medical resuscitation		
7. Pediatric Basic Life Support (PBLS)	AR12	19.2.3
8. Neonatal resuscitation (NRP)*	AR11	19.2.2
9. Pediatric Advanced Life Support (PALS)* cardiogenic, hypovolemic, distribute, anaphylactic, septic, neurogenic shock	AR04	19.2.3
10. Dose of epinephrine for cardiac arrest	PH04	19.2.1
11. Diagnosis and management of cardiac arrhythmia*	C07	3.4.1
12. Diagnosis and management of supraventricular tachycardia*	AR18	3.4.1.2
13. Diagnosis and management of ventricular fibrillation*	C10	3.4.1.1
14. Diagnosis and management of nonshockable rhythms*	C12	3.4.1
15. Diagnosis and management of pericardial effusion/tamponade*	C15	3.6.1
16. Diagnosis and management of anaphylaxis	AR19	9.2.2
17. Dose of epinephrine for anaphylaxis	AR21	9.2.2
Trauma resuscitation		
18. Diagnosis and management of major traumatic brain injury*	TR02	18.1.6
19. Diagnosis and management of blunt abdominal trauma	TR07	19.2.3
20. Diagnosis and management of penetrating trauma	TR09	18.1.2.5

*Items that were also included in Bank Curriculum.

Table 3
Pediatric Nonresuscitation Items That All Programs Must Teach Using Simulation

	Mitzman code	EM model code
Cardiology		
21. Diagnosis and management of neonatal congenital cardiovascular presentations	C01	3.2
22. Diagnosis and management of pediatric heart failure	C04	3.5.3
Endocrine/metabolic, nutrition		
23. Diagnosis and management of acute diabetic ketoacidosis & hyperglycemia	EN01	5.4.1.3.1/2
24. Diagnosis and management of congenital adrenal hyperplasia shock in neonates	EN02	5.2.1
25. Diagnosis and management of neonatal hypoglycemia	EN03	5.4.1.3.4
Infectious diseases		
26. Diagnosis and management of pediatric sepsis	ID01	10.1.7
27. Diagnosis and management of pediatric septic shock	ID01	10.1.7
28. Diagnosis and management febrile or septic neonate	ID10	10.1.7
Neurology		
29. Diagnosis and management severe status epilepticus*	NE08	12.9.1
Toxicology		
30. Diagnosis and management small-dose ingestions dangerous/fatal to infants/toddlers	TX01	19.2.3

*Items that were also included in Bank Curriculum.

the subsequent education that they get from that experience is variable. Due to the potential for variability in training experience, the Pediatric Simulation Collaborative came together to improve and standardize training for EM trainees across the country in the care of the unwell pediatric patient. Providing a framework of educational objectives, simulations, and related cases will provide the necessary building blocks for all trainees to attain competence in the care for the most vulnerable patients, no matter where their training occurs. Moreover, because the Pediatric Simulation Collaborative is supported by leaders from various national organizations, we hope that our provision of a national curriculum will provide leverage to struggling programs to build or maintain adequate simulation infrastructure. Ultimately, we hope that a national simulation-based curriculum will contribute to improvements in care of the pediatric emergency patients across the country.

The Pediatric Simulation Collaborative is using Kern's six-step framework for curriculum development.[32] The first steps of this framework (problem identification, general needs assessment, targeted needs assessment, and goals and objectives) were completed in the initial Delphi conducted by Mitzman et al.[13] The current Delphi completed the educational strategies step of Kern's framework by identifying high priority content that must be delivered through simulation-based instruction in all residency programs.[32]

This process generated consensus on 56 pediatric knowledge items and skills (20 resuscitation, 10 nonresuscitation, and 26 skills) that panelists believed "definitely must" be taught using simulation across all EM residency programs. These items will serve as the foundation for a national pediatric simulation-based curriculum for EM residency programs. The "probably should" and "possibly could" items can be used to inform the development of optional simulation content for EM residency training programs.

Currently, there are diverse and heterogeneous approaches to pediatric simulation across residency programs. The growth of EM simulation fellowships has improved our national capacity for high-quality EM simulation–based training.[33] Many simulation cases and curricula run at different training programs are not peer reviewed or disseminated through publication. Additionally, many of these cases are similar across programs leading to redundant and duplicative work as multiple educators develop similar simulations, while missing opportunities to study and refine individual scenarios and maximize evidence-based learning. Efforts to create a standardized pediatric simulation curricula have been conducted in EM. Adler and colleagues[34] developed a 1-day pediatric curriculum focused pediatric resuscitations the impact of which was studied across two Chicago-area EM residency programs. In contrast to this case-based approach focusing on severe illness, the proposed curriculum in this paper aims to start with learning

Table 4
Pediatric Skills That All Programs Should Teach Using Simulation

	Mitzman code	EM model code
Airway		
31. Basic airway maneuvers and positioning	AR01	19.1.2
32. Bag-valve-mask ventilation	AR05	19.1.4
33. Laryngeal mask airway*	AR08	19.1.4
34. Pediatric airway adjuncts	AR06	19.1.2
35. Endotracheal intubation of infants*	AR02	19.1.1
36. Endotracheal intubation of young children*	AR03	19.1.1
37. Complicated endotracheal intubation	AR26	19.1.1
38. Invasive airway rescue options–transtracheal jet	AR14	19.1.2
39. Needle decompression of a pneumothorax*	AR10	19.4.2.5
40. Pediatric cricothyrotomy*	CP2_25	19.1.3
41. Needle cricothyrotomy*	AR09	19.1.3
42. Tracheostomy tube placement*	CP2_14	19.1.2
43. Troubleshoot–tracheostomy device	ENT07	19.1.2
Nonairway procedures		
44. Place an intraosseous line*	CP2_01	19.2.8
45. Child lumbar puncture	CP2_04	19.4.7
46. Neonatal/infant lumbar puncture	CP2_05	19.4.7
47. Chest tube placement on young children	CP3_04	19.4.2.6
48. Install umbilical artery or vein catheters	CP3_05	19.2.7
49. Chest tube placement on infants	CP3_10	19.4.2.6
50. Pigtail thoracostomy	CP2_33	19.4.2.6
51. Pericardiocentesis*	CP2_20	19.4.2.4
52. External cardiac pacing*	CP3_02	19.4.2.1
53. Cardioversion/defibrillation*	CP2_02	19.4.2.2 19.2.9
54. Pediatric trauma resuscitation,* primary, secondary, interventions	TR12	19.2.3
55. Effective communication with parents	ICHP01	20.1.1.3
56. Delivering bad news	ICHP08	20.1.2.4

*Items that were also included in Bank Curriculum.

objectives/content items and then case development. In Canada, a national PEM simulation-based fellowship curriculum was developed in 2010.[35] Five years after implementation of this curriculum the group conducted a national Delphi process to assess and improve the content in this curriculum. This process identified 48 key curriculum items that largely overlapped with the ones generated in this study. The 12 components that were not included from the Canadian work included foreign body removal, drowning, altered mental status, spine immobilization, use of Magill forceps for foreign body removal, adenosine administration, leadership/followership, workload, reevaluation, teamwork, attention allocation, and priority setting. We speculate that the differences between the results of our Delphi and the Canadian one may relate to the focus of the Canadian Delphi process on fellowship-level trainees, while our focus was on general EM residents.

Some residency programs will face barriers to implementation related to inadequate simulation resources, faculty, and/or local support for pediatric scenarios. Through engagement of senior leaders in key stakeholder organizations, we hope that our rigorous curriculum development and evaluation processes lead to additional local support for simulation in the form of faculty time and resources. We hope that the opportunity to engage in a national scholarly project will serve as an incentive for these institutions to utilize this curriculum. A variety of comprehensive EM residency simulation curricula have been implemented in the United States and abroad showing great potential for this pediatric-focused work.[36–40] There are also successful examples of collaboratives that have developed national simulation curricula in different specialties (e.g., urology in the Netherlands, pulmonary and ophthalmology in Denmark, anesthesia and obstetrics in Canada, vascular and laparoscopic surgery in the United States, and pediatric surgery in France).[41–47]

Future Directions

The next steps for the collaborative will involve the development, testing, implementation, and iterative refinement of a curriculum that will cover the described content over a 3-year residency program.

LIMITATIONS

An important limitation of our collaborative is that we did not include nurses, advanced practice providers, or other health care team members and instead, decided to focus the first iteration of this simulation curriculum on EM physician trainees. We recognize that in many programs, simulation curricula are conducted with interprofessional teams. Another limitation of this study was the potential that the "electronic" Delphi served to suppress deliberation and debate as compared to Delphis conducted through the mail or in face-to-face meetings. Our choice of the electronic method was considered a tradeoff, chosen over the other methods to save the time and cost of meeting in person or having to manage large-scale mailings. The electronic Delphi also provided us the opportunity to involve a broader spectrum of panelists with more diverse backgrounds and experience. Additional future investigations are also needed to explore the potential for including objectives targeted at other team members including interprofessional or multidisciplinary health care providers.

CONCLUSIONS

This Delphi process identified content that should be prioritized for national simulation-based curriculum that can be used to supplement clinical training. The next steps for the collaborative will involve the development, testing, implementation, and iterative refinement of a curriculum that will cover the described content over a 3-year residency program. The formation of this collaborative and this Delphi process will result in the development of simulation training that will optimize pediatric emergency education for EM residents and, ideally, improve pediatric health care delivery.

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Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1002/aet2.10412/full

Data Supplement S1. Supplemental material.