Benchmark Performance of Emergency Medicine Residents in Pediatric Resuscitation: Are We Optimizing Pediatric Education for Emergency Medicine Trainees?

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ABSTRACT

Background: The majority of children in the United States seek emergency care at community-based general emergency departments (GEDs); however, the quality of GED pediatric emergency care varies widely. This may be explained by a number of factors, including residency training environments and postgraduate knowledge decay. Emergency medicine (EM) residents train in academic pediatric EDs, but didactic and clinical experience vary widely between programs, and little is known about the pediatric skills of these EM residents. This study aimed to assess the performance of senior EM residents in treating simulated pediatric patients at the end of their training.

Methods: This was a prospective, cross-sectional, simulation-based cohort study assessing the simulated performance of senior EM resident physicians from two Massachusetts programs leading medical teams caring for three critically ill patients. Sessions were video recorded and scored separately by three reviewers using a previously published simulation assessment tool. Self-efficacy surveys were completed prior to each session. The primary outcome was a median total performance score (TPS), calculated by the mean of individualized domain scores (IDS) for each case. Each IDS was calculated as a percentage of items performed on a checklist-based instrument.

Results: A total of 18 EM resident physicians participated (PGY-3 = 8, PGY-4 = 10). Median TPS for the cohort was 61% (IQR = 56%–70%). Median IDSs by case were as follows: sepsis 67% (IQR = 50%–67%), seizure 67% (IQR = 50%–83%), and cardiac arrest 67% (IQR = 43%–70%). The overall cohort self-efficacy for pediatric EM (PEM) was 64% (IQR = 60%–70%).

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Conclusions: This study has begun the process of benchmarking clinical performance of graduating EM resident physicians. Overall, the EM resident cohort in this study performed similar to prior GED teams. Self-efficacy related to PEM correlated well with performance, with the exception of knowledge relative to intravenous fluid and vasopressor administration in pediatric septic shock. A significant area of discrepancy and missed checklist items were those related to cardiopulmonary resuscitation and basic life support maneuvers.

Approximately 80% to 90% of children initially seek care at community-based general emergency departments (GEDs), accounting for more than 20% of all GED visits in the United States.^{1–7} In 2001, the American Academy of Pediatrics (AAP) and the American College of Emergency Physicians (ACEP) created the first joint guidelines for the care of children in emergency departments (EDs).⁸ Despite this, a report from the National Academy of Medicine (NAM) in 2006 described the “uneven” care provided to pediatric patients in GEDs across the United States.⁹ To combat this issue, the National Pediatric Readiness Project (NPRP), a national quality initiative, was created in 2013 to ensure all U.S. GEDs have the essential guidelines and resources in place to provide effective emergency care to children.^{5,10} Even with this initiative, recent studies continue to show variability in pediatric clinical care across GEDs, and new evidence suggests that mortality outcomes are worse for critically ill pediatric patients treated at centers with low pediatric readiness.^{11–13}

Many characteristics of critically ill pediatric patients allow for the high likelihood of medical error to exist. In addition to the “high-stakes/low-frequency” nature of pediatric critical resuscitation, data suggest that many health care providers are unfamiliar and uncomfortable treating pediatric patients.^{14–17} Many factors may contribute to this, some of which include, the diversity and complexity of pediatric complaints, the high stress and emotional environment involved, the limited information available in nonverbal patients, and the likely time pressure involved with management decisions.

In an attempt to compare differences in the quality of simulated pediatric resuscitative care provided by GED and pediatric ED (PED) teams across the United States, Auerbach et al.¹⁸ reported a novel, simulation-based pediatric assessment tool. They compared the in situ (within normal ED setting) simulated performance of ED teams managing three simulated pediatric critical care scenarios, across a spectrum of EDs. Their results suggest that quality of care may be higher in PEDs compared with GEDs. However, after controlling for patient volume, PED status alone did not

explain better performance, indicating that recurrent clinical exposure and higher volume of pediatric patients encountered, may be a more important determinant of quality than the GED or PED distinction.¹⁸

In addition to the variability in clinical care provided across the United States, there is considerable heterogeneity in the current pediatric emergency medicine (PEM) education provided to EM resident physicians.^{19–22} This variability is exhibited in both didactic curricula and the quantity and acuity of pediatric patient encounters.^{15,19,20,23–26} The American Board of Emergency Medicine (ABEM) lists 131 pediatric clinical entities that should be covered during EM residency.²⁷ However, to date, the Accreditation Council for Graduate Medical Education (ACGME) and the ABEM have not recommended standardized didactic curricula or educational modalities to meet these requirements.^{15,20,23–26} Moreover, research suggests that exposure to critically ill pediatric patients is especially minimal for EM residents.^{23,24,28} Even when rotating at large tertiary or quaternary pediatric academic centers with large PEDs, EM residents are not guaranteed to care for critically ill patients or participate in pediatric resuscitations.^{23,28} EM residency program directors have reported deficiencies in PEM education and suboptimal confidence in residents’ ability to perform critical pediatric procedures.^{15,19,21,25,29} To address this issue, multiple studies have attempted to assess the efficacy of PEM-specific curricula for EM resident physicians, many of which incorporate simulation. However, many studies either report minimal change in clinical performance after initiation of curricula or use only reported self-efficacy/confidence as their study outcomes.^{21,30–33}

Prior medical simulation research has assessed clinical performance of pediatric resident physicians during simulated pediatric resuscitations.^{34,35} However, there are minimal data to report the clinical performance of graduating EM resident physicians leading medical teams caring for critically ill pediatric patients. The concept of “forgetting curves” has been well described in the medical education literature.^{36,37} Without refresher training or sustained clinical experience, it is expected that medical knowledge and technical skill

will decay over time.³⁷ Therefore, do we focus resources on residency education, continuing medical education for postgraduate providers, or both? To answer this question, the acquisition of benchmark EM resident performance data is required as a first step. Therefore, the goal of this study was to describe the clinical performance of a small cohort of graduating EM resident physicians for their ability to lead medical teams during simulated pediatric resuscitations.

METHODS

Study Design

This was a prospective, cross-sectional, multicenter, simulation-based cohort study. The primary aim was to measure the clinical performance of senior EM resident physicians leading medical teams caring for a series of three simulated pediatric patients. Institutional review board approvals were obtained at Boston University School of Medicine and the University of Massachusetts Medical School prior to study initiation.

Study Setting and Population

Participants included graduating (third- and fourth-year) senior EM resident physicians from Boston Medical Center (4-year program, urban academic medical center) and the University of Massachusetts Memorial Medical Center (3-year program, urban academic medical center). Participants were identified through resident rosters and recruited through direct communication with respective residency program directors and chief residents. Written consent was obtained prior to participation. Nurse confederates were recruited through corresponding institutional nurse managers and were provided with continuing educational units for their participation. As confederates to the study, nurses were not blinded to the cases prior to simulation participation. Similarly, medical students were recruited as confederates to act as both EM medical assistants and the parent of the simulated patient. Students were recruited through respective medical school student affairs offices. Confederate roles were standardized via a predetermined script. To elicit direction/performance of critical actions by the EM resident team leader, study facilitators completed a scripted prebrief with the confederate team prior to each simulated case (Data Supplement S1, Supplemental Information #1, available as supporting information in the online version of this paper, which is

available at <http://onlinelibrary.wiley.com/doi/10.1002/aet2.10509/full>).

Inclusion/Exclusion Criteria

All graduating (third- and fourth-year) EM residents were eligible to participate in the study. There were 10 eligible resident physicians at Boston Medical Center and 10 at the University of Massachusetts Memorial Medical Center.

Simulation Protocol

Simulated pediatric resuscitations were performed in the simulation center at each institution. Prior to each simulation session, participants were oriented to medical simulation, the pediatric manikin, and simulation equipment via a standardized scripted PowerPoint introduction. Participants were given the chance to examine the pediatric manikin and manipulate all simulation material (medication and equipment) prior to initiation of the simulation session. The first case (foreign body aspiration) was used as a “warm-up” case. It was video recorded and used for the educational debrief session but not scored for data analysis. This case served to help the resident understand expectations, flow of the simulation cases, and the contribution of the confederates during the session. If there were issues or questions that needed to be addressed, it could be done with the initial brief case and not impact data collection for the following three. The other three cases, in order, included sepsis, seizure, and cardiac arrest. All cases were presented in quick succession with a 5-minute room reset/break. Debriefing for all four cases took place following completion of the final simulation.

Each simulation team was composed of one senior EM resident physician (participant), two or three EM nurses (confederates), and one or two EM medical assistants (confederates). Confederates were instructed to act only on directions given by the team leader, as directed by the prebrief script. The parent of the simulated patient was played by a confederate. Laboratory data and imaging were provided upon request. Two study facilitators observed each simulated scenario in real time to inform educational debriefs following each session. After the final case, two study facilitators led a 40-minute standardized educational debrief session. All simulation team members participated in the debrief sessions that focused on previously determined teaching points relevant to each case. Simulations were video recorded via two cameras (iPad and embedded

simulation center camera) for later review. More information on each of the cases is provided in Data Supplement S1, Supplemental Information #2.

Data Collection

Prior to simulated cases, study participants completed qualitative questionnaires to assess their self-efficacy (confidence) related to pediatric critical resuscitation. This questionnaire was a modified version of a previously validated self-efficacy assessment tool used to assess the self-efficacy of EM resident physicians after a crisis resource management training initiative, involving four simulated pediatric critical resuscitation cases (septic shock, diabetic ketoacidosis, respiratory failure, trauma).^{32,38} The modified questionnaire incorporated questions categorized to report self-efficacy related to “global team leader pediatric emergency self-efficacy” and “specific task related pediatric emergency self-efficacy.” For the purposes of the current study, and as per published expert opinion, the questionnaire was modified to a 100-point Likert scale (Data Supplement S1, Supplemental Information #3).³⁸

Videos were scored separately by three reviewers (two PEM providers, one EM provider) using performance checklists specific to each case. When discrepancies were noted in the scoring, all reviewers met to concurrently score the video and discuss the scoring until consensus was achieved. As described in the previous publication, these checklists were iteratively developed over a 6-month period and have been previously published.¹⁸ Initial content validity evidence was provided through adaptation of existing practice guidelines and a modified Delphi process with subsequent use to compare performance of PEDs versus GEDs, as mentioned above.¹⁸ Checklist items constitute specific observable tasks and actions for the pediatric assessment and stabilization required in each case (e.g., established intravenous [IV] access, began high-flow oxygen) scored dichotomously (i.e., completed/did not complete) and reported as the percent of steps completed. The final checklist scores were based on video review and not performed in real time. The checklist items are provided in Data Supplement S1, Supplemental Information #4.

Outcome Measures

The primary outcome measure was a total performance score (TPS) for the cohort, which was calculated as the mean of three individualized domain scores (IDSs) for each case. The IDSs were generated

using the previously published checklists as noted above. Secondary outcome measures were as follows: 1) assessment of resident self-efficacy related to pediatric critical resuscitation and correlation to both “global” and “task-specific” performance data and 2) comparison of TPS and IDS from the current study cohort to previously published data for GEDs and PEDs, using the same checklist.¹⁸

Data Analysis

All data were manually entered into Microsoft Excel version 14.0 (Microsoft) and transferred into SPSS version 22.0 (IBM Corp.) with which all analyses were performed. We examined calculated survey responses and simulation data using means with standard deviations or medians with interquartile ranges (IQR) for continuous variables. Data were examined for normality and homogeneity in each analysis. Normally distributed data (e.g., global and overall self-efficacy) were reported using means and standard error of the mean, whereas nonparametric data were reported with medians and IQRs. Inter-rater reliability was assessed using an Intraclass correlation coefficient (ICC) with a two-way mixed, consistency, single-measures ICC.

RESULTS

Participant Characteristics

A total of 18 of 20 eligible EM resident physicians (90%) participated. Two residents were unable to participate due to scheduling conflicts. Of the 18 residents, eight (44%) were third-year residents and 10 (56%) were fourth-year residents (Table 1). The majority of participants (13/18, 73%) were male.

Outcomes

Primary Outcome. Individual checklist performance data are presented in Table 2. The median TPS for the cohort was 67% (IQR = 56%–70%). Median IDSs by case were as follows: sepsis 67% (IQR = 50%–67%), seizure 67% (IQR = 50%–83%) and cardiac arrest 67% (IQR = 43%–70%). The checklist had good inter-rater reliability with an ICC calculated at 0.808 (95% confidence interval = 0.781 to 0.833, $p < 0.001$).

As described, each IDS was calculated using checklist items considered to be critical actions specific for each scenario (Table 2). During the sepsis case, only two (11%) of the EM residents administered the correct IV fluid volume, and three (17%) EM residents

started appropriate vasopressor support. During the seizure case, only 10 (56%) EM residents checked a finger-stick blood glucose within the first 2 minutes of the case and eight (44%) identified the correct IV glucose dose. The cardiac arrest case required the largest amount of team direction by the EM resident, especially for basic life support (BLS) skills. The cohort did well with a number of the checklist items such as correct dosing and timing of epinephrine (15 [83%] and 13 [72%], respectively), recognizing and verbalizing ventricular fibrillation (14 [87%]), defibrillation with correct dose and timing (15 [83%]), and resuming compressions after defibrillation (17 [94%]). However, there were many checklist items the cohort performed less well, such as recognizing and verbalizing pulseless electrical activity (10 [56%]), and BLS tasks such as ventilation rate, backboard use, compressor change every 2 minutes, and pulse check within 2 minutes of patient arrival (4 [28%], 2 [11%], 3 [17%], and 4 [22%], respectively).

Secondary Outcomes. Self-efficacy data are presented in Table 3. The overall cohort self-efficacy for PEM was 61% (standard error of the mean [SEM] = 3.5%). The mean global team leader pediatric emergency self-efficacy for the cohort was 61% (SEM = 3.8%) and mean specific task related pediatric emergency self-efficacy was 61% (SEM = 3.5%). In general, EM resident self-efficacy correlated well with their performance data for both global and specific PEM tasks. However, resident self-efficacy for their ability to use the correct IV fluid volume and rate during resuscitation in pediatric septic shock was 75% (IQR = 60%–90%), whereas only two (11%) participants completed the task correctly (Figure 1). Similarly, resident self-efficacy for their ability to start appropriate vasopressor support during resuscitation in pediatric septic shock

Table 1
EM Resident Cohort Demographics (N = 18)

Year	N (%)
PGY-3	8 (44%)
PGY-4	10 (56%)
Sex	
Male	13 (73%)
Female	5 (28%)
Sites	
Boston Medical Center	10 (56%)
University of Massachusetts Memorial Medical Center	8 (44%)

Data are reported as or n (%).

Table 2
TPS and IDS Data from Checklist Results

Checklist item	Residents (N = 18)
Sepsis	N (%)
Established first IV/IO	17 (94)
Began high-flow O ₂	16 (89)
Administered 60 mL/kg over 15 minutes	2 (11)
Vasopressor started after third bolus	3 (17)
Antibiotics given	15 (83)
Established second IV/IO	12 (67)
IDS #1	67% (50%–67%)
Seizure	
Respiratory depression	12 (67)
Placed on O ₂	12 (67)
Glucose checked	10 (56)
Glucose concentration correct	14 (78)
Glucose dose correct	8 (44)
Disposition	14 (78)
IDS #2	67% (50%–83%)
Cardiac arrest	
Compression rate	9 (50)
Ventilation	4 (28)
Backboard used	2 (11)
Compressor change	3 (17)
No interruptions other than preshock pause	15 (83)
Pulse check	4 (22)
Recognize/verbalize rhythm, PEA	10 (56)
Epinephrine first dose, correct dose/interval	15 (83)
Epinephrine second dose, correct dose/interval	13 (72)
Preshock pause	18 (100)
Recognize/verbalize, ventricular fibrillation	14 (78)
Defibrillation, correct dose and timing	15 (83)
Resume compression after defibrillation	17 (94)
ETT placed	16 (89)
Continuous end tidal monitoring used	6 (33)
IDS #3	67% (43%–70%)
TPS	67% (56%–70%)

Data are reported as n (%) or median (IQR).

ETT = endotracheal tube; IDS = individualized domain scores; PEA = pulseless electrical activity; TPS = total performance score.

was 64% (IQR = 50%–73%), whereas only three (17%) participants completed the task correctly (Figure 1).

DISCUSSION

This pilot study has begun the process of benchmarking clinical performance of graduating EM resident

Table 3
EM Resident Self-efficacy Questionnaire Data

Questionnaire Item	Median (of 100)	IQR
I can act as team leader in a case of pediatric trauma.	70	48, 70
I can act as team leader in a pediatric resuscitation when a patient presents with cardiogenic shock.	50	35–60
I can act as team leader in a pediatric resuscitation where a patient presents with distributive shock (i.e., anaphylaxis, spinal shock).	60	50–70
I can act as team leader in a pediatric resuscitation where a patient presents with hypovolemic shock.	70	50–73
I can act as team leader in a pediatric resuscitation where a patient presents with septic shock.	70	68–80
I can act as team leader in a pediatric resuscitation where a patient presents with respiratory failure.	68	50–70
I can act as team leader in a pediatric resuscitation where a patient presents with status epilepticus.	60	60–70
I am able to identify the correct ETT size required for pediatric patients of different ages.	65	50–80
I can decide which medications to administer for intubation in the pediatric population.	60	50–73
I am able to identify the correct volume of IV fluid for resuscitation of a pediatric patient in septic shock.	75	60–90
I am able to describe the correct rate and depth of chest compressions during CPR for a pediatric patient.	60	50–80
I am able to describe the correct dose of IV epinephrine to be administered during a case of pediatric PEA cardiac arrest.	70	50–73
I am able to describe the correct dose and concentration of IV glucose to administer for a pediatric patient presenting with symptomatic hypoglycemia.	55	38–64
I am able to identify the correct voltage dose for defibrillation for a pediatric patient in ventricular fibrillation cardiac arrest.	65	50–70
I am able to identify when it is necessary to initiate vasopressor support in a pediatric patient presenting with septic shock.	64	50–73
I am able to identify when to start positive pressure ventilatory support in a pediatric patient in respiratory failure.	60	40–70
Summary measures	Mean	SEM
Global team leader pediatric emergency self-efficacy	61	3.5
Specific task-related pediatric emergency self-efficacy	61	3.8
Overall pediatric emergency self-efficacy	61	3.5

IQR = Interquartile Range; SEM = Standard Error of the Mean

physicians. This study revealed some important initial benchmark performance data for graduating EM resident PEM knowledge and skills. The TPS and IDSs for the cohort approximated two-thirds of correct actions completed and correlated well with overall self-efficacy. A significant area of discrepancy and missed checklist items were those related to cardiopulmonary resuscitation (CPR) and BLS maneuvers.

Interestingly, there was significant discrepancy between self-efficacy and actual clinical performance for identifying the correct IV fluid dosing and vasopressor timing during resuscitation in the setting of septic shock. During the cardiac arrest case, the majority of checklist items missed by the EM resident cohort pertained to standard BLS maneuvers. Yet actions where they excelled included those associated with advanced cardiac life support training, such as limiting interruptions during CPR, epinephrine administration,

preshock pause, defibrillation dosing, resumption of CPR for 2 minutes following defibrillation, and recognition of ventricular fibrillation. This trend could be explained by the fact that EM residents lead many more adult resuscitations during residency than PEM providers, accounting for their comfort with higher-level resuscitation skills, such as ventricular fibrillation management.³⁹ Additionally, because residents typically train at large academic institutions, they tend to lead larger multidisciplinary teams, whereby many BLS steps in resuscitation are completed without their explicit direction (i.e., initial pulse check, CPR). This could possibly account for why more tasks were missed in this area.⁴⁰

Similarly, during the seizure case, the current EM resident cohort performed poorly with the initial glucose check. Checking point-of-care glucose is important in any critically ill patient. In many real-life

Figure 1. Comparison between self-efficacy and percentage complete by key checklist items.

resuscitations, nurses or emergency medical technicians (EMTs) automatically obtain point-of-care glucose measurements without explicit physician direction. As with the BLS maneuvers, it may be that this reality might make it more difficult for EM resident physicians to remember to explicitly order this task during times of high cognitive load. Also, like the prior GED cohort, the residents performed poorly at dosing IV dextrose in pediatric patients, which is consistent with prior studies.¹⁶ It is simple to order an ampule of “D50” during the resuscitation of adult patients, but this may be detrimental to pediatric patients.⁴¹ Therefore, these points may be important areas to target in future PEM educational curricula.

Some important sepsis-related tasks missed by the current EM resident cohort were correct IV fluid dosing and timing of vasopressor administration—i.e., the requirement to start vasopressors after 60 mL/kg IV fluid administered within the first 15 minutes of the resuscitation. These are arguably some of the most important checklist items clinically and have the potential to be lifesaving measures.^{42,43} Even more interesting is the discrepancy between performance and self-efficacy for these tasks. It may be that there is a lack of understanding regarding the speed of IV fluid administration required in these cases and perhaps the residents are less comfortable administering vasopressors to critically ill pediatric patients than to adult patients.

For all three cases, the majority of checklist items missed by the current EM resident cohort, and the prior GED cohort, were tasks that required specific calculations and dosing based on the patients’ age

and/or weight (such as CPR rate/depth, IV glucose dosing, and IV fluid volume). While not surprising, this should obviously be an area of future educational focus. Additionally, for the cardiac arrest case, the vast majority of items missed by the EM resident cohort pertained to poor performance of high-quality CPR. Therefore, these data may support the use of a CPR coach during resuscitations. Additional educational interventions should include improving continuing medical education regarding BLS maneuvers, and the emphasis of close oversight of high-quality CPR by team leaders.

Although we could not directly compare the results of this study to prior GED and PED data due to differences in study design, it is worth highlighting some discrepancies between data from this study and the previously published cohort by Auerbach et al. For example, there were significant differences in the sepsis case. Only 11% of EM residents in this study administered the correct IV fluid volume versus 28% of the teams from the prior GED cohort and 100% of teams from the PED cohort. Appropriate vasopressor support was also much less frequent in the current study (17% of EM residents vs. 79% of GEDs and 100% of PEDs). Similarly, during the seizure case, fewer EM residents checked a fingerstick blood glucose within 3 minutes of patient arrival (56% of EM residents vs. 98% of GEDs and 100% of PEDs). A greater number of EM residents chose the correct glucose concentration vs. GEDs and PEDs (78% vs. 12 and 40%, respectively) but fewer chose the correct dose (44% vs. 46 and 80%, respectively). During the cardiac arrest case, fewer EM residents identified the

correct CPR rate versus GEDs and PEDs (50% vs. 63 and 93%, respectively) and fewer used a backboard during CPR (11% vs. 24 and 60%, respectively). They were also better at minimizing CPR interruptions (83% vs. 29 and 13%, respectively). Overall, when compared to previously published performance data, it appears that the current EM resident cohort performed slightly better than the GED teams for the cardiac arrest case and similar to GED teams for the sepsis and seizure cases. However, given limitations in the data comparison, this conclusion cannot definitely be made.

Despite national initiatives, there appears to be significant variability in the quality of pediatric emergency care across the United States.^{1–6,12} Similarly, considerable variability exists in both current didactic curricula and clinical experience provided to EM resident physicians in the United States.^{15,19,20,23–26} Recent data suggest worse mortality outcomes for pediatric patients presenting with sepsis or cardiac arrest to facilities with low pediatric readiness.^{12,13} This study is attempting to shed light on the current state of EM resident PEM education. This knowledge may help organizations such as ACEP, AAP, ACGME, and NAM determine where future educational resources may be most efficiently allocated to improve and maximize the quality of pediatric emergency care across the United States. It may be that these data suggest the need for additional PEM education within EM residency programs, but as previous data suggest, this most likely cannot be achieved by increasing clinical exposure to pediatric patients.^{23,24,28} Therefore, the results of this study and future larger studies may help add to the growing body of literature advocating for additional pediatric simulation curriculum within EM residency programs and its use for maintaining competency in independent postgraduate medical practitioners.

FUTURE DIRECTIONS

This pilot study provides the basis of a future study that will enroll a proposed larger multicenter cohort (14 sites), with the hope to obtain a more generalizable benchmark dataset to begin to address deficiencies in PEM education in the United States. With a larger cohort, we hope to address additional secondary outcomes such as 1) comparing resident simulated performance in 3- versus 4-year EM residency programs, 2) correlating clinical performance and leadership ability, and 3) correlating clinical performance with actual

PEM didactic and clinical exposure as reported by residency program directors. These data will be integral when considering where to allocate future educational resources. To date, no study has used pediatric simulation in this capacity. Given recent published data showing increased mortality for critically ill pediatric patients presenting to GEDs versus PEDs, this study and subsequent research may contribute to improved pediatric emergency care outcomes in the United States.

LIMITATIONS

This study has a number of limitations. First, due to small sample size of this pilot study, this cohort was not powered to achieve statistical significance with comparison data. It is hoped that a larger, subsequent multicenter cohort will allow for appropriate power and generalizable data. Second, while previously published, the checklist used in this study has limited validity data, and its relationship with patient outcomes is unknown. A benefit of this study, unlike prior research using the same simulated cases, is that selection bias has been virtually eliminated by enrolling all eligible EM residents.

Additionally, a number of significant limitations exist in the comparison of EM resident cohort data to prior data from GEDs and PEDs. First, while the simulated cases used in this study were the same as those used for prior cohorts, the practice environment differed greatly. EM residents in this study had to practice in the unfamiliar and artificial setting of a simulation center, whereas the prior comparison cohort managed cases in their respective resuscitation rooms with their own equipment and multidisciplinary teams. Despite this, the authors deem these data clinically significant, as the checklist items for each case pertain to management decisions and tasks that should be completed by, or at least ordered by, the team leader in each case. This is especially evident in the cardiac arrest case, whereby the EMT confederates were scripted to initially perform inadequate CPR. These inadequacies needed to be identified and corrected by instruction from the team leader, thereby standardizing this element of evaluation.

Finally, since the checklists used in this study were created using existing practice guidelines and expert opinion, the assumption is that good pediatric care would be associated with scores close to 100%. Since we do not have data to correlate simulated performance to actual pediatric outcomes, we cannot yet

definitively say that any of the simulated performance data correspond to actual pediatric emergency care outcomes. However, we hope that future studies will address this question and remain confident that simulation-based metrics serve as a good proxy for processes of care in high-stakes, low-frequency events such as cardiac arrest and sepsis.

CONCLUSION

This study has begun the process of benchmarking clinical performance of graduating emergency medicine resident physicians to address the current state of pediatric emergency medicine education in the United States. Overall, the emergency medicine resident cohort in this study, while not at the level of pediatric ED teams, performed similar to general ED teams. Their self-efficacy related to pediatric emergency medicine correlated well with their performance, with the exception of knowledge relative to intravenous fluid and vasopressor administration in pediatric septic shock. Additionally, a significant area of discrepancy, and missed checklist items, were those related to cardiopulmonary resuscitation and basic life support maneuvers and weight-based dosing calculations.

Thus, from this small cohort we conclude that we may not be optimizing pediatric education for our emergency medicine residency trainees. We hypothesize that our next study will show a correlation between performance and education at each institution and will hopefully illustrate further data-driven conclusions regarding this topic. Prior medical simulation research has assessed the clinical performance of pediatric resident physicians during simulated pediatric resuscitations.^{34,35} However, to date, there are minimal data to report the clinical performance of graduating emergency medicine resident physicians leading medical teams caring for critically ill pediatric patients. This is the first study to use medical simulation to take steps in assessing the state of current pediatric emergency medicine training for senior emergency medicine resident physicians. We have demonstrated gaps in emergency medicine resident care that will help engage dialogue to hopefully target future educational interventions.

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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/aet2.10509/full>

Data Supplement S1. Supplemental material.