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Proceedings of the 2018 AEM Consensus Conference: Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps
Guest Editors: Robert L. Cloutier, MD, MCR and Rakesh Mistry, MD, MS

CONSENSUS CONFERENCE

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Executive Summary: The 2018 *Academic Emergency Medicine* Consensus Conference: Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps

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ABSTRACT

Emergency care providers share a compelling interest in developing an effective patient-centered, outcomes-based research agenda that can decrease variability in pediatric outcomes. The 2018 *Academic Emergency Medicine* Consensus Conference "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps (AEMCC)" aimed to fulfill this role. This conference convened major thought leaders and stakeholders to introduce a research, scholarship, and innovation agenda for pediatric emergency care specifically to reduce health outcome gaps. Planning committee and conference participants included emergency physicians, pediatric emergency physicians, pediatricians, and researchers with expertise in research dissemination and translation, as well as comparative effectiveness, in collaboration with patients, patient and family advocates from national advocacy organizations, and trainees. Topics that were explored and deliberated through subcommittee breakout sessions led by content experts included 1) pediatric emergency medical services research, 2) pediatric emergency medicine (PEM) research network collaboration, 3) PEM education for emergency medicine providers, 4) workforce development for PEM, and 5) enhancing collaboration across emergency departments (PEM practice in non–children's hospitals). The work product of this conference is a research agenda that aims to identify areas of future research, innovation, and scholarship in PEM.

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CASE VIGNETTE

A 22-month-old girl with cerebral palsy, development delay, and epilepsy develops status epilepticus in a rural part of the state. Her parents call 9-1-1, and the paramedics note that she has intermittent seizure activity and shallow, irregular respirations. The paramedics check a blood glucose level and initiate bag-valve-mask ventilation, but they are unable to obtain intravenous access, and the child continues to seize. A small emergency department (ED) is 20 minutes away by ground. The ED is staffed by physicians residency trained in emergency medicine, the staff undergoes ongoing pediatric education, and the hospital is loosely affiliated with the regional children's hospital. However, this ED rarely sees seriously ill children. The regional children's hospital, which serves as the child's medical home, is 60 minutes away by helicopter. The paramedics contact the base hospital for management and transport orders.

CASE DISCUSSION

This illustrative case raises numerous questions about how to assure that the highest possible quality care is available for all acutely ill and injured children. What are the most effective interventions for children in the prehospital setting? How does the core training, experience, and continuing education of emergency providers affect patient care? What are the respective roles of general and pediatric EDs, and how can these effectively collaborate within the pediatric emergency care system? Are these and other questions answerable through high-quality, multicenter studies? The 2018 *Academic Emergency Medicine* Consensus Conference "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps" aims to identify and address areas of focus for future pediatric emergency medicine (PEM) research and scholarship that can propel actionable change.

CURRENT STATE OF PEM

The health care system in the United States fails to provide consistent, high-quality care to all people,[1] leading to clear inequalities in health outcomes. Disparities in health outcomes are driven by many determinants. Many of the factors associated with these differences are sociodemographic, such as race and ethnicity, poverty, education, and geographic location,[2] and are associated with clinically relevant differences in outcomes for many of the conditions seen in the ED: rates of appendicitis with perforation,[3] time to surgery in patients with appendicitis,[4] analgesia for painful conditions,[5,6] use of antibiotic in presumed viral illnesses,[7] and rates of ED aftercare compliance.[8]

Clinical factors and differential access to care also contribute to health disparities.[9–11] In 1993, the National Academies of Sciences, Engineering, and Medicine (NASEM), previously known as the Institute of Medicine, conducted a study of pediatric emergency medical care in the United States, "Emergency Medical Services for Children." This report described the evolving state of emergency care for children and identified factors contributing to the challenges of delivering consistent, high-quality emergency care. These factors include "complexities of the organization, delivery, and financing of health care; financial, insurance, and other barriers to access to appropriate care; inadequate numbers of health care personnel and perverse patterns of specialization and geographic location; and great variations in use of services and questions about the appropriateness and quality of health care." This report contained specific personnel and equipment recommendations and also recommended areas for future research.[12]

A subsequent report in 2006 from the NASEM, "Emergency Care for Children: Growing Pains," evaluated interim progress. The authors described successes in the overall state of pediatric emergency care since the NASEM report published 13 years earlier. Yet they also noted that the overall state of pediatric emergency care was "uneven," outlining continued disparities in access to care, pediatric expertise among emergency care providers, and resource availability.[13] The report focused extensively on research and described a widening information gap in basic, translational, and health systems research in pediatric emergency care. However, the report also noted the early successes of the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics and the promise of the nascent Pediatric Emergency Care Applied Research Network. Overall, it reiterated the call to address the uneven landscape of pediatric emergency care and promoted research that advanced sound, evidence-based practices.

To date, there has been inconsistent progress in the delivery of consistent high-quality emergency care for

infants and children. Substantial gains have been achieved in ED pediatric preparedness through guidelines published in 2001[14,15] and revised in 2009.[16,17] In the time between these guidelines, a study reported that 17% of EDs did not have access to emergency physicians, PEM, or pediatric attending physicians, and only 6% of EDs had all of the pediatric equipment recommended in the 2001 guidelines.[18] Concerted efforts by stakeholders led to the National Pediatric Readiness Project, with marked improvements in the overall pediatric readiness of EDs.[19,20] Other recent initiatives by PEM stakeholders resulted in the development of Pediatric Emergency Medicine Milestones by the American Board of Emergency Medicine, the American Board of Pediatrics, and the Accreditation Council for Graduate Medical Education; the launch of the Advanced Pediatric Emergency Medicine Assembly by the American College of Emergency Physicians and the American Academy of Pediatrics; and the ongoing successes of the federal Emergency Medical Services for Children (EMSC) Program.

Despite important gains on a national level, progress has unfortunately been tempered by ongoing geographic and provider-based gaps in pediatric emergency care. These gaps constitute a vital impediment to assuring consistent, high-quality pediatric emergency care. There are data to suggest an association between hospital type and pediatric mortality for critically ill children, even though this outcome measure is confounded by overall low pediatric mortality rates.[21,22] The evidence for substantial variability among EDs in the rates of computed tomographic imaging in pediatric trauma[23–27] and children with abdominal pain[28] is more robust. While the clinical outcomes are comparable between general and pediatric EDs, the rates of unnecessary exposure to ionizing radiation are different and constitute a higher risk to children in the general ED setting.

There is variability in access to EDs in general,[10,11,29] and access to "pediatric-ready" EDs remains a challenge in many regions of the United States.[30] Substantial variability exists in adherence to pediatric cardiac arrest[31] and sepsis[32] guidelines across EDs. The distribution of fellowship-trained pediatric emergency physicians continues to be uneven, with a relative abundance of board-certified pediatric emergency physicians in some urban areas, many regions with far fewer pediatric emergency physicians and five states with none at all.[33] Viewed in this context, "progress on improving the quality of care for children in emergencies has remained slow at best."[34]

CONFERENCE PLANNING

The *Academic Emergency Medicine* Consensus Conference (AEMCC) is an annual research conference that has been held since 2000 in conjunction with the Society for Academic Emergency Medicine Annual Meeting. The AEMCC is intended to generate a research agenda that fosters progress in evolving disciplines of emergency medicine. An array of thought leaders in pediatrics, emergency medicine, and PEM joined together as a core group to form the initial AEMCC Executive Committee to create a proposal for a conference that focuses on PEM (Table 1).

The AEMCC Executive Committee created a survey to identify specific thematic content and to generate additional multi-organization interest in the conference. This survey was distributed to multiple organizations, including the American Academy of Pediatrics Section on Emergency Medicine, the American College of Emergency Physicians PEM Committee and PEM Section, the Academic Pediatric Association Pediatric Emergency Medicine Special Interest Group, the National Association of EMS Physicians, the EMSC Program, the Society for Pediatric Research, and the Emergency Medicine Resident Association.

Over 250 respondents completed the survey, which helped to identify possible topic domains warranting additional focus at the AEMCC. Five specific areas of research interest were identified based on the results of this questionnaire: pediatric EMS research, PEM research network collaboration, PEM education for EM providers, workforce development for PEM, and enhancing collaboration across EDs (PEM practice in non–children's hospitals). These became the five themes for the breakout sessions at the AEMCC. Incorporating input from this survey, the Executive Committee wrote and submitted an AEMCC proposal. The proposed conference, "Addressing the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcomes Gaps," underwent a competitive review process and was selected by the *Academic Emergency Medicine* (*AEM*) editorial board as the topic for the 2018 AEMCC.

The initial AEMCC survey also helped to identify further stakeholders who wanted to participate in the conference planning process. These additional volunteers joined with the members of the executive

committee to form the planning committee for the conference. Subcommittees were created to address each of the five themes, and chairs were appointed to lead each of these subcommittees (Table 2). All of the planning committee members were subsequently assigned to one of the five subcommittees to collaborate on subcommittee planning (Table 3).

The co-chairs and executive committee oversaw all aspects of conference development throughout the planning year for the AEMCC, which included formulating the conference agenda, identifying and inviting keynote speakers and subcommittee oversight. The planning committee also worked on grant writing, fundraising and marketing for the conference, primarily via electronic mail and monthly conference calls. Members of the planning committee met in person at both the 2017 AEMCC in Orlando, Florida, and the 2017 American College of Emergency Physicians Scientific Assembly in Washington, DC. The entire planning committee held a final meeting on the evening prior to the conference.

Much of the conference planning was conducted at the subcommittee level. Each subcommittee generated a list of research topics, informed by the expertise of the panelists and outside experts, literature review, electronic discussions, and conference calls. The subcommittees then distributed a preliminary list of prioritized research topics. In the weeks before the conference date, a survey was distributed to both confirmed attendees and other PEM stakeholders to help further identify and prioritize the research topics within these five domains; thus, 178 respondents helped to further refine the topic areas of focus for subcommittees. The combined input from subcommittee members and survey respondents was used to finalize the subcommittee agendas for the AEMCC breakout sessions.

Role of Patient Advocates

The conference organizers recognized that the perspective of both pediatric patients and caretakers was crucial to the AEMCC given the unique patient/caretaker/clinician relationship that underpins the emergency care of all infants and children. Thus patient and parent advocates were recruited to participate in the conference planning process (Table 4). An advocate was assigned to each of the five subcommittees, and they participated in the monthly teleconferences and subcommittee planning. On the day of the conference, each advocate participated in their subcommittee breakout sessions, and all of the advocates served on a patient-focused lunchtime panel. The advocates also contributed to manuscript preparation and were included as authors on these proceedings.

CONFERENCE AIMS

The overarching goal of the 2018 AEMCC was to develop a research agenda for the future to reduce health outcome gaps in ill and injured children. To achieve this goal, the consensus conference had five specific aims:

Table 1
2018 *Academic Emergency Medicine* Consensus Conference Executive Committee

Name	Institution	Role
Kurt Denninghoff, MD	University of Arizona	Co-Chair
Paul Ishimine, MD	University of California, San Diego	Co-Chair
Kathleen Adelgais, MD, MPH	University of Colorado	Subcommittee Chair
Isabel Barata, MS, MD, MBA	Donald and Barbara Zucker School of Medicine at Hofstra/Northwell	Subcommittee Chair
Jean Klig, MD	Massachusetts General Hospital	Subcommittee Co-Chair
Maybelle Kou, MD	Inova Fairfax Hospital	Subcommittee Co-Chair
Prashant Mahajan, MD, MPH, MBA	University of Michigan	Subcommittee Co-Chair
Chris Merritt, MD, MPH	Brown University	Subcommittee Chair
Michael J. Stoner, MD	Nationwide Children's Hospital & The Ohio State University	Subcommittee Co-Chair
Jeffrey Kline, MD	Indiana University	*Academic Emergency Medicine* Editor-in-Chief
Robert Cloutier, MD, MCR	Oregon Health & Science University	*Academic Emergency Medicine* Guest Editor
Rakesh Mistry, MD, MS	University of Colorado	*Academic Emergency Medicine* Guest Editor
Melissa McMillian, CNP	Society for Academic Emergency Medicine	Director, Foundation and Business Development

Table 2
Subcommittees

Subcommittees	Chair(s)	Goals and Objectives
Pediatric Emergency Medical Services Research	Kathleen Adelgais, MD, MPH	Goal: • Create a research agenda for the pediatric EMS research community that will advance the science of EMS for children and ultimately improve patient outcomes.
		Objectives:
		• Explore research opportunities to determine whether established best practice for pediatric EMS care improves patient-oriented outcomes.
		• Discuss the best methods to study challenging but high-impact clinical conditions such as out-of-hospital cardiac arrest, drowning, severe trauma, and respiratory failure.
		• Identify opportunities to translate knowledge and evidence into the prehospital setting.
Pediatric Emergency Medicine Education	Jean Klig, MD, Maybelle Kou, MD	Goal: • Introduce a research agenda that can unify and advance PEM education, promote a network for ongoing progress, and improve outcomes for acutely ill and injured children.
		Objectives:
		• Identify fundamental research priorities to close the many education gaps that underlie nonuniform care for children across EDs and urgent care centers in the United States.
		• Propose key steps to launch a PEM education research network • Discuss how information from the patient experience may be integrated into PEM education research.
Enhancing collaboration across EDs (PEM in non–children's hospitals)	Isabel Barata, MS, MD, MBA	Goal: • To include general EDs based in non–children's hospitals in creating a research agenda to advance the quality and safety of pediatric emergency care across all EDs, understand the challenges and enhance the collaboration with children's hospitals to achieve optimal health outcomes.
		Objectives: • Create best practices for developing a system of care for general EDs and those in children's hospitals to collaborate and focus on solutions to close the gap on safety, quality, and evidence-based practice in a patient/family-centered setting. This system should meet the needs of both groups to provide the best clinical care for pediatric patients.
		• Develop pediatric specific outcome measures and implementation processes to ensure continuous quality improvement.
		• Evaluate the National Pediatric Readiness Project (NPRP) initiative, a quality improvement project.
Research Networks	Michael J. Stoner, MD	Goals:
	Prashant Mahajan, MD, MPH, MBA	• To increase attendee understanding of, participation in, and prioritization of PEM network research.
		• To demonstrate how PEM network research results can improve care of acutely ill and injured children.
		Objectives: • To identify priorities for future PEM network research.
		• To provide conference participants a forum to brainstorm and discuss potential future network research studies.
Workforce Development for Pediatric Emergency Medicine	Chris Merritt, MD, MPH	Goals: • Delineate and prioritize a research agenda to advance our understanding of the unique workforce needs in the emergency care of children in the interest of ensuring excellence in pediatric care and improve patient outcomes across emergency care settings.

(Continued)

Table 2 (continued)

Subcommittees	Chair(s)	Goals and Objectives
		Objectives: • Define highest-priority areas of research and workforce needs in pediatric emergency care.
		• Engage a group of stakeholders in a discussion of means and targets for workforce research in pediatric emergency care.
		• Identify opportunities to translate workforce knowledge and evidence into the array of pediatric care environments.

1. Aligning PEM leaders across organizations and foster new leadership;
2. Developing a research agenda for PEM across all access points to the emergency care system;
3. Identifying pathways to achieve core pediatric emergency knowledge and skills among all care providers to children;
4. Launching networks for research and innovation in PEM education and workforce development; and
5. Integrating PEM research networks to foster high-quality research of high-risk and/or low-frequency clinical conditions.

While the 2018 conference is the first AEMCC to focus exclusively on pediatric emergencies, it also aims to build on the past efforts of the previous AEMCCs and to incorporate relevant works into current research recommendations. Themes of several previous AEMCCs have been broadly applicable to PEM and have included health care disparities;[35] educational research,[36] knowledge translation[37] (this conference included one pediatric-specific topic[38]), and the regionalization of emergency care.[39]

CONFERENCE AGENDA (FIGURE 1)

The AEMCC was held on May 15, 2018, in Indianapolis, Indiana, in conjunction with the Society for Academic Emergency Medicine Annual Meeting. A total of 119 stakeholders, including physicians, nurses, advanced practice providers, prehospital providers, trainees, researchers, patient representatives, and representatives from funding agencies attended this conference.

After an introduction by Jeffrey Kline, MD, the editor-in-chief of *Academic Emergency Medicine,* conference co-chairs Drs. Ishimine and Denninghoff discussed the current state of PEM and the background leading up to this conference, the goals of the conference, and the conference plan. The conference included a morning keynote presentation by Nate Kuppermann, MD, MPH, highlighting the power of research network collaboration.[40,41] This was followed by three morning subcommittee breakout sessions on pediatric EMS research, PEM research networks, and PEM education. Each attendee participated in one of these three morning sessions. Each session was led by the subcommittee chairs, which facilitated discussions among breakout session participants to build consensus around and prioritize the proposed research topics that had been identified in the preconference planning process.

The conference attendees reconvened at lunch, where a panel of four of the patient advocates described their experiences in the pediatric emergency care system and participated in a moderated question-and-answer session. After this lunchtime panel session, all conference participants then attended either the workforce development for PEM breakout session or the enhancing collaboration across EDs (PEM practice in non–children's hospitals) breakout session, working in the same fashion as the morning sessions. Terry Klassen, MD, MSc, then gave the closing address, describing opportunities in translational research to decrease the gaps between evidence-based knowledge and clinical practice.[42–45] The consensus ideas, challenges, and conclusions from all of the five breakout sessions were then summarized and presented by the subcommittee chairs, followed by adjournment after concluding remarks by the consensus conference chairs.

After the conclusion of the conference, the subcommittees began writing manuscripts summarizing the discussions that had occurred during their breakout sessions and detailing the prioritized research, innovation, and scholarship agendas as a consensus for each theme. These proceedings are published in this issue of *Academic Emergency Medicine*. Additionally, the Society

Table 3
Planning Committee Members by Subcommittee

Education Subcommittee	Research Networks Subcommittee
Jean Klig, MD, and Maybelle Kou, MD (Chairs) Rahul Bhat, MD Troy Denslow (Patient Advocate) Andrea Fang, MD Sean Fox, MD Jeffrey Hom, MD Ashley Strobel, DO Sonny Tat, MD Jessica Wall, MD Eric Weinberg, MD	Michael J. Stoner, MD (Chair) Prashant Mahajan, MD, MPH, MBA (Co-Chair) Jill Baren, MD, MBE Silvia Bressan, MD, PhD Corrie E. Chumpitazi, MD, MS Stephen B. Freedman, MDCM, MSc Parris Keane (Patient Advocate) Aaron E. Kornblith, MD Nate Kuppermann, MD, MPH Sam H. F. Lam, MD, MPH Lise E. Nigrovic, MD, MPH Damian Roland, BMedSci, BMBS, MRCPCH, PhD
Emergency Medical Services Subcommittee	**Workforce Subcommittee**
Kathleen Adelgais, MD MPH (Chair) Kathleen Brown, MD Paula Denslow (Patient Advocate) J. Joelle Donofrio, DO Matt Hansen, MD MSCR Kabir Yadav, MDCM MS MSHS E. Brooke Lerner, PhD Lenora Olson, PhD (Moderator)	Chris Merritt, MD, MPH (Chair) Christopher Amato, MD Mary Kay Ballasiotes (Patient Advocate) Amanda Bogie, MD Ann Dietrich, MD Michael Gerardi, MD Kajal Khanna, MD, JD Mohsen Saidinejad, MD, MPH, MBA Fred Wu, MHS, PA-C
Enhancing Collaboration Across EDs (PEM in Non–Children's Hospitals) Subcommittee	
Isabel Barata, MS, MD, MBA (Chair) Marc Auerbach, MD Oluwakemi Badaki-Makun, MD Lee Benjamin, MD Madeline Joseph, MD Moon Lee, MD Kim Mears (Patient Advocate) Emory Petrack, MD Dina Wallin, MD	

for Academic Emergency Medicine has free online access to most of the conference presentations.[46]

LIMITATIONS

A major limitation of any consensus conference is that the results are influenced significantly by attendees and their active participation. Combining the AEMCC with a major emergency medicine conference helped to leverage conference support infrastructure in an efficient manner. However, attendance is often limited by competing interests and obligations.

Table 4
Patient Advocates

Name	Organization
Mary Kay Ballasiotes	Founder/President, International Alliance for Pediatric Stroke
Paula Denslow	Patient Advocate, Tennessee Disability Coalition
Troy Denslow	Patient Advocate
Kim Mears	Patient Advocate, Children's Hospital Volunteer
Parris Shelley	Patient Advocate

One such conflict was a national pediatric research conference held nearly simultaneously with this conference in a different North American city. Although the dilemma was unavoidable, this understandably made it very challenging for some of the PEM stakeholders to attend the AEMCC in person. To mitigate this impact, the planning committee sought preconference input by attendees and nonattendee stakeholders alike via two preconference surveys and disseminated background materials prior to the conference to help attendees prepare for the breakout session discussions.

SUMMARY

The 2018 *Academic Emergency Medicine* Consensus Conference "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcomes Gaps" brought together a wide array of stakeholders with a vested interest in the emergency care of children, which led to the development of a consensus-driven research agenda in five domains of pediatric emergency care. We hope that these conference proceedings will drive essential research and scholarship that promotes innovation, advances clinical practice, and broadens collaboration across institutions and organizations to improve the emergency care of children. The future for acutely ill and injured children nationwide depends on it.

The authors acknowledge the assistance of Melissa McMillian, CNP, who provided invaluable guidance throughout the entirety of the 2018 AEMCC planning process. The authors acknowledge Jennifer Walthall, MD, MPH, who conceived the idea for this conference, brought together the original planning committee, and submitted the initial AEMCC proposal. The authors would also like to thank the scribes for the AEMCC: Isabelle Chea; Ryan Hartman, MD; Seth Linakis, MD; Teresa Liu, MD; and Nadira Ramkhelawan, MD.

7:30 am - 8:00 am	•**Registration/Continental Breakfast/Networking**
8:00 am - 8:15 am	•**Opening Remarks** Jeffrey Kline, MD Editor-in-Chief, *Academic Emergency Medicine*
8:15 am - 8:45 am	•**Welcome, Setting the Agenda, and Conference Plan** Paul Ishimine, MD and Kurt Denninghoff, MD AEM Consensus Conference Co-Chairs
8:45 am - 9:30 am	•**Keynote Address: "Generating Evidence that is Ripe for Translation: Not All Evidence is Created Equal"** Nate Kuppermann, MD, MPH Bo Tomas Brofeldt Endowed Chair, Department of Emergency Medicine Distinguished Professor, Departments of Emergency Medicine and Pediatrics University of California, Davis School of Medicine
9:30 am - 9:45 am	•**Break**
9:45 am - 11:20 am	•**Breakout Session/Morning** • Pediatric EMS Research • Pediatric Emergency Medicine Research Networks • Pediatric Emergency Medicine Education
11:20 am - 11:35 am	•**Break**
11:35 am -12:35 pm	•**Lunchtime Panel: "The Power of Collaboration"** Patient Advocacy Panel: Rakesh Mistry, MD, MS (Moderator) • Paula Denslow, Tennessee Disability Coalition, Patient Advocate • Troy Denslow, Patient Advocate • Kim Mears, Children's Hospital Volunteer, Patient Advocate • Mary Kay Ballasiotes, Founder/President, International Alliance for Pediatric Stroke
12: 35 pm - 12:50 pm	•**Break**
12:50 pm - 2:30 pm	•**Breakout Session/Afternoon** • Workforce Development for Pediatric Emergency Medicine • Enhancing Collaboration Across EDs (PEM in Non-Childrens Hospitals)
2:30 pm - 2:45 pm	•**Break**
2:45 pm - 3:30 pm	•**Closing Address: "Reducing the Gap: Getting Evidence to the Point of Care"** Terry Klassen, MD, MSc Professor and Head, Department of Pediatrics & Child Health Max Rady College of Medicine, Rady Faculty of Health Sciences University of Manitoba
3:30 pm - 4:45pm	•**Breakout Session Reports** Subcommittee Chairs
4:45 pm - 5:00 pm	•**Future Directions and Closing Remarks** Kurt Denninghoff, MD and Paul Ishimine, MD AEM Consensus Conference Co-Chairs

Figure 1. Conference agenda.

References

1. Institute of Medicine Committee on Quality of Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington DC: National Academies Press, 2001.
2. Givens M, Gennuso K, Jovaag A, Willems Van Dijk J. 2018 County Health Rankings Key Findings Report. Available at: http://www.countyhealthrankings.org/explore-health-rankings/rankings-reports/2018-county-health-rankings-key-findings-report. Accessed October 1, 2018.
3. Guagliardo MF, Teach SJ, Huang ZJ, Chamberlain JM, Joseph JG. Racial and ethnic disparities in pediatric appendicitis rupture rate. Acad Emerg Med 2003;10:1218–27.
4. Wang L, Haberland C, Thurm C, Bhattacharya J, Park KT. Health outcomes in US children with abdominal pain at major emergency departments associated with race and socioeconomic status. PloS one 2015;10:e0132758.
5. Lee HH, Lewis CW, McKinney CM. Disparities in emergency department pain treatment for toothache. JDR Clin Trans Res 2016;1:226–33.
6. Goyal MK, Kuppermann N, Cleary SD, Teach SJ, Chamberlain JM. Racial disparities in pain management of children with appendicitis in emergency departments. JAMA Pediatr 2015;169:996–1002.
7. Goyal MK, Johnson TJ, Chamberlain JM, et al. Racial and ethnic differences in antibiotic use for viral illness in emergency departments. Pediatrics 2017;140. pii: e20171l0203.
8. Wang NE, Gisondi MA, Golzari M, Van Der Vlugt TM, Tuuli M. Socioeconomic disparities are negatively associated with pediatric emergency department aftercare compliance. Acad Emerg Med 2003;10:1278–84.
9. Carr BG, Branas CC, Metlay JP, Sullivan AF, Camargo CA Jr. Access to emergency care in the United States. Ann Emerg Med. 2009;54:261–9.
10. Ravikumar D, Hsia R. Do California counties with lower socioeconomic levels have less access to emergency department care? Acad Emerg Med. 2010;17:508–13.
11. Hsia RY, Srebotnjak T, Kanzaria HK, McCulloch C, Auerbach AD. System-level health disparities in California emergency departments: minorities and Medicaid patients are at higher risk of losing their emergency departments. Ann Emerg Med. 2012;59:358–65.
12. Durch J, Lohr KN; Institute of Medicine Committee on Pediatric Emergency Medical Services. Emergency Medical Services for Children. Washington, DC: National Academy Press, 1993.
13. Institute of Medicine Committee on the Future of Emergency Care in the United States Health System. Emergency care for children: growing pains. Washington DC: National Academies Press; 2007.
14. American College of Emergency Physicians, American Academy of Pediatrics. Care of children in the emergency department: guidelines for preparedness. Ann Emerg Med 2001;37:423–7.
15. American Academy of Pediatrics, American College of Emergency Physicians. Care of children in the emergency department: guidelines for preparedness. Pediatrics 2001;107:777–81.
16. American Academy of Pediatrics, American College of Emergency Physicians, Emergency Nurses Association Pediatric Committee. Joint policy statement–guidelines for care of children in the emergency department. Pediatrics 2009;124:1233–43.
17. American College of Emergency Physicians, American Academy of Pediatrics, Emergency Nurses Association Pediatric Committee. Joint policy statement–guidelines for care of children in the emergency department. Ann Emerg Med 2009;54:543–52.
18. Gausche-Hill M, Schmitz C, Lewis RJ. Pediatric preparedness of US emergency departments: a 2003 survey. Pediatrics 2007;120:1229–37.
19. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
20. Remick K, Kaji AH, Olson L, et al. Pediatric readiness and facility verification. Ann Emerg Med 2016;67:320–8.e1.
21. Webman RB, Carter EA, Mittal S, et al. Association between trauma center type and mortality among injured adolescent patients. JAMA Pediatr 2016;170:780–6.
22. Hansen M, Fleischman R, Meckler G, Newgard CD. The association between hospital type and mortality among critically ill children in US EDs. Resuscitation 2013;84:488–91.
23. Mannix R, Nigrovic LE, Schutzman SA, et al. Factors associated with the use of cervical spine computed tomography imaging in pediatric trauma patients. Acad Emerg Med 2011;18:905–11.
24. Marin JR, Weaver MD, Barnato AE, Yabes JG, Yealy DM, Roberts MS. Variation in emergency department head computed tomography use for pediatric head trauma. Acad Emerg Med 2014;21:987–95.
25. Marin JR, Wang L, Winger DG, Mannix RC. Variation in computed tomography imaging for pediatric injury-related emergency visits. J Pediatr 2015;167:897–904.e3.
26. Stanley RM, Hoyle JD Jr, Dayan PS, et al. Emergency department practice variation in computed tomography use for children with minor blunt head trauma. J Pediatr 2014;165:1201–6.e2.
27. Meltzer JA, Stone ME Jr, Reddy SH, Silver EJ. Association of whole-body computed tomography with mortality risk in children with blunt trauma. JAMA Pediatr 2018;172:542–9.
28. Niles LM, Goyal MK, Badolato GM, Chamberlain JM, Cohen JS. US emergency department trends in imaging

for pediatric nontraumatic abdominal pain. Pediatrics 2017;140. pii: e20170615.
29. Hsia RY, Kellermann AL, Shen YC. Factors associated with closures of emergency departments in the United States. JAMA. 2011;305:1978–85.
30. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. J Pediatr 2018;194:225–32.e1.
31. Auerbach M, Brown L, Whitfill T, et al. Adherence to pediatric cardiac arrest guidelines across a spectrum of fifty emergency departments: a prospective, in situ, simulation-based study. Acad Emerg Med 2018 Sep 8. https://doi.org/10.1111/acem.13564 [Epub ahead of print]
32. Kessler DO, Walsh B, Whitfill T, et al. Disparities in adherence to pediatric sepsis guidelines across a spectrum of emergency departments: a multicenter, cross-sectional observational in situ simulation study. J Emerg Med 2016;50:403–15.e1–3.
33. 2017–2018 ABMS Board Certification Report 2018. Available at: https://www.abms.org/media/194885/abms-board-certification-report-2017-2018.pdf. Accessed October 1, 2018.
34. Alessandrini EA, Wright JL. The continuing evolution of pediatric emergency care. JAMA Pediatr 2015;169:523–4.
35. Executive summary: disparities in emergency health care. Acad Emerg Med 2003;10:1153–4.
36. LaMantia J, Deiorio NM, Yarris LM. Executive summary: education research in emergency medicine–opportunities, challenges, and strategies for success. Acad Emerg Med 2012;19:1319–22.
37. Lang ES, Wyer PC, Eskin B. Executive summary: knowledge translation in emergency medicine: establishing a research agenda and guide map for evidence uptake. Acad Emerg Med 2007;14:915–8.
38. Hartling L, Scott-Findlay S, Johnson D, et al. Bridging the gap between clinical research and knowledge translation in pediatric emergency medicine. Acad Emerg Med 2007;14:968–77.
39. Carr BG, Martinez R. Executive summary–2010 consensus conference. Acad Emerg Med 2010;17:1269–73.
40. Glaser N, Barnett P, McCaslin I, et al. Risk factors for cerebral edema in children with diabetic ketoacidosis. The Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics. N Engl J Med 2001;344:264–9.
41. Kuppermann N, Ghetti S, Schunk JE, et al. Clinical trial of fluid infusion rates for pediatric diabetic ketoacidosis. N Engl J Med 2018;378:2275–87.
42. Wittmeier KD, Klassen TP, Sibley KM. Implementation science in pediatric health care: advances and opportunities. JAMA Pediatr 2015;169:307–9.
43. Crockett LK, Leggett C, Curran JA, et al. Knowledge sharing between general and pediatric emergency departments: connections, barriers, and opportunities. CJEM 2018:1–9.
44. Featherstone RM, Leggett C, Knisley L, et al. Creation of an integrated knowledge translation process to improve pediatric emergency care in Canada. Health Commun 2018;33:980–7.
45. Scott SD, Albrecht L, Given LM, et al. Pediatric information seeking behaviour, information needs, and information preferences of health care professionals in general emergency departments: results from the Translating Emergency Knowledge for Kids (TREKK) Needs Assessment. CJEM 2018;20:89–99.
46. 2018 Academic Emergency Medicine Consensus Conference: Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps. Available at: http://ondemand.saem.org/common/media-player.aspx/5/16/389/1405. Accessed September 1, 2018.

2018 *Academic Emergency Medicine* Consensus Conference: Advancing Pediatric Emergency Medicine Education Through Research and Scholarship

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ABSTRACT

To achieve high-quality emergency care for pediatric patients nationwide, it is necessary to define the key elements for pediatric emergency medicine (PEM) education and scholarship that would: 1) close the gaps in fundamental PEM education and 2) promote systems and standards that assure an ongoing communication of best practices between tertiary pediatric institutions, general (nonchildren's) hospital emergency departments, and urgent care centers. A working group of medical educators was formed to review the literature, develop a framework for consensus discussion at the breakout session, and then translate their findings into recommendations for future research and scholarship. The breakout session consensus discussion yielded many recommendations. The group concluded that future progress depends on multicenter collaborations as a PEM education research network and a unified vision for PEM education that bridges organizations, providers, and institutions to assure the best possible outcomes for acutely ill or injured children.

Successful pediatric emergency medicine (PEM) education research and scholarship can alter the varied landscape of care that is delivered outside of children's hospitals in the United States. It is well established that most pediatric emergency care occurs in general emergency departments (EDs) and urgent care centers by a diverse group of providers, whose core training and experience in treating acutely ill or injured

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children can be quite limited.[1] Beyond gaps in fundamental PEM education, there are no systems, processes, or even standards that fully assure an ongoing communication of best practices between tertiary pediatric institutions and general (nonchildren's) hospital EDs. To achieve high-quality emergency care for pediatric patients nationwide, there will need to be a significant shift both in core training and in dissemination of state-of-the-art practices. Large-scale PEM education research and innovative scholarship are vital to future progress that can unify standards for core training and delineate effective continuing education pathways that integrate program-based and online modalities. Our consensus session therefore focused on defining the essential goals for PEM education and scholarship that would help establish a continuum of high-quality pediatric emergency care in all centers.

A working subcommittee was formed for this consensus process. The subcommittee cochairs were nominated by executive committee members from the American Academy of Pediatrics (AAP), American College of Emergency Physicians (ACEP), American Board of Emergency Medicine (ABEM), and American Board of Pediatrics (ABP). Working-group members were solicited through organization listserves and/or via professional networks. Subcommittee meetings spanned 2 years with bimonthly teleconferences, during which members discussed background assumptions, identified gaps in the literature and available curricula, and proposed and refined the main topics for discussion at the conference.

The education breakout session had a total of 29 participants at the consensus meeting. The session launched with a brief overview of assumptions and issues that were previously identified by the working committee and then introduced the four major topics (outcome gaps as below) for discussion. This was followed by small group discussions that focused on each outcome gap, each led by different members of the subcommittee. Tools utilized to capture thoughts and ideas included sticky notes, worksheets, and scribes. Recommendations from the round-table working subgroups were then briefly presented to the full session group for further input. Consensus was reached through discussion, restatement of barriers to progress, and identification of research priorities.

The subcommittee on PEM education and scholarship consisted of a broad range of physician experts in PEM, medical education, and a patient advocate. All physician subcommittee members were ABMS certified: six PEM fellowship trained, one an EM-trained PEM fellow, two dual trained in EM and pediatrics, and one in EM alone. Leadership roles of the committee members spanned the gamut of PEM education from EM and pediatric clerkship, residency, and fellowship programs. Several members had expertise in simulation education and educational technology, and others had expertise in the utilization of social media platforms for continuing medical education and professional development. Two were nationally recognized speakers. The professional subcommittee members all had published in peer-reviewed journals and presented research nationally on topics related to PEM. There were many levels of involvement in regional and national PEM advocacy groups. One member had expertise in pediatric urgent care–related clinical practice, provider education, and fellowship development. The subcommittee patient advocate provided essential nonmedical input on the patient experience and gave suggestions on gaps in pediatric emergency care.

CLINICAL VIGNETTE/CASE SCENARIO

A 3-year-old fully immunized female has a 4-day history of fever and 3 days of decreased liquid and solid food intake. She is evaluated at her pediatrician's office on the first day of fever and is diagnosed with a viral infection. Two days later, her parents bring her to a neighborhood walk-in urgent care clinic because she still has fever and will not take her usual liquid or solid foods. At the urgent care clinic, a rapid strep test is performed that is negative, and a macrolide antibiotic is prescribed for a diagnosis of throat infection. The symptoms continue despite the oral antibiotic, and the next day she is brought to a community ED. After initial evaluation, she has finger stick blood tests with a white blood cell count of 20×10^9 cells/L. She is given intramuscular antibiotics, oral ibuprofen, and discharged. Her parents remain concerned as her illness persists the next morning, so they opt to travel to a pediatric ED that is 30 miles away. The patient arrives initially febrile and fussy, and she has vesicles in the back of her throat on physical examination without other focal findings. These findings are consistent with herpangina, a hallmark of coxsackie virus infection that is well described in general pediatrics. She improves after a correct dose of antipyretic and is ultimately discharged to home with supportive measures and follow-up at her primary care provider.

The trajectory of clinical care and patient experience in the above vignette is among many scenarios that highlight the wide variations in practice that are invariably created by insufficient core training and dissemination of new knowledge in PEM. It is exemplar of so many issues—notably unnecessary testing and treatment and multiple care visits that stress families and strain resources—that are witnessed in pediatric EDs on a daily basis. Patient advocates describe the many difficult decisions they encounter when choosing the best possible acute care for their children. These gaps in our system, the preventable adverse outcomes that can occur, and the struggles of our patients and their parents are the elements that shaped and motivated our consensus discussion on PEM education research and scholarship.

STATEMENT OF OUTCOME GAPS

Essential outcome gaps that can be overcome through progress in PEM education are: 1) unnecessary testing and treatment; 2) underrecognition of acuity and resuscitation needs in nonpediatric ED settings; and 3) multiple unnecessary health care visits and interfacility transfers when pediatric experience is limited. Education is a cornerstone of pediatric emergency care, as learning and practice are inextricably linked together. Yet progress in PEM education has evolved slowly compared to the proliferation of clinical practices and research since the specialty launched in the 1980s, leaving many gaps unaddressed.[2]

Among the milestones in PEM education, the concept that "children are not small adults" is now widely recognized by all providers.[3] Certificate courses such as Pediatric Advanced Life Support, Neonatal Advanced Life Support, and Advanced Pediatric Life Support have had a demonstrably positive effect on outcomes for pediatric patients, although these cannot substitute for core and ongoing training in pediatric emergencies.[4] Advances in PEM education exist on the horizon, with an array of education research that will refine simulation, ultrasound, online learning, and other areas that can advance pediatric emergency care.

The next phase of progress in PEM education hinges on consensus in both training goals and utilization of novel methods to achieve these goals. Clinical outcome-based research including innovative clinical educational strategies will play a pivotal role in defining the success of these efforts. Themes that emerged from the discussion to reduce gaps in education include the following:

1. PEM core knowledge and skills training, and retention after initial training, is highly variable for all providers.
2. There is a wide array of urgent care pediatric providers in non-ED settings for which PEM education is lacking.
3. Feedback from the patient experience that can inform PEM education initiatives is lacking.
4. No PEM education research network exists to facilitate innovative approaches, enable multisite studies, and evaluate progress.

Although many barriers exist that impede progress in PEM education, we can and must achieve a unified vision that reflects best education practices, rigorous multicenter education research, evidence-based scholarship, and a common curriculum that can be adapted to train an array of clinical care providers.

CONCEPTUAL FRAMEWORK AND RESEARCH AGENDA

Overarching Research Issues to be Addressed

Our consensus session utilized many elements of the 2012 consensus conference "Education Research in Emergency Medicine—Opportunities, Challenges, and Strategies for Success" as a framework to discuss what research agenda is most essential to close the gaps in emergency care for children.[5] Each of the four themes adapted from the aforementioned gaps in pediatric emergency care education was discussed individually by groups of session participants: disparities in core education; the patient experience; alignment across providers; and research networks. Each theme was used to identify the top priorities for PEM education research.

For the *disparities in core education* theme, participants deliberated on how to close the many education gaps that underlie nonuniform care for children across EDs in the United States. The discussion focused on research to elucidate realistic goals in PEM education for EM providers, outcomes to measure progress and innovation, and an assessment of how online learning can be effectively integrated.

The above discussion was paired with the *patient experience* theme, where participants considered how patient feedback may be integrated into PEM

education. This discussion included questions on how input from the patient's perspective may contribute to PEM education and how it may offer a paradigm for ongoing education initiatives.

In the *alignment across providers* group, participants discussed how to integrate PEM education across the many providers who treat acutely ill and injured children. This included discussion about what would be needed to advance interdisciplinary care in PEM; how to align with providers in urgent care settings; and what role simulation, technology, and online learning should play. The discussion was paired with the *research networks* theme for collaborative PEM education research and scholarship. Participants explored options for how a network (or networks) can facilitate multicenter studies and promote progress. Key steps to establishing a PEM education research network was targeted for consensus recommendations. The overarching goal of the breakout session was to establish a research agenda that promotes innovation in teaching approaches individual learning strategies and in establishing appropriate curricula—as a unified foundation in PEM education for all levels of emergency care providers.

Research Priorities/Agenda Identified

The top priorities for PEM education research and scholarship were identified through the individual consensus discussions as below. Necessary to drive progress are: establishing a broad needs assessment of gaps in education, identifying the factors that hamper a unified PEM curriculum, and determining the costs of suboptimal pediatric emergency care. These can be approached by a comprehensive multiphase project or through research on each component. Indeed, a nationwide PEM education research network is sorely needed to complete any needs assessment and to then advance toward a more unified system of PEM education with demonstrable gains in clinical outcomes. Two additional priorities also stand alone as essential tools for progress. First, a centralized online learning menu must be established and evaluated as a pathway to better align PEM education and to link the many large organizations that include all PEM providers as members. This can emphasize valuable e-learning methods and promote a unified pathway for asynchronous learning. Second, the "voice" of patient experience must be "heard," aligned with future goals, and then integrated into the data used to drive further innovations in PEM education.

INDIVIDUAL RESEARCH PRIORITY/AGENDA ITEMS

Disparities in Core Education

Even after three decades of efforts to improve PEM education for medical students, residents, and emergency providers, there remains no clearly defined core PEM curriculum that unifies and drives the learning process.[1,6–11] A central tenet of the consensus discussion was that dissemination of PEM knowledge must be achieved through a standardized pediatric emergency curriculum, notably for board certification of emergency medicine residents and ultimately for maintenance of certification.[11] The curriculum should have a parallel for all physicians and advanced practice providers.

The essential next step is a broad needs assessment to identify and evaluate existing curricula and systems gaps in EM training and maintenance of certification[1] To assess systems gaps, the analysis must include an array of ED settings in each region of the United States, using hospital volume, level of care, and/or number of pediatric emergency visits to identify common themes that can be used to shape a unified PEM curriculum.[12] It must include data on variations in online learning and how it is utilized across the educational continuum. The needs assessment may also include data from patient and family feedback to better understand the motivating factors in choosing a certain resource setting for their ill or injured child. As an adjunct to the needs assessment, it is critical to establish reliable, vetted pathways to disseminate PEM educational materials and resources through a consortium of organizations that include PEM as a priority (Table 1). This is vital to achieving unified education in PEM and should be both free or low cost and easy to access electronically.

Important outcomes for PEM research on disparities in core education span the curricular, organizational, and patient care realms. Comparative data for PEM education in varied practice settings from tertiary pediatric EDs to general EDs offers a realistic route to assess outcomes and unify progress.[13] If the goal of standardized PEM education is achieved, the next research priority will be to evaluate its impact on clinical care. Outcomes can range from evaluating physician perception of comfort with certain clinical problems, feedback from patients, resource utilization statistics, online assessments, and reviewing changes

Table 1
Organizations for a U.S. PEM Consortium

Groups and societies
American College of Emergency Physicians (ACEP)
Society for Academic Emergency Medicine (SAEM)
American Academy of Emergency Medicine (AAEM)
American Academy of Pediatrics (AAP)
Emergency Nurses Association (ENA)
Emergency Medical Services for Children (EMSC)
Society of Emergency Medicine Physician Assistants (SEMPA)
Patient-Centered Outcomes Research Institute (PCORI)
Research networks
Pediatric Emergency Care Applied Research Network (PECARN)
PERN (Pediatric Emergency Research Networks)
INSPIRE (International Network for Simulation-based Pediatric Innovation, Research and Education)
Pediatric Advanced Life Support organizations
Advanced Pediatric Life Support (APLS) sponsored by AAP and ACEP
Pediatric Advance Life Support (PALS) sponsored by the American Heart Association (AHA)

PEM = pediatric emergency medicine.

in quality improvement metrics. Data on barriers to standardization can include variations in compliance with education, establishing outcomes of interest across resource settings, and reaching a wide audience of pediatric emergency care providers across varied settings.[7,8] Future research can establish a unified, iterative education quality improvement process to ensure that children receive high quality care in all EDs across the United States.

Patient Experience

Feedback from the patient experience has become a relatively integral part of physician and systems evaluations by means that include formal solicited evaluations, voluntary feedback, media ranking, and Internet-based discussion. Nevertheless, the patient experience and outcomes of care have not been incorporated into emergency medicine resident education, and no clear pathway exists to incorporate the patient perspective within structured education.[14,15] The patient experiences during care and after discharge remain a minimally tapped resource for clinical reflection and PEM education. Achievable metrics for learning through patient feedback can and should be established to foster education in PEM and can result in better pediatric emergency care overall.

Two main research priorities emerged during the consensus discussion of the patient experience in PEM education. First, the communication patterns between providers and patients (described as "scripts") throughout the spectrum of ED care need to be reviewed to highlight best practices and to develop frameworks for teaching and learning. Second, gaps in communication between care settings should be examined specifically from the perspective of the patient and family, to inform PEM education on communicating transitions in care. Proposed study methods could include patient follow-up, to determine their perceptions of care; understanding patient/family expectations of the care process, specifically both verbal and written discharge information; and feedback to or from transferring facilities regarding patient expectations, outcomes, and results of the transfer process. Given the emphasis on patient and family follow-up in achieving our research goals, focus should also be placed on developing and validating modern communication methods of the follow-up process, such as by text messaging, by e-mail, or by other social media outreach. These tools can mitigate some of the sizeable utilization of resources and low-response rates associated with more traditional telephone and/or mail-in surveys.

Several outcomes were proposed during the consensus discussion. A central outcome would be to determine variations in ED usage patterns for pediatric emergency care that may indicate community preferences and/or parent perceptions of the quality of care. This would require a scalable tool for the long-term tracking of ED usage patterns for pediatric patients. Further outcomes may include patient and family surveys on a large or national level to allow researchers to elucidate patient-based determinations of "excellent" versus "average" care that can contribute to provider education. Next steps should include a needs assessment aimed at both the practitioner and the patient community regarding the care experience, and investigation of patient perceptions of the care experience in "real time."

Although it may be difficult to capture the total patient experience and translate it for educational purposes, the endeavor is worthwhile for research and scholarship in PEM education. A focus on communication patterns and strategies between the provider and the patient/family is an important first step in improving the care of pediatric patients in all EDs. The patient experience is a valuable and underutilized perspective that we believe can benefit both clinical care and medical education in PEM.

Alignment Across Providers

The consensus discussion initially reviewed the wide array of clinicians who provide urgent and emergency care to children across the United States. Participants uniformly agreed that while some variations in care are inevitable across the spectrum of providers, urgent and emergency care for children should adhere to established best practices irrespective of where the care is received. As an additional benefit, PEM education can also lead with a framework to disseminate new discoveries and innovations for clinical care providers across other specialties. Future PEM educational research and scholarship must include all settings across the spectrum of all providers where children receive emergency care. In this way, dedicated children's hospitals and academic centers can share their new practices and discoveries that improve outcomes for pediatric emergencies with practitioners at all levels of care.

Evidence of the variations in PEM education across providers is broadly demonstrated in the literature. When viewed from either diagnosis or treatment, laboratory tests and imaging studies, or admission patterns for common illnesses in the ED, the variations in practice patterns between physicians who are trained in PEM, general EM, or pediatrics remain an issue.[16–20] These differences invariably extend to advanced practice practitioners, who provide care in over half of the PEDs in a recent study, but also do not have a PEM curriculum that is aligned with other providers.[21] Urgent care settings and retail clinics abound in the United States. The 10 most common clinical presentations to these centers account for an estimated 6.5 million visits by children to EDs—or 23% of U.S. ED visits by children—all without any specific alignment of PEM education to assure high-quality care.[11,22] Because there is such a great diversity of pediatric urgent and emergency care providers, the opportunity is equally great for collaboration in PEM education research. Differences in emergency care for children that result from highly variable provider training is a call to action: for consensus on practice standards, to identify the issues that drive these differences in practice, and to validate effective educational approaches that align pediatric emergency care across the provider spectrum.

The consensus discussion identified three research priorities: a cross-disciplinary needs assessment of practice and available educational resources; evaluating core standards across the spectrum of provider training; and identifying how best practices can be continually disseminated to and implemented by all providers. A cross-disciplinary needs assessment that captures perceived and actual PEM skills and knowledge across the wide range of providers of urgent and emergency pediatric care is essential. Data from this research can be used to overcome reluctance to change, focus future PEM education initiatives, and foster new alignments between providers and/or care settings. Available core standards for urgent and emergency pediatric care must be evaluated as a key step toward unifying PEM education that is consistent with provider capabilities. Future studies may also identify specific and measurable standards of care for the most common pediatric conditions, which can also be used in aligning PEM education. Finally, research that identifies and validates methods for translating best practices in PEM across a diverse array of providers will assure that ongoing PEM education can occur. Asynchronous, Web-based e-learning may ultimately prove a highly valuable tool to teach and assess PEM knowledge and clinical skills across a range of providers. Several e-learning and multimedia studies have demonstrated early results.[30,31] The development of a large-scale PEM e-learning platform that aligns provider education can potentially resolve many gaps in care and thus remains a goal for the future.

Aligning care across PEM providers is a vast and somewhat uncharted realm. We nonetheless believe that it can be achieved through sound educational research and innovation that addresses all PEM providers and offers solutions for the future.

Research Networks

It was agreed that large-scale multicenter research is needed to address the many issues in PEM education that plague consistent and effective emergency care for children in all centers across the U.S. consensus discussion on the development of a PEM research network identified two vital complementary forces: a singular voice and key stakeholders. The former includes leaders who collaboratively can articulate the mission and goals of the PEM research network, and the latter includes other stakeholders who fulfill the steering committee and/or operational support for the network.[32] It was recognized that there would be many challenges to overcome in the early phases of establishing this research network. Several highly successful networks that are currently active for PEM clinical research may serve as a model for a parallel network to facilitate multicenter studies for PEM education.

Four priorities were identified as initial areas of investigation to justify a PEM education research

network: 1) identify common diagnoses for which gaps in education may impact on treatment costs, 2) determine best education practices for the dissemination of clinical research and innovation, 3) evaluate the factors that impact on "buy-ins" from large organizations and institutions, and 4) assess the electronic medical record as a means to power educational tools. Each of these priorities offers the foundation for an array of PEM education research that can reduce the costs of care and improve outcomes for pediatric patients. As one example, gaps in education can be identified through unnecessary transfers between community and tertiary care pediatric EDs. These data can not only link improved education with cost reduction, but also shape pathways to advance practice through ED systemswide education initiatives.

There are many important outcomes to evaluate through a multicenter PEM education research network. First and foremost, a demonstrable loss of revenue can be aligned with the lack of consistent core and ongoing training in PEM across the United States. Multicenter data can be used to identify index or common PEM clinical problems that highlight education disparities and to evaluate pathways for implementation of large-scale educational projects. The data can also be used to target additional funding opportunities from community, state, and federal resources. Funding resources will be vital to establish and sustain a research network and its infrastructure.[33] The Emergency Medical Services for Children (EMSC) program is an essential partner to advance emergency care for children and one that can now help to address the most difficult outcomes that improve clinical performance through education that reaches EDs across the United States.

The time to create a PEM education research network has arrived. We cannot assure that every child receives a high level of emergency care without consistency in practice across EDs—which in turn cannot be assured without broad-scale, data-driven research to inform future initiatives in PEM education. The benefits of a research network have already been proven through existing clinical PEM research networks. With the support and guidance of these entities, we can join PEM education leaders and researchers as a critical partner to improve outcomes for acutely ill and injured children.

CHALLENGES

There are many challenges ahead for PEM education research, as is manifest in the lack of an existing unified system of PEM teaching and learning. Four elements were identified as crucial impediments that need to be overcome for future progress. First, there are large regions of the United States that are underserved for emergency care overall. The geographically diverse population distribution in our country is not proportionally matched by readily available emergency care. This dilemma is magnified when pediatric emergency care centers are geographically mapped—and then considered as referral centers and resources for education. Second, coordination and collaboration across the varied PEM provider stakeholder organizations is lacking. The development of any networks, centralized PEM education resources, or finalized products is thus confounded by a maze of overlapping and unreconciled stakeholder priorities. Third, funding for education research is traditionally lacking on an organizational, state, or federal level. PEM education has yet to emerge as a clear funding priority. Options for funding education research are often subsumed within clinical research grants, for which collaboration rather than competition must prevail in the future. Finally, clinical research is historically in many ways ahead of education research, which is evolving validated methods, tools, and outcomes that assure sound and generalizable results.

To overcome these significant challenges, we must make the case for PEM education as a central priority to advance the care of acutely ill and injured children. Greater PEM education scholarship is a pivotal step toward progress, as is methodologically rigorous PEM education research.[5] The latter can highlight the impact of PEM education through metrics that capture gaps and improvements in both clinical outcomes and costs of care. Resultant changes can be pivotal to establish a basis for multicenter education research network funding through grant support and propel the formation of comprehensive, collaborative PEM education networks at the institutional and organizational levels. Finally, PEM education research and clinical research are complimentary forces that can collaborate to advance pediatric emergency care through both data-driven innovation and knowledge translation.

CONCLUSIONS

The overarching goal of the breakout session was to establish a research agenda that promotes innovation—both in teaching and in learning strategies and in curricula—as a unified foundation in pediatric emergency medicine education for all levels of emergency care

providers. In an era of global communication and advanced technology, we can harness these changes to unify pediatric emergency medicine education and promote multicenter collaborations that were previously unachievable for education research and/or teaching and learning. Our vision is a unified "world" of pediatric emergency medicine education that bridges all pediatric emergency medicine providers and ultimately spans from core training through ongoing knowledge dissemination and lifelong learning. It will invariably include Web-based communication networks that consistently link pediatric emergency medicine education from tertiary care centers through community practice settings, asynchronous pathways for learning with aligned resources that assure a consistency of information, and integration of patient outcomes and experiences to inform clinical practice in real time. Future steps are through pediatric emergency medicine education scholarship and research that: 1) provides key needs assessment data; 2) attaches financial value to improved and unified pediatric emergency medicine education; 3) fosters collaboration between all pediatric emergency medicine providers, notably pediatric and emergency medicine organizations; 4) captures data to justify multicenter research networks and funding; and 5) constructively integrates the patient experience as part of the justification for change. We call on all pediatric emergency medicine providers to unite for the future of infants and children, and reach to pediatric emergency medicine education innovators, researchers, thought leaders, program directors, and all who lead and shape the world of pediatric emergency care to make a unified world of pediatric emergency medicine education a future reality.

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References

1. Cloutier RL, Walthall JD, Mull CC, et al. Best educational practices in pediatric emergency medicine during emergency medicine residency training: guiding principles and expert recommendations. Acad Emerg Med 2010;17 Suppl 2:S104–13.
2. Althouse LA, Stockman JA. Pediatric workforce: a look at pediatric emergency medicine data from the American Board of Pediatrics. J Pediatr 2006;149:600–2.
3. Gillis J, Loughlan P. Not just small adults: the metaphors of paediatrics. Arch Dis Child 2007;9:946–7.
4. American Heart Association. Available at: https://www.heart.org/. Accessed Jun 25, 2018.
5. LaMantia J, Deiorio NM, Yarris LM. Executive summary: education research in emergency medicine—opportunities, challenges, and strategies for success. Acad Emerg Med 2012;19:1319–22.
6. Mitzman J, King A, Fastle R, et al. A modified Delphi study for development of a pediatric curriculum for emergency medicine residents. AEM Educ Train 2018;1:140–50.
7. Burnette K, Ramundo M, Stevenson M, Beeson MS. Evaluation of a web-based asynchronous pediatric emergency medicine learning tool for residents and medical students. Acad Emerg Med 2009;16 Suppl 2:S46–50.
8. Chang TP, Pham PK, Sobolewski B, et al. Pediatric emergency medicine asynchronous e-learning: a multicenter randomized controlled Solomon four-group study. Acad Emerg Med 2014;21:912–9.
9. Merritt C, Gaines SA, Smith J, Santen SA. A novel curriculum to optimize emergency medicine residents' exposure to pediatrics. West J Emerg Med 2017;18:14–19.
10. Counselman FL, Babu K, Edens MA, et al. The 2016 Model of the Clinical Practice of Emergency Medicine. J Emerg Med 2017;52:846–9.
11. ACGME Program Requirements for Graduate Medical Education in Emergency Medicine. Chicago, IL: Accreditation Council for Graduate Medical Education, 2017. pp. 13–21.
12. Sharieff GQ, Benjamin L, Mace S, Sacchetti A. Emergency physicians and the care of children. Am J Emerg Med 2005;23:890–3.
13. Chen EH, Cho CS, Shofer FS, Mills AM, Baren JM. Resident exposure to critical patients in a pediatric emergency department. Pediatr Emerg Care 2007;23:774–8.
14. American Academy of Pediatrics Committee on Pediatric Emergency Medicine; American College of Emergency Physicians; Pediatric Emergency Medicine Committee; O'Malley P, Brown K, Mace SE. Patient- and family-centered care and the role of the emergency physician providing care to a child in the emergency department. Pediatrics 2006;118:2242–4.
15. Magaret ND, Clark TA, Warden CR, Magnusson AR, Hedges JR. Patient satisfaction in the emergency department–a survey of pediatric patients and their parents. Acad Emerg Med 2002;9:1379–88.

16. Johnson DW, Adair C, Brant R, Holmwood J, Mitchell I. Bronchiolitis - differences in admission rates of children with bronchiolitis by pediatric and general emergency departments: commentary. Paediatr Child Health (Oxford) 2004;9:397–8.
17. Bekmezian A, Hersh AL, Maselli JH, Cabana MD. Pediatric emergency departments are more likely than general emergency departments to treat asthma exacerbation with systemic corticosteroids. J Asthma 2011;48:69–74.
18. Isaacman DJ, Kaminer K, Veligeti H, Jones M, Davis P, Mason JD. Comparative practice patterns of emergency medicine physicians and pediatric emergency medicine physicians managing fever in young children. Pediatrics 2001;108:354–8.
19. Gaucher N, Bailey B, Gravel J, et al. Effect of physicians' characteristics on the risk of admission among children visiting a pediatric emergency department. 2010 Soc Acad Emerg Med (SAEM 2010) 2010;30:613–6.
20. Weiner SG, Ruffing RP, Barnewolt BA. A comparison of resource utilization between emergency physicians and pediatric emergency physicians. Acad Emerg Med 2011;18:S18–9.
21. Wood C, Wettlaufer J, Shaha SH, Lillis K. Nurse practitioner roles in pediatric emergency departments: a national survey. Pediatr Emerg Care 2010;26:406–7.
22. Tamaraiz VP, Fuchs S, Baren JM, Pollack ES, Kim J, Seidel JS. Pediatric emergency medicine education in emergency medicine training programs. Acad Emerg Med 2000;7:797–9.
23. ACGME Program Requirements for Graduate Medical Education in Pediatrics. Chicago, IL: Accreditation Council for Graduate Medical Education, 2017. pp. 1–34.
24. ACGME Program Requirements for Graduate Medical Education in Family Medicine. Chicago, IL: Accreditation Council for Graduate Medical Education, 2017.
25. Schmuhl P, Telford R, Remick KE, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
26. Hudgins JD, Monuteaux MC, Bourgeois FT, et al. Complexity and severity of pediatric patients treated at United States emergency departments. J Pediatr 2017;186:145–9.
27. Remick K, Kaji AH, Olson L, et al. Pediatric readiness and facility verification. Ann Emerg Med 2016;67:320–8.
28. Auerbach M, Whitfill T, Gawel M, et al. Differences in the quality of pediatric resuscitative care across a spectrum of emergency departments. JAMA Pediatr 2016;170:987–94.
29. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. J Pediatr 2018;194:225–32.
30. Chang TP, Pham PK, Sobolewski B, et al. Pediatric emergency medicine asynchronous e-learning: a multicenter randomized controlled Solomon four-group study. Acad Emerg Med 2014;21:912–9.
31. Patel A, Unaka N, Sobolewski B, Statile A. Five steps for success in building your own educational website. Acad Pediatr 2016;17:345–8.
32. Newgard CD, Beeson MS, Kessler CS, et al. Establishing an emergency medicine education research network. Acad Emerg Med 2012;19:1468–75.
33. Choo EK, Fernandez R, Hayden EM, et al. An agenda for increasing grand funding of emergency medicine education research. Acad Emerg Med 2012;19:1434–41.

Pediatric Emergency Care Research Networks: A Research Agenda

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ABSTRACT

Background: Pediatric emergency care research networks have evolved substantially over the past two decades. Some networks are specialized in specific areas (e.g., sedation, simulation) while others study a variety of medical and traumatic conditions. Given the increased collaboration between pediatric emergency research networks, the logical next step is the development of a research priorities agenda to guide global research in emergency medical services for children (EMSC).

Objectives: An international group of pediatric emergency network research leaders was assembled to develop a list of research priorities for future collaborative endeavors within and between pediatric emergency research networks.

Methods: Before an in-person meeting, we used a modified Delphi approach to achieve consensus around pediatric emergency research network topic priorities. Further discussions took place on May 15, 2018, in Indianapolis, Indiana, at the *Academic Emergency Medicine* (*AEM*) consensus conference "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps." Here, a group of 40 organizers and participants met in a 90-minute "breakout" session to review and further develop the initial priorities.

Results: We reached consensus on five clinical research priorities that would benefit from collaboration among the existing and future emergency networks focused on EMSC: sepsis, trauma, respiratory conditions, pharmacology of emergency conditions, and mental health emergencies. Furthermore, we identified nonclinical research priorities categorized under the domains of technology, knowledge translation, and organization/administration of pediatric emergency care.

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Conclusion: The identification of pediatric emergency care network research priorities within the domains of clinical care, technology, knowledge translation and organization/administration of EMSC will facilitate and help focus collaborative research within and among research networks globally. Engagement of essential stakeholders including EMSC researchers, policy makers, patients, and their caregivers will stimulate advances in the delivery of emergency care to children around the globe.

In a series of three seminal reports on the state of emergency services in the United States, the National Academies of Science, Engineering, and Medicine (NASEM) concluded that the system was fragmented, overburdened, and desperately in need of reform.[1–3] Importantly, the report on the state of emergency medical services for children (EMSC) identified that pediatric emergency services are particularly vulnerable for several reasons including a workforce inadequate to meet the unique needs of children, lack of appropriate equipment in emergency departments (EDs) and inattention to research focused on critically ill and injured children.[1–4] One of NASEM's recommendations focused on the importance of improving the evidence base and highlighted the fact that no single emergency medical services (EMS) agency or ED is likely to have adequate numbers of critically ill or injured children to answer important clinical questions pertaining to the care of this vulnerable population. This is not only seen in the United States, but is also a worldwide issue.[5]

Pediatric research networks focused on specific conditions/diseases (e.g., Children's Oncology Group)[6] or populations (e.g., Neonatal Research Network)[7] have been particularly successful in generating evidence regarding low-frequency/high-impact conditions. Several global networks pertaining to research in EMSC have developed and matured over the past two decades,[8–15] and evidence generated by both U.S. and non–U.S.-based EMSC research networks has substantially improved the emergency care for critically ill and injured children worldwide.[8–19] These networks share the common goal of improving care for children with emergency conditions, while individual research networks' organizational structures and research priorities are appropriately focused on regional and national needs. Recently, the Pediatric Emergency Research Networks (PERN),[20] a "network of pediatric emergency networks" developed a platform to conduct EMSC research on a global level. Given the number of EMSC research networks and the presence of a truly global structure (PERN), a logical next step is to develop a global research agenda to guide EMSC research.

The 2018 *Academic Emergency Medicine* (*AEM*) Consensus Conference on "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps" provided a unique opportunity to bring together representatives from individual pediatric emergency care research networks and to obtain input from patient representatives to develop consensus-driven global research priorities.[21] Research agendas have been developed independently among many of the pediatric emergency care networks, but here we strive to bring together many networks.[22–25] In this article, we describe the development process and the finalized research priorities list. We focus on identifying research topics that are ideal for networks to address and identify barriers that need to be overcome to facilitate collaboration among various emergency research networks and develop a broad list of topics that can guide priorities for global EMSC research. This includes high-frequency illnesses without adequate evidence to support current therapies and testing novel interventions for these high-frequency illnesses. Also, exploring low-frequency but high-impact conditions that need evidence to define epidemiology, facilitate identification, and substantiate interventions.

METHODS

The consensus conference was organized by two pediatric emergency care leaders (KD and PI) who developed a steering committee that oversaw the activities of five subcommittees: EMS, multicenter network research, education, workforce development, and PEM in non–children's hospitals.[26] The development of research priorities for multicenter networks was the charge of the pediatric emergency care research network subcommittee led by three pediatric emergency medicine physicians and investigators (MS, PM, NK). Among them, the leaders of the subcommittee represented the Pediatric Emergency Medicine Collaborative Research Committee (PEM CRC)[12] of the American Academy of Pediatrics, the Pediatric Emergency Care Applied Research Network (PECARN),[10] and the PERN.[20] A workgroup was created consisting of 11

Table 1
Synopsis of Represented Pediatric Emergency Care Research Networks

Network Name	Year Founded	Locale	Funding and Focus
PECARN (Pediatric Emergency Care Applied Research Network)	2001	United States	High-priority federally funded research pertaining to acutely ill and injured children and requiring substantial research infrastructure
PEM CRC (Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics)	Early 1990's	United States	Unfunded research pertaining to acutely ill and injured children
PERN (Pediatric Emergency Research Networks)	2009	Global	Meaningful and scientifically rigorous international collaborative research in pediatric emergency care for global health problems
PERC (Pediatric Emergency Research Canada)	1995	Canada	Creating knowledge through research involving clinical and epidemiologic studies in pediatric emergency medicine
PREDICT: (Paediatric Research in Emergency Departments International Collaborative)	2004	Australia and New Zealand	High-priority federally funded multicenter pediatric emergency care research
PERUKI (Paediatric Emergency Research in the United Kingdom & Ireland)	2012	England, Ireland, Northern Ireland, Scotland and Wales	Unfunded, and federal grant–funded, multicenter pediatric emergency care research
REPEM (Research in European Pediatric Emergency Medicine)	2006	Europe and the Middle East	Unfunded pediatric emergency care research
P2 Network		Global	Building research collaborations and offering mentorship in pediatric point-of-care ultrasound
INSPIRE (International Network for Simulation-based Pediatric Innovation Research & Education)	2011	Global	Funded multicenter and multinational researchers, educators, and clinicians examining simulation as an educational intervention and leveraging simulation as a research environment to improve the care delivered to all neonates, infants, and children
RIDEPLA (Red de Investigación y Desarrollo de la Emergencia Pediatrica de Latinoamérica)	2011	Argentina, Uruguay, and Paraguay	Unfunded multicenter pediatric emergency care research
PSRC (Pediatric Sedation Research Consortium)	2003	United States	Federally funded research, focused on improving sedation practice through sharing of prospective observational outcome data on pediatric procedural sedation encounters
TREKK (Translating Emergency Knowledge for Kids)	2011	Canada	Federally and institutionally funded, focused on pediatric emergency medicine knowledge translation

Table 2
Research Priorities for Nonclinical Topics by Themes

Top 5 Ranked From Preconference Modified Delphi	Final Top 5 Ranked From *AEM* Consensus Conference
Technology	
1. Study the use of telemedicine as a means of providing ED care to areas lacking PEM expertise, including impact on outcomes and cost effectiveness 2. Investigate the best methods of knowledge translation via use of the electronic health record 3. Study how to best use the electronic health record for predictive analytics 4. Investigate impact of bedside ultrasound on clinical outcomes of specific diseases (e.g., blunt abdominal trauma, resuscitation for intravascular volume status) 5. Investigate how do use precision medicine for emergency care through the use of electronic health record data	1. Study how to best use the electronic health record for predictive analytics 2. Machine learning 3. Telemedicine (provider to provider) 4. Simulation training 5. Clinical decision support via the electronic health record
Knowledge Translation	
1. Evaluate how to identify priority topics for knowledge translation (KT) 2. Investigate how to use shared patient/parent decision making in network research 3. Develop KT strategies—how to use PEM research networks to best disseminate and implement evidence-based practice to all emergency care settings 4. Role of social media for KT 5. Exploring patient and family acceptance of medical practices across different cultures to anticipate barriers/success of implementation of new practices	1. Dissemination and implementation of evidence-based practice 2. Changing provider behavior—motivations and metrics 3. Evaluate how to identify priority topics for KT 4. Develop KT strategies—how to use PEM research networks to best disseminate and implement evidence-based practice to all emergency care settings 5. Investigate how best to use shared patient decision making in network research
Organizational Research Topics (Regulatory, Administrative, and Collaboration)	
1. Network resource utilization and economies of scale between networks (Should we duplicate research studies to validate each other or "divide and conquer" pressing new research questions among networks?) 2. Exception from informed consent (EFIC) for time-sensitive enrollment of patients in the ED (when should we use EFIC, when is it not needed, can we do EFIC studies across networks across countries?) 3. Ethical considerations for multicenter studies within and across international boundaries 4. Research into cost efficiency of network research 5. Development of a standard PEM research training that can be shared among networks 6. Globalization—how to efficiently improve care in resource poor/constrained settings	1. Barriers to reporting clinical data, building diverse registries 2. Research collaboration between PEM, EMS, and non-PEM providers and dissemination of evidence from research 3. Network resource utilization and economies of scale between networks 4. Global identification of "top 5" research questions and collaboration to answer those questions 5. Exception from informed consent (EFIC) for time-sensitive enrollment of patients in the ED

Left column = Subcommittee priorities from the preconference modified Delphi; right column = final priorities developed at the *AEM* Consensus conference by the participants (participants had the results of the preconference modified Delphi prior to initiating.
PEM = pediatric emergency medicine.

members who represented eight pediatric emergency care multicenter research networks around the globe including the PEM CRC, PECARN, PERN, Pediatric Emergency Research in the United Kingdom & Ireland (PERUKI),[13] Pediatric Emergency Research Canada (PERC),[14] P2Network,[9] Pediatric Sedation Research Consortium (PSRC),[11] and Research in European Pediatric Emergency Medicine (REPEM).[15] In addition, the main workgroup collaborated closely with many other members of global pediatric emergency care research networks (mentioned in the acknowledgments) who contributed to the prioritization process and manuscript. A brief outline of the pediatric emergency care research networks is reported Table 1.

The preliminary work was completed remotely by the workgroup. Initially, open-ended input formed the four broad themes for the future direction of pediatric emergency care multicenter network research. These included 1) clinical care, 2) technology, 3) knowledge translation, and 4) organization/administration of pediatric emergency care.

After we achieved consensus around the above-mentioned four themes, we formed an expert panel that

included the 11 members of the workgroup and 10 other members of the PERN executive committee, representing many global pediatric emergency care research networks. We used the modified Delphi consensus method, which consisted of three rounds of electronic surveys to arrive at the preconference agenda with a preliminary list of research priorities, which was followed by an in-person meeting at the 2018 *AEM* consensus conference in Indianapolis, Indianapolis.[21,27–29] The three rounds of surveys were performed using SurveyMonkey[30] to rate research priorities divided among the four broad themes. In the first round, we asked each survey recipient to rate each of 66 research priorities (in the four themes) from 1 to 5, with 1 representing the highest priority. Respondents were permitted to use each value as often as they felt was warranted. The survey also allowed the participants to offer suggestions to modify and/or add more topics to each theme. There was a 100% response rate from the 21-member expert panel for each of the three rounds. After the first round of the survey, the highest priority items (defined as being scored a 1 or 2 by at least 50% of those surveyed) were included in the next round of surveys. Additionally, comments were addressed and new items that were suggested were added to the subsequent survey. This resulted in 46 research priorities. The second round of the electronic survey proceeded in a similar fashion with the 46 questions divided among the four themes. This time, in addition to rating the 46 priorities, the participants were tasked to add to the list of clinical priorities. As in the previous round, the priorities that were rated the highest in each electronic survey (i.e., rated as 1 or 2 by at least 50% of the respondents) were retained on the priority list. In the second round, we eliminated nine priorities, but with the open-ended clinical additions, 67 priorities were considered in the third round, 47 of which were in the clinical care theme. The new clinical priorities from the second round's open-ended questions were ranked, and only the top 10 were kept. After the completion of the three rounds of surveys, a list of 47 research priority topics remained, 30 of which fell into the theme of clinical care. We focused the in-person *AEM* consensus conference on this list of 47 research priority topics. The priority list was distributed prior to the conference to the registered participants, allowing time for preparation.

At the *AEM* conference 40 total participants were involved in the pediatric emergency care research network breakout. This included seven members of the workgroup plus 33 new participants. Among them was a member of the International Network for Simulation-based Pediatric Innovation Research & Education (INSPIRE)[8] and a member of TRanslating Emergency Knowledge for Kids (TREKK).[31] These were added as experts in technology and knowledge translation, respectively, to help guide the discussions during the breakout. The participants were divided evenly into four discussion groups, at separate tables, based on the four broad research themes identified by the expert panel: clinical, technology, knowledge translation, and organization/administration of pediatric emergency care. The consensus conference participants discussed individual priorities, further defined them, added or removed from the list after discussion, and finally ranked them in order of importance. Participants were given approximately 30 minutes for this process. Once these breakout subgroups completed their tasks, all participants regrouped and were allowed to review, add to, and rank the top 5 priorities from the themes from the other groups in which they had not originally been involved. Because the research priority list of clinical topics was more extensive than those in the other themes, participants were asked to identify their top 10 priorities within this subcategory (rather than only five as in the other themes). After analyzing the priority lists modified at the conference, we determined that there was consensus in three of the four themes, with the exception of research priorities on clinical care topics. Because of this, a fourth survey distributed among the original 21-member expert panel was required to achieve consensus on research priorities for the clinical topics. This was done after the conclusion of the consensus conference using REDCap electronic data capture tools.[32]

STATEMENT OF OUTCOME GAPS

Within pediatric emergency care, we identified several clinical areas with "knowledge gaps" that could be addressed by coordinating research and collaborating to share limited resources at a global level. Examples include high-frequency illnesses without adequate evidence to support current therapies or testing novel interventions for these high-frequency illnesses. Also included in this group of network priorities are low-frequency conditions that have the potential for high morbidity without adequate or known therapy. During the process, we identified four broad areas for research

prioritization for pediatric emergency care research networks, which include clinical care, technology, knowledge translation, and organization/administration of pediatric emergency care. Many critical childhood illnesses are uncommon events, so only through open communication and the sharing of knowledge can these high-priority research topics in EMSC be adequately addressed.

RESEARCH PRIORITY/AGENDA ITEM

Consensus was achieved around the four broad themes/topics below that would benefit from collaboration between the current multicenter research networks. The following high-priority research themes were defined for each broad category and discussed with participants at the *AEM* consensus conference:

Clinical

Conditions with risk for high morbidity that lack sufficient evidence including sepsis, trauma, respiratory conditions, pharmacology of emergency conditions, and pediatric mental health issues in the ED. Using sepsis as an example, there are limited data on the optimal therapy for children with sepsis, leading to the consensus that sepsis should be a multicenter research priority. Networks should collaborate on such topics as sepsis, sharing knowledge and resources, so that, for example, one network can address novel therapies for pediatric sepsis and others can validate another networks findings. Following this, all networks can come together for global implementation of an intervention.

Technology

Several topics emerged under the umbrella of technology, such as how to apply new/emerging technology in the pediatric ED; how to teach technology to pediatric emergency care providers; how to research the impact of technology; and how to share technology. For example, point-of-care ultrasound (POCUS) is growing rapidly in the pediatric ED, but indications for its use and its application may differ between centers. In some networks POCUS may be used to study hydration and circulatory volume status, which can then be validated in another network. Certain aspects of POCUS may be applicable to certain networks. For example, FAST training could be of value to PEM sites that care for high volumes of pediatric trauma while POCUS for incision and drainage of abscesses could be needed for certain other sites. This training in POCUS (education) or use of POCUS as an integral part of evaluation could be incorporated in a research network as a part of a project on implementation or knowledge translation.

Knowledge Translation

Under the category of knowledge translation, several topics emerged as important, including identifying differences between children's hospital EDs and community EDs in the translation of knowledge into practice; how to best disseminate information and evidence to all settings in which pediatric emergency care is provided; and after implementing change, how best to maintain these changes.

Organization/Administration of Pediatric Emergency Care

High-priority topics included how to best allocate resources, how best to collaborate in this area, best practices in data management, and ethical issues. Examples would include organization of network steering committees, best use of network infrastructure funding or lessons learned from issues pertaining to data transfer or institutional review boards, and informed consent.

A final list of nonclinical research priorities was created based on the preconference modified Delphi process and from input from participants at the *AEM* consensus conference as reported in Table 2. Five priorities were designated in each of the three nonclinical themes (technology, knowledge translation, and organization/administration of pediatric emergency care). A final electronic survey after the *AEM* conference with the 21 network members further refined the priorities within the clinical care category (Table 3). In addition, a list of 10 research priority topics was also ranked from a larger pool of miscellaneous topics proposed by both pediatric emergency care research network members and participants at the *AEM* consensus conference (Table 4).

CHALLENGES

In this document we describe the consensus process used to generate a priority list of pediatric emergency care research gaps that would benefit from research within and collaboration between pediatric emergency care research networks. Our aim is for these results to help focus the research agenda of pediatric emergency care networks globally. However, there are substantial

Table 3
Research Priorities of Clinical Topics

Sepsis
1. Improving early identification of sepsis (age specific screening tool) 2. Working definition of sepsis in the emergency department 3. Does fluid choice (e.g., lactated Ringer's, Plasma-Lyte, 0.9% NS) impact sepsis outcomes? 4. Effectiveness of protocol-driven sepsis care 5. Effectiveness of "rules/criteria" embedded into electronic health records to improve care and outcomes (e.g., identification tools, order sets, and guidelines)
Trauma
1. Head a. Severe head injury evaluation and treatment (penetrating trauma, skull fracture, intracranial hemorrhage) b. Concussion evaluation and treatment 2. Cervical spine a. Effect of immobilization on outcomes b. Radiologic assessment 3. Blunt torso trauma assessment
Respiratory emergencies
a. Pneumonia i Evaluation and severity assessment ii Management b. Bronchiolitis i Management ii Evaluation and severity assessment c. Asthma i. Best medications for acute exacerbation ii. Effectiveness/impact of asthma score/protocol driven care iii. Effectiveness of early non-invasive positive pressure
Pharmacology/sedation in pediatric emergency care
1. Procedural sedation in the ED 2. Safety outcomes of medications 3. Pain and anxiety—acute treatment
Mental health
1. Telemedicine for remote evaluation and treatment of adolescent mental health issues 2. Media effects on adolescent suicide risk 3. Impact of peer support on victims of violence

Table 4
Miscellaneous Research Priority Topics

1. Delivery of evidence based medicine to the ED provider at the point of care. 2. Caring for the pediatric patient in a general ED setting. 3. Shared decision making and culturally related differences. 4. Reduction in inappropriate diagnostic imaging (e.g., Choosing Wisely). 5. Impact of scoring systems (e.g., asthma, sepsis) on outcomes. 6. Patient safety using multicenter quality improvement initiatives—effects on outcomes. 7. How to improve diagnosis/care of uncommon but severe conditions. 8. How do differences in health care systems impact care? Investigate methods to reduce variation and optimize care. 9. Disposition appropriateness—how best to study. 10. Individual studies using "omics" for advanced diagnosis and tailored therapies in the ED.

challenges to pursuing this agenda. Meaningful and impactful multicenter research requires federal research funding as well as private sector support. In the current fiscal environment of many countries, funding is a challenge to current and future pediatric emergency care research priorities

The inherent organization, infrastructure, and support of individual networks vary, posing barriers to collaboration among networks. Furthermore, aligning global networks with a common goal and bringing them together to address common conditions remains challenging, as each has unique goals and objectives. By aligning networks on overlapping priorities, similar to what PERN has done, will bridge this gap to better focus the research agenda and provide definitive answers to high-priority questions of global importance to the PEM community. Another challenge is sustaining interest by investigators in multicenter research given competing responsibilities and the limited funding and support each participating network investigator receives. Finally, we must determine how to enhance the interest and participation in pediatric emergency care research at non–children's hospitals and general EDs, where most acutely ill and injured children are evaluated and managed. Key to this will be the interest and engagement of local champions at each hospital and resources to enhance pediatric emergency care. While it is true that non–children's hospitals see the majority of pediatric patients nationally and globally, the number of pediatric patients at each individual ED is small. With limited resources available, alignment of electronic health records to populate databases that can be used and shared by networks and embed pediatric emergency care decision support are options. Another barrier is dissemination of information to these hospitals, which is an ongoing problem of knowledge translation. Again, use of the electronic health record for dissemination research is but one avenue for multicenter research in this area.

LIMITATIONS

Although the conference participants developed an important list of research priorities for pediatric emergency care research networks, the consensus process included a somewhat limited number of perspectives and individuals. We closely adhered to modified Delphi techniques, but this process has some inherent

variability and lack of formal structure. Attempts were made to represent as many pediatric emergency care research networks as possible by including investigators from around the globe, but it was not possible to capture input from every possible source of information or network. Research networks and priorities for EMSC research in non-/underrepresented geographical regions such as South America, Africa, or Asia were also not included.

CONCLUSION

We developed consensus around topics in pediatric emergency care that would benefit from multicenter collaborative research, with the top five clinical conditions being sepsis, trauma, respiratory conditions, pharmacology of emergency conditions, and mental health. Furthermore, we identified high-priority nonclinical issues categorized under the domains of technology, knowledge translation, and organization/administration of pediatric emergency care that should be explored by EMSC researchers, policy makers, and other stakeholders to advance the global research agenda.

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References

1. Institute of Medicine. Emergency Medical Services: At the Crossroads. Washington, DC: The National Academies Press, 2007.
2. Institute of Medicine. Hospital-Based Emergency Care: At the Breaking Point. Washington, DC: The National Academies Press, 2007.
3. Institute of Medicine. Emergency Care for Children: Growing Pains. Washington, DC: The National Academies Press, 2007.
4. Institute of Medicine. Emergency Medical Services for Children. Washington, DC: The National Academies Press, 1993.
5. The Intercollegiate Committee for Standards for Children and Young People in Emergency Care Settings. Facing the Future: Standards for Children in Emergency Care Settings. London: Royal College of Paediatrics and Child Health, 2018.
6. Children's Oncology Group. Available at: http://www.childrensoncologygroup.org. Accessed September 5, 2015.
7. Neonatal Research Network. Available at: http://neonatal.rti.org. Accessed September 5, 2018.
8. International Network for Simulation-based Pediatric Innovation, Research, & Education. Available at: https://inspiresim.com. Accessed September 5, 2018.
9. P2 Network. Available at: https://p2network.com. Accessed September 5, 2018.
10. Pediatric Emergency Care Applied Research Network. Available at: http://www.pecarn.org/. Accessed September 5, 2018.
11. Pediatric Sedation Research Consortium. Available at: http://www.pedsedation.org/resources/research/. Accessed September 5, 2018.
12. Pediatric Emergency Medicine Collaborative Research Committee. Available at: http://pemcrc.pemfellows.com/. Accessed September 5, 2018.
13. Paediatric Emergency Research in the United Kingdom & Ireland. Available at: http://www.peruki.org. Accessed September 5, 2018.
14. Pediatric Emergency Research Canada. Available at: http://www.perc-canada.ca. Accessed September 11, 2018.
15. REPEM. Research in European Pediatric Emergency Medicine Network. Available at: https://sites.google.com/site/repemnetwork/. Accessed Nov 23, 2018.
16. Bialy L, Plint A, Zemek R, et al. Pediatric Emergency Research Canada: origins and evolution. Pediatr Emerg Care 2018;34:138–44.
17. Cheng A, Auerbach M, Calhoun A, et al. Building a community of practice for researchers: the International Network for Simulation-Based Pediatric Innovation, Research and Education. Simul Healthc 2018;13:S28–34.
18. Klassen TP, Acworth J, Bialy L, et al. Pediatric emergency research networks: a global initiative in pediatric emergency medicine. Pediatr Emerg Care 2010;26:541–3.
19. Cheng A, Kessler D, Mackinnon R, et al. Conducting multicenter research in healthcare simulation: lessons learned from the INSPIRE network. Adv Simul (Lond) 2017;2:6.
20. Pediatric Emergency Research Networks. Available at: http://www.pern-global.com. Accessed September 5, 2018.
21. Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps. Available at: https://www.saem.org/annual-meeting-18/education/consensus-conference. Accessed Nov 23, 2018.
22. Bialy L, Plint AC, Freedman SB, et al. Pediatric Emergency Research Canada (PERC): patient/family-informed research priorities for pediatric emergency medicine. Acad Emerg Med 2018 [Epub ahead of print].
23. Deane HC, Wilson CL, Babl FE, et al. PREDICT prioritisation study: establishing the research priorities of

paediatric emergency medicine physicians in Australia and New Zealand. Emerg Med J 2018;35:39–45.
24. Hartshorn S, O'Sullivan R, Maconochie IK, et al. Establishing the research priorities of paediatric emergency medicine clinicians in the UK and Ireland. Emerg Med J 2015;32:864–8.
25. Miller SZ, Rincon H. Kuppermann N; Pediatric Emergency Care Applied Research Network. Revisiting the emergency medicine services for children research agenda: priorities for multicenter research in pediatric emergency care. Acad Emerg Med 2008;15:377–83.
26. Ishimine P, Adelgais K, Barata I, et al. The 2018 Academic Emergency Medicine Consensus Conference: Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps. Acad Emerg Med 2018;23:1317–26.
27. Dalkey NC, Brown BB, Cochran S. The Delphi Method. Santa Monica, CA: Rand Corp., 1969.
28. Hsu CC, Brian A. The Delphi technique: making sense of consensus. Pract Assess Res Eval 2007;12.
29. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. J Adv Nurs 2000;32:1008–15.
30. SurveyMonkey. Available at: http://www.surveymonkey.com/. Accessed September 5, 2018.
31. Translating Emergency Knowledge for Kids. Available at: https://trekk.ca/. Accessed September 10, 2018.
32. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42:377–81.

Establishing the Key Outcomes for Pediatric Emergency Medical Services Research

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ABSTRACT

The evidence supporting best practices when treating children in the prehospital setting or even the effect emergency medical services (EMS) has on patient outcomes is limited. Standardizing the critical outcomes for EMS research will allow for focused and comparable effort among the small but growing group of pediatric EMS investigators on specific topics. Standardized outcomes will also provide the opportunity to collectively advance the science of EMS for children and demonstrate the effect of EMS on patient outcomes.

This article describes a consensus process among stakeholders in the pediatric emergency medicine and EMS community that identified the critical outcomes for EMS care in five clinical areas (traumatic brain injury, general injury, respiratory disease/failure, sepsis, and seizures). These areas were selected based on both their known public health importance and their commonality in EMS encounters. Key research outcomes identified by participating stakeholders using a modified nominal group technique for consensus building, which included small group brainstorming and independent voting for ranking outcomes that were feasible and/or important for the field.

Approximately 1.7 million children are cared for by emergency medical services (EMS) annually in the United States. Despite the unique nature of the EMS environment and the distinct challenges of caring for children in the prehospital environment, there is little context-specific research to guide the development of prehospital protocols. Recently, pediatric EMS clinical research has seen significant growth

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This article reports on a breakout session of the *Academic Emergency Medicine* consensus conference "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps," held in Indianapolis, IN, May 15, 2018.

Breakout session attendees: Kathleen Adelgais, Morgan Bobb-Swanson, Robert Cloutier, Kurt Denninghoff, Paula Denslow, Joelle Donofrio, Susan Fuchs, Joshua Gaither, Toni Gross, Matt Hansen, Sandra Herr, Hilary Hewes, Michael Kim, E. Brooke Lerner, Kim Mears, Rakesh Mistry, Lenora Olson, Mark Piehl, Diane Pilkey, Lindsey Query, Manish Shah, Joelle Simpson, Daniel Spaite, Tou-Yuan Tsai, Chad Viscusi, N. Ewan Wang, Elizabeth Weinstein, and Kabir Yadav.

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in both the number of publications and investigators; however, the majority of these studies are observational in nature.[1–10] To date, to our knowledge, there have only been two randomized trials conducted specifically for children in the EMS setting, one that addressed airway management and one related to treatment for active seizures.[11,12] Recently, pediatric EMS clinical research has seen significant growth in both the number of publications and the number of investigators; however, the majority of these studies are observational in nature.[1–10] There is also a concerted effort among national organizations and researchers to focus on defining and implementing "best practices" in pediatric EMS care derived from the currently available evidence base even though this knowledge base is generally recognized to be limited.[13–18]

There are specific challenges to designing clinical research studies of children in the EMS setting. These include 1) the broad range of topics that could be studied; 2) the rarity of critical events, necessitating expensive multicenter studies; and 3) the difficulty in assessing the effect of prehospital care due to confounding by emergency department (ED) and subsequent inpatient hospital care. Starting in 1993 with a National Academies of Science, Engineering, and Medicine report and followed by numerous updates from other organizations, several potential pediatric EMS research priorities have been identified.[19–21] However, progress investigating high-priority topics has been slow as demonstrated by the paucity of publications in high-impact journals and few National Institutes of Health–funded research projects in the field of pediatric EMS research.[22]

Compared to previous reports that relied on focused groups of experts, the Consensus Conference entitled "Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps" offered an opportunity to convene a broad audience of stakeholders, both in person and remotely using social media, to discuss scientific priorities with the potential to generate new ideas and engage new investigators. In addition, this conference provided the opportunity to use a nominal group technique as a consensus method to focus on important and/or feasible scientific priorities.[23] The objectives of this article are to 1) evaluate the current scientific priorities of the pediatric EMS research community among a broad population of investigators as well as patient advocates and 2) explore specific barriers that may prevent achievement of the scientific priorities.

CLINICAL VIGNETTE: CASE SCENARIO

A family calls 911 after a 2-year-old child falls from an open second-story window in their apartment onto a concrete sidewalk. The family reports that the child was unconscious for 2 to 3 minutes after the fall then awakened and is now agitated. EMS arrives and notes the child had a large boggy scalp hematoma, is somnolent with GCS of 8, and has sonorous respirations. The initial vital signs are notable for heart rate of 130, blood pressure of 110/70, respiratory rate of 10, and oxygen saturation of 85% on room air.

The EMS providers are faced with multiple clinical management decisions including:

1. What would be the safest and most effective method to immobilize this patient and prevent potential secondary spinal injury while optimizing a position to reduce intracranial pressure?
2. What is the best way to manage the airway to support oxygenation and ventilation?

The EMS system leadership also needs to know:

1. What are the most effective protocols for children with brain injury treated in EMS?
2. What is the most effective equipment to support the airway and breathing?

EMS researchers also need to know:

1. What are the most important clinical and patient-oriented outcomes in investigating treatment of children with traumatic brain injury (TBI) by EMS providers?
2. Which interventions are feasible and acceptable in the EMS setting?

Currently there is very little evidence to answer these important questions, and methodologic challenges only increase the difficulty of research in this field.

METHODS

The consensus conference convened at the Society for Academic Emergency Medicine (SAEM) Annual Meeting held in May 2018. The conference included five breakout sessions, one devoted to the subject of EMS outcomes research. To develop initial candidate ideas for creating a pediatric EMS research agenda, we formed a committee of experienced EMS researchers and educators (Consensus Conference EMS Subcommittee) to guide our consensus conference breakout

session. Stakeholders in the EMS community were contacted through their respective organizations (Table 1) and invited to participate in a pre-conference survey to help inform preparation for the conference and gain input from a wide range of people within the EMS community. Researchers, educators, program managers, EMS medical directors, and EMS personnel were invited to participate in the breakout session and were also invited to complete a preconference electronic survey. This survey was utilized by all consensus conference subcommittees in the planning of their breakout session. Specific to issues related to EMS research, the survey asked respondents to rank three overarching objectives in order of importance. These objectives, initially selected by the Consensus Conference EMS Subcommittee, were:

1. Do established best practice for pediatric EMS care improve patient-oriented outcomes?
2. What are the best methods to study challenging but high-impact clinical conditions such as out-of-hospital cardiac arrest, drowning, severe trauma, and respiratory failure?
3. Can we identify opportunities to translate knowledge and evidence into practice in the out-of-hospital setting?

In addition to these overarching themes, survey respondents were asked to rank specific research questions to further explore the importance of various aspects of each theme (Figure 1).

The results of this survey were used to structure and organize the breakout session into a more narrowly defined area. The Consensus Conference EMS Subcommittee organized the breakout session attendees into four groups that rotated between clinical conditions, which were decided upon in advance of the meeting: TBI, general injury and trauma, respiratory disease/failure, and sepsis/seizure. These clinical conditions were chosen as they included both the most prevalent and high-risk out-of-hospital pediatric encounters as well as the leading causes of death in children.[24,25] The clinical conditions were prominently displayed in four areas of the room on large sheets of paper. Each condition group had a facilitator and self-adhesive notes. Participants were given 10 minutes to write down potential candidate research topics for each condition. The topics were posted on the wall reviewed by the subsequent groups who either added to the topics or created new ones. Once each group had rotated through each area, the groups participated in a multivoting session. Each participant was given a total of eight votes for each clinical condition (four for feasibility and four for importance). The multivoting process using these two criteria provided an opportunity to explore what was both feasible and important. This in turn provides relevant information to early stage investigators who may need to focus on more feasible outcomes. In addition, this process also assists other investigators in the identification of topics deemed important despite requiring more resources to investigate. At the conclusion of the multivoting, the entire participant group walked around the room to examine common themes and discuss the implications for each of the clinical domains. This discussion was audio-recorded and transcribed (YTL). The transcribed notes were used to check facts and verify consensus among the breakout participants. The final results of the multivoting were tallied and reported to the general consensus conference attendees for feedback and questions.

Given the importance of engaging a wide range of stakeholders, the breakout session utilized Twitter (#AEMCC_pedsEMS) and a closed Facebook member group ("EMS Docs"). One member of the planning committee (JD) functioned as the social media moderator and posted candidate research topics suggested by the online stakeholders. Those participating through social media were not given the opportunity to vote on candidate research topics; however, candidate topics suggested by social media participants could be voted on by those participating face to face in the breakout session.

Table 1
List of Stakeholder Organizations for EMS Breakout Session

National Association of EMS Physicians, Pediatric Committee
Health Resources and Services Administration, EMS for Children Program
American Academy of Pediatrics, Section on Emergency Medicine
National Association of State EMS Officials
Society for Academic Emergency Medicine, Pediatric Interest Group
American College of Emergency Physicians, EMS Committee

RESULTS

Preconference Survey Results

Prior to the conference the survey was sent to 72 individuals and was completed by 33, giving a response rate of 45.8%. Survey results for questions

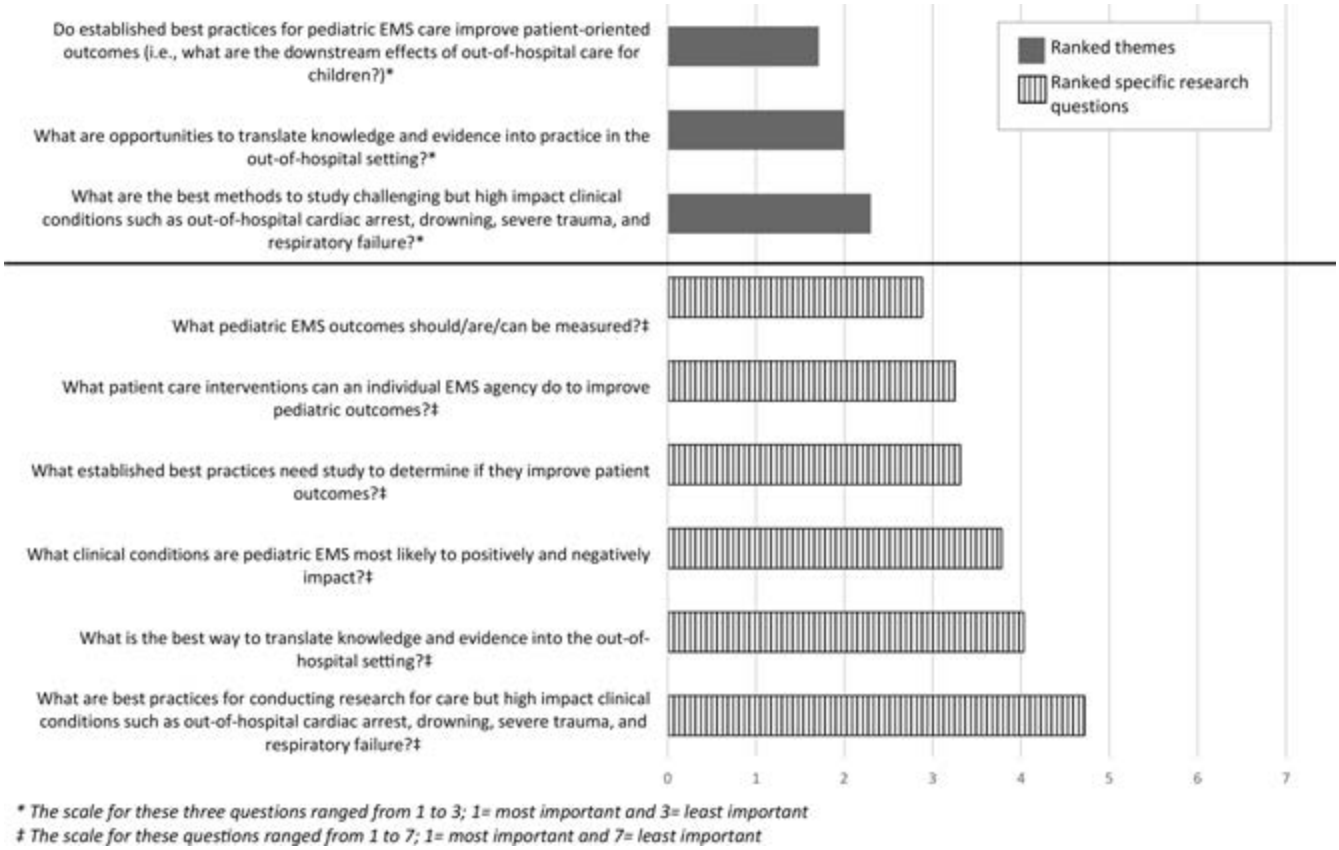

Figure 1. Results of the preconference survey: rank of themes for breakout session by importance.

are shown in Figure 1. The primary topic that was ranked first and second by 67% was the question, "Do established best practice for pediatric EMS care improve patient-oriented outcomes?" This initial survey result prompted the group to consider the question of which patient-oriented outcomes were relevant to EMS research, recognizing that this differed by medical condition. The selection of an appropriate outcome is a critical component of a high-impact study and thus we believed would benefit from the consensus process.

The pediatric EMS breakout session had a total of 27 individuals participating in person. On Twitter, the moderator posted 21 tweets and had 4,727 impressions (number of times the moderator's tweets were viewed) and 418 engagements (tweet clicked on/liked/commented/retweeted). The closed Facebook page, which had 552 EMS physician members, led to 42 comments from 10 individuals. The face-to-face and social media attendees identified a total of 153 candidate outcome measures during the brainstorming session (40 TBI; 45 general injury; 25 respiratory disease/failure; 22 seizure; 17 sepsis; and four cross-cutting). During the in-person multivoting, a total of 84 (54.9%) candidate outcome measures received at least one vote for importance, and 101 (66.0%) outcome measures received at least one vote for feasibility. The overlap between the two metrics for all outcome measures (i.e., identified as being both important and feasible) was 50.3%. Figure 2 shows the derivation of the key outcomes and the resulting top five outcomes by clinical condition.

Research Priorities

Disease-specific Prehospital Research Outcomes. The top five key outcome measures for the five specific clinical conditions are shown in Table 2. The supplemental tables in Data Supplement S1 (available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13637/full) provide all key outcome measures for each clinical condition (head injury, general injury, respiratory disease/failure, seizure, and sepsis) with their respective votes for importance and feasibility.

1. TBI: For TBI, attendees identified a total of 40 potential outcomes during the brainstorming sessions,

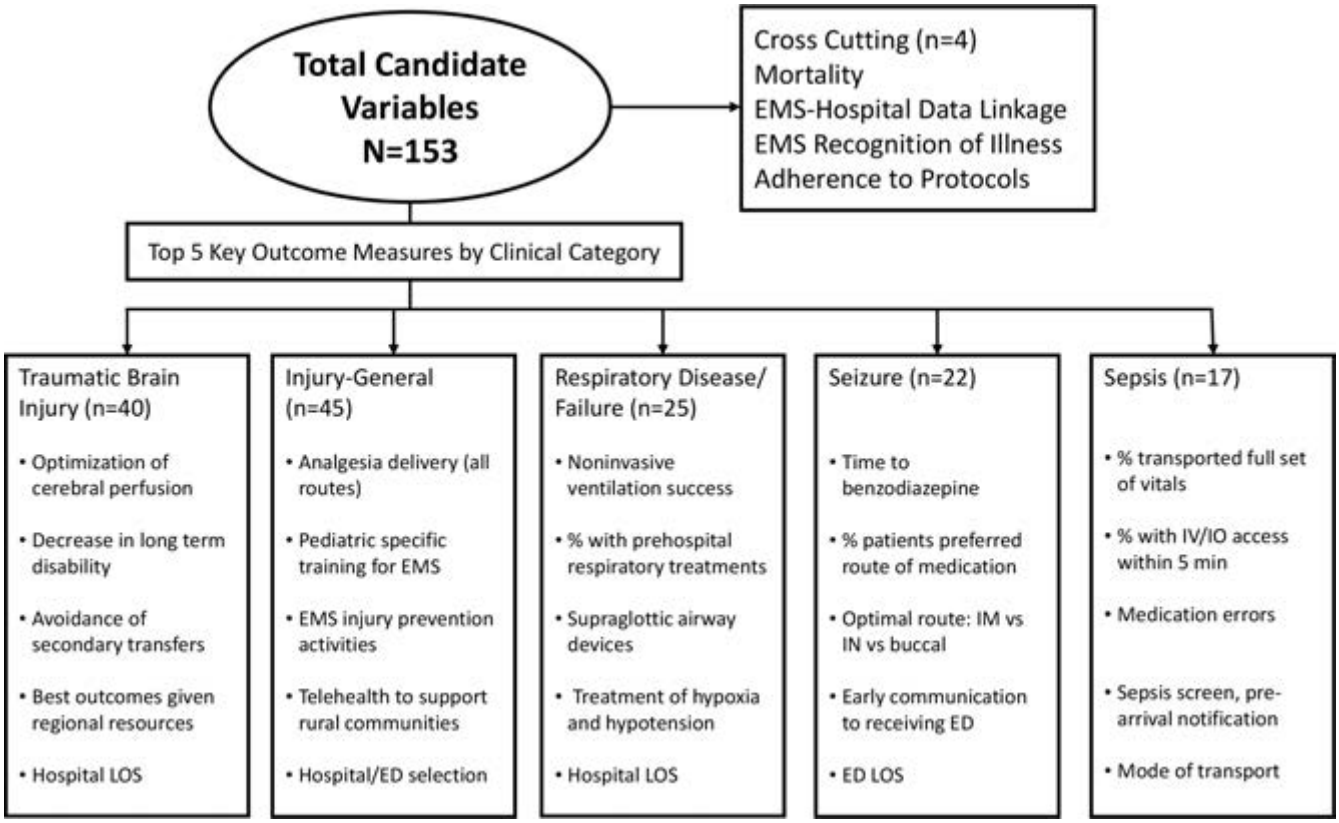

Figure 2. Derivation of candidate outcome measures and results of top five outcomes for each clinical categories.

with only 50% (n = 22) receiving any votes for either feasibility or importance. Outcomes ranking highest in importance and feasibility were EMS optimization of cerebral perfusion, delivery of best evidence-based care, avoidance of secondary transfers, and increase in patients with good neurologic outcome (Table 3). Given the importance of outcomes related to neurologic outcomes, EMS interventions including successful airway management without hypoxia, targeted ventilation using capnography, and avoidance of hypotension were all identified as important to the prehospital management of TBI but not thought to be very feasible to study (median votes for importance, 2; votes for feasibility, 0).

2. *General injury:* Out of a total of 45 key outcome measures discussed during multi voting, 22 (49%) general injury measures had at least one vote for importance and 24 (53%) had at least one vote for feasibility. Table 3 shows that the three highest ranked outcomes for importance and/or feasibility in this category were hospital/ED selection (17 total votes), resource utilization including pediatric-specific training on trauma management (12 total votes), and traumatic pain management, including access to oral and intranasal analgesia (13 total votes).

3. *Respiratory disease and failure:* The breakout participants generated a total of 25 key outcome measures for respiratory disease and failure, of which 14 (56%) received at least one vote for importance and 13 (52%) received at least one vote for feasibility. The majority of the outcomes deemed important and feasible were related to the management respiratory failure (Table 3). In contrast to the clinical conditions of TBI and general injury, hospital-related outcomes including ED and hospital length of stay and number of days on a ventilator were considered important outcomes for respiratory disease and failure. Recognition of respiratory failure and correct classification of underlying cause of respiratory distress were both noted to be important (importance votes, 7 and 4, respectively) but not thought to be very feasible (0 votes).

4. *Seizure management:* For seizure management, breakout participants identified a total of 22 key outcome measures, of which 13 (59%) had at least one vote for importance and 16 (73%) had at least one vote for feasibility. All key outcome measures are shown in the supplemental tables in Data Supplement S1 (Table S5). The key outcome measures of highest importance to the group included recognition of seizure activity (votes: importance 5, feasibility 4),

Table 2
Highest Rated Key Prehospital Outcome Measures for Five Clinical Conditions as Measured by Importance and Feasibility

Top Five Key Outcome Measures by Clinical Condition*	Important	Feasible	Total
Head injury			
Optimize cerebral perfusion	7	8	15
Decrease in long-term disability	9	1	10
Hospital LOS	0	9	9
Avoid secondary transfers to trauma centers	4	4	8
Best care or outcomes given regional resources and triage	4	2	6
Improved neurologic return to baseline function	3	3	6
General injury			
Hospital/ED selection	9	8	17
Pain control, including access to oral and nasal medications	6	7	13
Pediatric specific training for trauma management	5	7	12
EMS injury prevention activities	2	8	10
Telehealth to support rural communities	4	4	8
Respiratory disease/illness			
Frequency of successful noninvasive ventilation	8	10	18
Proportion of patients receiving prehospital respiratory treatments (steroids, albuterol, epi, ipratropium)	3	13	16
Optimal supraglottic airway	6	7	13
Avoidance of hypoxia and hypotension	6	3	9
LOS for ED, hospital, and ICU; LOS on hospital ventilator	4	3	7
Seizure			
Time to administration of benzodiazepine	3	10	13
Proportion of patients getting medication by preferred route	4	6	10
Early or appropriate communication to receiving ED	4	2	6
ED LOS	0	5	5
Optimal medication route: IM vs. IN vs. buccal	3	1	4
Sepsis			
Proportion of patients with IV/IO access within 5 min of recognition of shock	6	10	16
Sepsis screen and prearrival notification	4	2	6
Medication errors	4	1	5
Proportion of patients transported full set of vitals	0	4	4
Best mode of transport	2	1	3

LOS = length of stay.
*Not including cross-cutting key outcome measures (mortality, EMS–mortality data linkage, recognition of illness, adherence to protocols)

Table 3
Key Cross-cutting Outcome Measures by Clinical Condition

Key Outcome Measure	Importance	Feasibility	Total
Mortality			
Sepsis	2	5	7
Seizure	2	5	7
Head injury	9	11	20
Respiratory failure	1	7	8
Injury (general)	6	8	14
EMS–hospital data linkage			
Sepsis	10	1	11
Seizure	10	1	11
Respiratory distress	14	0	14
Head injury	13	4	17
Injury general	12	3	15
Recognition of illness			
Sepsis	11	5	16
Seizure	4	5	9
Respiratory distress	7	0	7
Head injury	7	2	9
Injury general (sp. shock)	1	2	3
Adherence to clinical protocols, barriers, and facilitators			
Sepsis	1	0	1
Seizure	0	0	0
Respiratory distress	3	4	7
Head injury (sp. concussion)	5	2	7
Injury general	0	1	1

determination of the optimal route of medication delivery (votes: importance 3, feasibility 1), and the proportion of patients getting the correct dose of medication via that route (votes: importance 4, feasibility 1; Data Supplement S1, supplemental tables). Of note, among the safety-related outcomes in the prehospital management of seizures, respiratory depression was not seen as important as the administration of the correct dose of medication (Importance votes: 1 vs. 4, respectively).

5. Sepsis management: For prehospital management of sepsis, the breakout participants identified 17 key outcome measures, of which 12 (70%) had at least one vote for importance and 13 (76%) had at least one vote for feasibility. The primary outcome identified as most important and feasible was the accurate identification of a patient in septic shock (Importance, 11; feasibility, 5). Out-of-hospital utilization of sepsis screens and the provision of adequate prearrival notification during the transport of a patient with suspected septic shock was also found to have high importance but lower feasibility (importance, 4; feasibility, 2; Data Supplement S1, supplemental tables).

Cross-cutting Measures. Table 3 shows the ranked importance and feasibility among the four measures that were noted to be common or "cross-cutting" among all disease groups (mortality, EMS–hospital data linkage, EMS recognition of illness, and adherence to guidelines and protocols) stratified by clinical condition.

1. *Mortality*: The direct downstream outcomes of EMS care are still not well understood, particularly specific EMS interventions and risk of death. For this reason, mortality was a specific outcome identified across all disease categories. Overall, mortality is a very feasible outcome to measure. However, it was not important across all conditions. The primary health conditions in which mortality was identified as an important outcome were TBI and general injury (Table 3). This is not surprising given that injury is the leading cause of death for most pediatric age groups.[25]

2. *EMS–hospital data linkage*: The ability to link data between prehospital and hospital systems was universally identified an important measure to promote and work toward and received many votes in the multivote process (Table 3). During the breakout session, discussion ensued as to whether this is specifically a prehospital outcome measure; the larger group reached consensus that this is an important structural process that should be tracked to ensure the ability to perform future research.

3. *EMS recognition of illness:* EMS provider recognition of illness was another common theme across all five clinical conditions. This was identified as particularly important with regard to sepsis (importance: 11 votes), as well as respiratory disease and failure (importance: 7 votes) and TBI (importance: 7 votes). Overall, however, the feasibility of this cross-cutting measure was recognized as low among breakout participants.

4. *Adherence to guidelines and protocols:* Finally, the last cross-cutting measure found in each of the five disease categories was the need to examine methods to support adherence to prehospital guidelines and protocols. Overall, although this was included in all five clinical areas, ultimately it received few votes for importance or feasibility. The only area where it was recognized as important was for TBI (importance votes: 5).

DISCUSSION

As demonstrated in the clinical vignette above, gaps exist in what EMS providers, medical directors, and researchers need to know to ensure the best care possible for pediatric patients during out-of-hospital encounters. During the 2018 SAEM Consensus Conference designed to identify gaps and create a research agenda for pediatric emergency care, a group of EMS researchers and other stakeholders came together to identify key patient-oriented and EMS system outcomes related to five important clinical conditions. The group considered 153 candidate outcomes and achieved consensus on what is both important and feasible for future EMS researchers to explore. In addition, the group also identified several outcomes or measures consistent across various clinical conditions that may serve as support for EMS systems research as a whole.

For our five specific clinical conditions it became apparent that outcomes that are feasible or easy to measure often were not necessarily considered important, reflecting that research in the field of pediatric EMS is evolving and true gaps in knowledge are in areas that have not previously been studied. For example, in the case of TBI many hospital-based outcomes that are readily quantifiable (days in the hospital, computed tomography imaging) were not considered as important as neurologic outcome after injury, which was not thought to be very feasible. Identifying the contribution of prehospital care to longer term outcomes is difficult given the potential confounders related to ED and inpatient care. The same trend was seen in the discussion around respiratory disease and failure. EMS interventions around respiratory disease management such as the administration of steroids and beta-agonist treatments or use of capnography or high-flow nasal canula oxygen were determined to be feasible with limited importance. This suggests that the management of lower-acuity respiratory illness may not be the important key outcomes requiring study in the field of pediatric prehospital care. Again, the factors that are easy to measure in prehospital research may not necessarily reflect the true nature of what is now regarded as important outcomes to study.

Some outcomes were seen as having equal feasibility and importance. For example, in general injury, the study of trauma occurring in rural communities was thought to be equally important as it was feasible. Cost of trauma care also had equal feasibility and importance, which may reflect the already identified importance of hospital destination selection, as secondary transfers can often increase the total cost of care. It is the outcomes with equal feasibility and

importance that may form the basis for next steps in research across these clinical conditions.

Overall, three cross-cutting measures received votes for importance among the five clinical conditions: mortality, the ability to link prehospital data to hospital outcomes, and the need to ensure recognition of illness among prehospital providers. Mortality was listed as a key outcome measure for each clinical condition, with importance most noted in TBI and general injury. For the other three medical conditions, respiratory disease/failure, seizure, and sepsis, mortality was not seen as important, because the immediate risk of death in these clinical conditions is quite low and unlikely to be impacted by prehospital care. Given the perceived importance of mortality as it relates to prehospital management of general trauma and TBI, further research should consider using mortality as one of the important outcomes related to the prehospital care of pediatric trauma patients. Methods to examine risk of death such as those used in the PECARN intraabdominal and intracranial injury studies (e.g., review of morgue records) should be utilized to track this important outcome.[26,27]

With regard to the second cross-cutting measure, EMS to hospital data linkage, the strong desire for this among those participating in the breakout session clearly overwhelmed the fact that our questions were focused on patient-oriented outcomes, which was an unexpected outcome of the process. Consensus among the group indicated that research must be directed to this issue and should address the both the reliability of the linkage and the ability to achieve linkage using administrative data sets. Large EMS linkage projects using existing data have been successfully performed and validated in federally funded studies involving adult patients indicating the process is feasible when the resources are available.[28–30] In addition, cardiac arrest registries and trauma registries also systematically combine prehospital and hospital data, typically using manual data abstraction, although they offer varying degrees of detail in the data.[31,32] However, if prehospital and hospital data were electronically linked routinely, the need for resources to conduct large observational studies and even prospective pragmatic trials could be decreased substantially.

The third cross-cutting measure, EMS recognition of illness, is not surprising. During prehospital encounters, EMS providers must recognize a variety of clinical conditions along with the severity of their presentation. Recognition of certain clinical conditions among pediatric patients is a particular challenge for EMS providers given that less than 10% of all prehospital encounters involve children.[33,34] The accurate recognition of illness and illness severity affects EMS provider decisions including treatment and destination. As a result, throughout the breakout session, EMS provider recognition of the type of illness and illness severity was identified as important across all disease categories. To date, however, numerous studies demonstrate that EMS providers struggle to correctly identify certain clinical conditions among their pediatric patients, particularly respiratory failure and shock.[8,15,35–40] Given the importance of this cross-cutting measure, research is warranted to evaluate the resources required to achieve and maintain competency in pediatric illness recognition. Given the potential for systems barriers such as training time and budgets, future studies could explore the feasibility of using real-time decision support tools to improve patient assessment. Simulation can provide a certain degree of realism and provide prehospital providers with the opportunity to identify certain clinical conditions through moulage and physiologic data. Simulator training also provides a valuable way to examine the specific challenges in the type of clinical conditions that are particularly challenging.[41–43] Ultimately, the translation from simulator to live patient requires additional study.

CONCLUSION

We used a nominal group technique among a group of 27 face-to-face and 10 social media stakeholders in the pediatric emergency medicine and emergency medical services community to generate ideas and determine importance and feasibility of research outcomes, in five clinical areas as part of a research agenda for pediatric emergency medical services. The nominal group technique included small group brainstorming and multivoting to rank the outcomes in terms of importance and feasibility. The five clinical areas—traumatic brain injury, general injury, respiratory disease/failure, sepsis, and seizures—were selected based on both their known public health importance and their commonality in emergency medical services encounters. Regardless of importance or feasibility, optimization of cerebral perfusion garnered the most votes for TBI, analgesia delivery was ranked highest for general injury, noninvasive ventilation success for respiratory disease, time to benzodiazepine for seizure,

and the percent transported with a full set of vitals for sepsis. Four cross-cutting issues were identified—mortality, emergency medical services–hospital data linkage, emergency medical services recognition of illness, and adherence to protocols. While mortality is a feasible outcome to measure it was not found to be important among all disease conditions. Data linkage and emergency medical services recognition of illness was considered important but not necessarily feasible while adherence to protocols received few votes for importance or feasibility. Our process resulted in stakeholders identifying and considering over 150 candidate measures and achieved consensus on what is both important and feasible for future emergency medical services researchers to explore.

References

1. Lammers R, Byrwa M, Fales W. Root causes of errors in a simulated prehospital pediatric emergency. Acad Emerg Med 2012;19:37–47.
2. Lammers R, Willoughby-Byrwa M, Fales W. Medication errors in prehospital management of simulated pediatric anaphylaxis. Prehosp Emerg Care 2014;18:295–304.
3. Lammers RL, Willoughby-Byrwa M, Fales WD. Errors and error-producing conditions during a simulated, prehospital, pediatric cardiopulmonary arrest. Simul Healthc 2014;9:174–83.
4. Hoyle JD Jr, Sleight D, Henry R, Chassee T, Fales B, Mavis B. Pediatric prehospital medication dosing errors: a mixed-methods study. Prehosp Emerg Care 2016;20:117–24.
5. Hoyle JD Jr, Davis AT, Putman KK, Trytko JA, Fales WD. Medication dosing errors in pediatric patients treated by emergency medical services. Prehosp Emerg Care 2011;16:59–66.
6. Duby R, Hansen M, Meckler G, Skarica B, Lambert W, Guise JM. Safety events in high risk prehospital neonatal calls. Prehosp Emerg Care 2018;22:34–40.
7. Guise JM, Hansen M, O'Brien K, et al. Emergency medical services responders' perceptions of the effect of stress and anxiety on patient safety in the out-of-hospital emergency care of children: a qualitative study. BMJ Open 2017;7:e014057.
8. Hansen M, Meckler G, Lambert W, Dickinson C, Kickinson K, Guise JM. Paramedic assessment and treatment of upper airway obstruction in pediatric patients: an exploratory analysis by the Children's Safety Initiative-Emergency Medical Services. Am J Emerg Med 2016;34:599–601.
9. Meckler G, Hansen M, Lambert W, et al. Out-of-hospital pediatric patient safety events: results of the CSI chart review. Prehosp Emerg Care 2018;22:290–9.
10. Hewes HA, Dai M, Mann NC, Baca T, Taillac P. Prehospital pain management: disparity by age and race. Prehosp Emerg Care 2018;22:189–97.
11. Gausche M, Lewis RJ, Stratton SJ, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. JAMA 2000;283:783–90.
12. Silbergleit R, Lowenstein D, Durkalski V, Conwit R; Neurological Emergency Treatment Trials I. RAMPART (Rapid Anticonvulsant Medication Prior to Arrival Trial): a double-blind randomized clinical trial of the efficacy of intramuscular midazolam versus intravenous lorazepam in the prehospital treatment of status epilepticus by paramedics. Epilepsia 2011;52 Suppl 8:45–7.
13. Lang ES, Spaite DW, Oliver ZJ, et al. A national model for developing, implementing, and evaluating evidence-based guidelines for prehospital care. Acad Emerg Med 2012;19:201–9.
14. Institute of Medicine. Emergency Medical Services: At the Crossroads. Washington, DC: The National Academies Press, 2006.
15. Shah MI, Carey JM, Rapp SE, et al. Impact of high-fidelity pediatric simulation on paramedic seizure management. Prehosp Emerg Care 2016;20:499–507.
16. Gausche-Hill M, Brown KM, Oliver ZJ, et al. An evidence-based guideline for prehospital analgesia in trauma. Prehosp Emerg Care 2014;18 Suppl 1:25–34.
17. Shah MI, Macias CG, Dayan PS, et al. An evidence-based guideline for pediatric prehospital seizure management using GRADE methodology. Prehosp Emerg Care 2014;18 Suppl 1:15–24.
18. Rappaport LD, Brou L, Givens T, et al. Comparison of errors using two length-based tape systems for prehospital care in children. Prehosp Emerg Care 2016;20:508–17.
19. Institute of Medicine. Emergency Medical Services for Children. Washington, DC: The National Academies Press, 1993.
20. Browne LR, Shah MI, Studnek JR, et al. 2015 pediatric research priorities in prehospital care. Prehosp Emerg Care 2016;20:311–6.
21. Foltin GL, Dayan P, Tunik M, et al. Priorities for pediatric prehospital research. Pediatr Emerg Care 2010;26:773–7.
22. Leonard JC, Scharff DP, Koors V, et al. A qualitative assessment of factors that influence emergency medical services partnerships in prehospital research. Acad Emerg Med 2012;19:161–73.
23. McMillian SS, Kelly F, Sav A, et al. Using the nominal group technique: how to analyse across multiple groups. Health Serv Outcomes Res Method 2014;14:99–108.
24. Lerner EB, Dayan PS, Brown K, et al. Characteristics of the pediatric patients treated by the Pediatric Emergency Care Applied Research Network's affiliated EMS agencies. Prehosp Emerg Care 2014;18:52–9.

25. Centers for Disease Control and Prevention. 10 Leading Causes of Death by Age Group, United States – 2016. 2016. Available at: https://www.cdc.gov/injury/wisqars/pdf/leading_causes_of_death_by_age_group_2016-508.pdf. Accessed July 13, 2018.
26. Holmes JF, Lillis K, Monroe D, et al. Identifying children at very low risk of clinically important blunt abdominal injuries. Ann Emerg Med 2013;62:107–16.e102.
27. Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. Lancet 2009;374:1160–70.
28. Newgard C, Malveau S, Staudenmayer K, et al. Evaluating the use of existing data sources, probabilistic linkage, and multiple imputation to build population-based injury databases across phases of trauma care. Acad Emerg Med 2012;19:469–80.
29. Newgard CD. Validation of probabilistic linkage to match de-identified ambulance records to a state trauma registry. Acad Emerg Med 2006;13:69–75.
30. Newgard CD, Zive D, Malveau S, Leopold R, Worrall W, Sahni R. Developing a statewide emergency medical services database linked to hospital outcomes: a feasibility study. Prehosp Emerg Care 2011;15:303–19.
31. Wang HE, Balasubramani GK, Cook LJ, Lave JR, Yealy DM. Out-of-hospital endotracheal intubation experience and patient outcomes. Ann Emerg Med 2010;55:527–37.e526.
32. Wang HE, Cook LJ, Chang CC, Yealy DM, Lave JR. Outcomes after out-of-hospital endotracheal intubation errors. Resuscitation 2009;80:50–5.
33. Tsai A, Kallsen G. Epidemiology of pediatric prehospital care. Ann Emerg Med 1987;16:284–92.
34. National EMS Information Center Technical Assistance Center. National EMS Information System. 2016. Available at: https://nemsis.org. Accessed July 18, 2018.
35. Drayna PC, Browne LR, Guse CE, Brousseau DC, Lerner EB. Prehospital pediatric care: opportunities for training, treatment, and research. Prehosp Emerg Care 2015;19:441–7.
36. Graham SD, Olson LM, Sapien RE, Tandberg D, Sklar DP. Adequacy of EMS data collection during pediatric cardiac arrest: are EMTs getting the whole story? Prehosp Emerg Care 1997;1:28–31.
37. Markenson D, Tunik M, Cooper A, et al. A national assessment of knowledge, attitudes, and confidence of prehospital providers in the assessment and management of child maltreatment. Pediatrics 2007;119:e103–8.
38. Hansen ML, Lin A, Eriksson C, et al. A comparison of pediatric airway management techniques during out-of-hospital cardiac arrest using the CARES database. Resuscitation 2017;120:51–6.
39. Lammers RL, Byrwa MJ, Fales WD, Hale RA. Simulation-based assessment of paramedic pediatric resuscitation skills. Prehosp Emerg Care 2009;13:345–56.
40. Browne LR, Shah MI, Studnek JR, et al. Multicenter evaluation of prehospital opioid pain management in injured children. Prehosp Emerg Care 2016;20:759–67.
41. Fleischman RJ, Yarris LM, Curry MT, Yuen SC, Breon AR, Meckler GD. Pediatric educational needs assessment for urban and rural emergency medical technicians. Pediatr Emerg Care 2011;27:1130–5.
42. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA 2011;306:978–88.
43. Ganss PE, McCain C. Task training and simulation in the pre-hospital environment. Mo Med 2013;110:125–8.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13637/full

Data Supplement S1. Supplemental tables.

Use of a National Database to Assess Pediatric Emergency Care Across United States Emergency Departments

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ABSTRACT

Objectives: Differences in emergency care for children exist between general and pediatric emergency departments (EDs). Some pediatric quality measures are available but are not routinely employed nationwide. We sought to create a short list of applied measures that would provide a starting point for EDs to measure pediatric emergency care quality and to compare care between general and pediatric EDs for these measures.

Methods: Previously reported lists comprising 465 pediatric emergency care quality measures were reconciled. Preset criteria were used to create a diverse list of quality measures measurable using a national database. We used the National Hospital Ambulatory Medical Care Survey from 2010 to 2015 to measure performance. Measures were excluded for total observation counts under a prespecified power threshold, being unmeasurable in the data set, or for missing clear definitions. Using survey-weighted statistics, we reported summary performance (mean, proportion, or count) with 95% confidence intervals for each analyzed quality measure and compared general and pediatric ED performance.

Results: Among 465 quality measures, 28 (6%) were included in the analysis, including seven condition-specific measures and 21 general measures. We analyzed a sample of 36,430 visits corresponding to 179.0 million survey-weighted ED visits, of which 150.8 million (84.3%) were in general EDs. Performance was better in pediatric EDs for three of seven condition-specific measures, including antibiotics for viral infections (–6.2%), chest X-rays for asthma (–18.7%), and topical anesthesia for wound closures (+25.7%). Performance was similar for four of seven condition-specific measures: computed tomography for head trauma, steroids for asthma, steroids for croup, and oral rehydration for dehydration. Compared with pediatric EDs, general EDs discharged and transferred higher proportions of children, had shorter lengths of stay, and sent patients home with fewer prescriptions. General EDs obtained fewer pain scores for injured children. Pediatric EDs had a lower proportion of pediatric visits in which patients left against medical advice. General and pediatric EDs had similar rates of mortality, left without being seen, incomplete vital signs, labs in nonacute patients, and similar numbers of medications given per patient.

Conclusions: Using a national sample of ED visits, we demonstrated the feasibility of using nationally representative data to assess quality measures for children cared for in the ED. Differences between pediatric and general ED care identify targets for quality improvement.

Measuring pediatric emergency care quality care is challenging because of the lack of uniform agreement on measures that should be adopted systemwide, the investment required to create a pediatric

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quality measurement infrastructure, and the heterogeneity of emergency departments (EDs) that care for children. Furthermore, pediatric emergency medicine lacks uniformly accepted quality goals and has lagged behind general emergency medicine in developing and utilizing setting-specific quality measures.[1] Yet, providing high-quality emergency care to children is a national priority.[2] In 2011, Alessandrini and colleagues[3] summarized 405 candidate pediatric emergency medicine quality measures, creating a comprehensive inventory. This formed the basis for recent work by the Pediatric Emergency Care Applied Research Network, which created a separate, partially overlapping list of 60 measures in a Pediatric Performance Measures Toolbox, based on input solicited from pediatric emergency physicians, general emergency physicians, nurses, and parents.[4] Combined, the 2011 Inventory and later Toolbox measures offer an opportunity to assess the quality of care provided to children in EDs across multiple conditions.

Many of the Inventory and Toolbox measures are challenging to measure in clinical practice, particularly in general EDs. As many as 95% of pediatric patients visit general EDs, which differ significantly from pediatric EDs in patient volume, complexity, and severity.[5–7] Understanding and addressing variation in pediatric emergency care quality for all children therefore requires assessing both general and pediatric EDs. National databases offer a unique opportunity to measure and evaluate the quality of care provided. These databases allow comparisons between pediatric and general EDs across multiple measures simultaneously, reducing measurement efforts at the individual department level.

An informative report of key measures would cover multiple domains of care, draw from established and endorsed lists of measures, and provide benchmarking parameters. In this study, we aimed to develop a limited but broad list of ascertainable quality measures and use a national administrative database to compare pediatric and general EDs on these measures.

METHODS

Study Design and Setting

We conducted a retrospective, population-based, cross-sectional study using the nationally representative 2010 to 2015 National Hospital Ambulatory Medical Care Survey (NHAMCS).[8] The NHAMCS is managed by the Centers for Disease Control and Prevention's National Center for Health Statistics. Each year, approximately 30,000 to 40,000 ED records are sampled and abstracted from noninstitutional, general, and short-stay hospitals. The weighted four-stage probability sample allows for extrapolation of national estimates, from primary sampling units in all 50 states and the District of Columbia. Trained observers at each sampled ED collect data during a random 4-week period, and field supervisors review the case report forms to ensure data quality.[9]

The unit of analysis for this study was the ED visit. We included visits for patients less than 18 years presenting to an ED between 2010 and 2015. No visits were excluded.

Study Definitions

Emergency department visits were classified as occurring at either a pediatric or general ED. A pediatric ED was defined as having more than 75% of its visits made by patients under 18 years of age.[6,10]

Variables

Demographics, chief complaint, vital signs, diagnoses, treatments, and process measures such as length of stay and disposition are all recorded in NHAMCS. We reported the demographics of the general and pediatric ED samples by age, sex, race, ethnicity, insurance, severity of illness, and presence of an injury (as recorded by the survey respondent). Drug treatments provided were categorized using the Cerner Multum drug database (Cerner Corp.), which categorizes individual drugs into groups such as corticosteroids. Procedures were recorded by the trained observer completing the survey. Timing of treatments was unavailable. Diagnoses were identified by International Classification of Diseases, Version 9, Clinical Modification codes (Table 1). Chief complaints were identified using reason-for-visit codes. EDs are coded with a unique identifier, with each identifier only valid within one data year. We did not report any cells with fewer than 10 observations to limit disclosure risk.

Quality Measures

Our goal was to create a measurable, wide-ranging list of pediatric emergency care quality measures. Sets of quality measures have been proposed for evaluating pediatric ED care, including Alessandrini and colleagues' 2011 list of 405 measures ("the Inventory")[3] and the 60-measure Pediatric Performance Measures Toolbox ("the Toolbox").[4]

Table 1
Analyzed Measures Included in Final Quality Report, Drawn From a Broad Inventory of Pediatric Quality Measures[3] and the Pediatric Emergency Care Applied Research Network's Performance Toolbox[4]

Measure	Source	Statistical Analysis	Process or Outcome	Numerator	Denominator
General Measures					
Incomplete vitals documented	Toolbox	Proportion	Process	Visits without all of temperature, heart rate, respiratory rate, and blood pressure documented	All visits
Pain score not documented in trauma	Inventory	Proportion	Process	Visits without pain score documented	Visits with urgency level "immediate" or "emergent" *and* with injury flag present
Labs in nonacute patients	Inventory	Proportion	Process	Visits with any blood test performed	Visits with urgency level "nonurgent" or "semiurgent"
Urinary catheter	Inventory	Proportion	Process	Visits with a bladder catheterization procedure	All visits
LOS > 6 hours	Inventory	Proportion	Process	Visits with length of stay of ≥ 6 hours	All visits
Left without being seen	Toolbox	Proportion	Outcome	Visits with a disposition "left without being seen"	All visits
Left AMA	Inventory	Proportion	Outcome	Visits with a disposition "left AMA"	All visits
Hospitalization	Inventory	Proportion	Process	Visits resulting in hospitalization	All visits
Transfer	Inventory	Proportion	Process	Visits resulting in transfer	All visits
Transfer after 6 hours	Inventory	Proportion	Process	Visits with length of stay ≥ 6 hours	Visits resulting in transfer
Death in ED	Inventory	Proportion	Outcome	Visits in which patient expired in the ED	All visits
Prescriptions/patient	Inventory	Mean	Process	Number of prescriptions	Number of visits
Medications/patient	Inventory	Mean	Process	Number of medications given in the ED	Number of visits
LOS	Toolbox*	Mean	Outcome	Total time of all patients spent in the ED	Number of visits
Central line counts	Inventory	Count	Process	Count of procedures	Count of ED-years
Lumbar puncture counts	Inventory	Count	Process	Count of procedures	Count of ED-years
Intubation counts	Inventory	Count	Process	Count of procedures	Count of ED-years
ECG counts	Inventory	Count	Process	Count of procedures	Count of ED-years
CT scan counts	Inventory	Count	Process	Count of procedures	Count of ED-years
X-ray counts	Inventory	Count	Process	Count of procedures	Count of ED-years
Condition-specific Measures					
Radiography in asthma	Inventory	Proportion	Process	Visits with an X-ray performed	Visits for patients with age ≥ 2 years with any diagnosis of asthma (ICD-9 493.xx) *and* not transferred in
Antibiotics for viral illness	Toolbox*	Proportion	Process	Visits with ≥ 1 antibiotic given in the ED or prescribed (Multum level 2 codes 8, 9, 11–16, 18, 240, and 315).	Visits with any combination of viral illness diagnoses (ICD-9 079.99, 465.9, 780.60) and no other diagnoses
CT for head trauma	Toolbox*	Proportion	Process	Visits with a head CT performed	Visits with a chief complaint of fracture, dislocation, contusion, laceration, or injury of the head, face, or eyes
Steroids for asthma	Toolbox*	Proportion	Process	Visits with a steroid given in the ED (Multum level 3 code 301)	Visits for patients with age ≥ 2 years with a sole diagnosis of asthma *and* a bronchodilator given (Multum level 2 code 125) *and* not transferred in
Steroids for croup	Toolbox	Proportion	Process	Visits with a steroid given in the ED (Multum level 3 code 138 or 301)	Visits for patients with any diagnosis of croup (ICD-9 464.4) *and* not transferred in

(Continued)

Table 1 (continued)

Measure	Source	Statistical Analysis	Process or Outcome	Numerator	Denominator
Oral rehydration for dehydration	Inventory	Proportion	Process	Visits with no IV fluids given	Visits with any combination of dehydration diagnoses (276.5x, 558.9, 787.01–787.03, 787.91) and no other diagnosis
Topical anesthesia for wounds	Toolbox	Proportion	Process	Visits with a topical anesthetic given in the ED (Multum level 3 code 139)	Visits with a suture or staple procedure *and* a chief complaint of open wound of the head, neck, or face

Measures are clustered into general and condition-specific categories and further organized by method of statistical analysis. Fifteen of 60 Toolbox measures were designated as having special priority and are denoted below.
AMA = against medical advice; ECG = electrocardiogram; ICD-9 = International Classification of Diseases, Clinical Modification, 9th Edition; LOS = length of stay.
*Top-15 special priority Toolbox measures.

Because a consensus-based process generated the Toolbox, we automatically included all Toolbox measures. Among the 405 Inventory measures not in the Toolbox, we included those based on criteria defined a priori.[3] First, we included all general measures (those that applied to multiple conditions). These included measures on the list that were simple counts of procedures performed, representing an ED's experience with that procedure. Next, we evaluated each condition-specific measure if it was approved unanimously by a local expert review panel.[4] We convened a panel of three independent pediatric emergency medicine experts who were blinded to the purpose of this study and to each other's responses. Each expert was chosen based on having more than 10 years of clinical pediatric emergency medicine experience. A condition-specific measure was included if the three experts unanimously agreed the measure met all of the following criteria: 1) the condition is sufficiently common that all emergency medicine practitioners should be familiar with standard management, 2) patients to whom the quality measure should be applied can usually be identified by chief complaint or diagnosis code, and 3) high performance on the quality measure should be a priority for the emergency care of children nationally.

After the initial list of included measures was created from consensus review, we applied exclusion criteria. First, we excluded measures for which there were fewer than 348 unweighted observations in the database with data required to evaluate the measure. The number 348 was chosen based on 80% power to detect least a 15% difference in a proportion outcome with two-sided alpha of 0.05. Second, measures were excluded when NHAMCS did not include the necessary variables to evaluate that measure. Third, we excluded measures that were not well defined (not enough information about the measure to objectively measure it) or were redundant (nearly the exact same measure listed more than once, such as length of stay in both the Inventory and Toolbox measures).

Main Analysis

Measures were analyzed statistically by comparing performance for each quality measure between pediatric and general EDs, comparing survey-weighted effect estimates and 95% confidence intervals (CIs). For Inventory measures, the authors developed precise numerator and denominator definitions since these were not fully specified in the primary source. We applied Toolbox measures as defined in the primary source. Proportion measures (e.g., proportion of patients with complete vital signs recorded) were compared using univariable logistic regression, with odds ratios converted to absolute risk differences. Means (e.g., mean length of stay) were compared using univariable linear regression. Counts were compared with univariable Poisson regression, and the counts were reported by normalizing per ED per year (e.g., by dividing the total number of intubations across all general EDs by the total number of ED-years to obtain intubations per general ED per year). For every measure, statistically significant differences were defined as a 95% CI of the difference that did not overlap zero. Missing data for medications, diagnoses, procedures, and disposition were treated as absent (e.g., an unchecked box for endotracheal intubation meant that it was not performed and an unchecked box for left against medical advice was treated as "no"). Missing vital signs and pain scores were assumed to be unobtained. All other missing data were treated as missing and excluded from calculations.

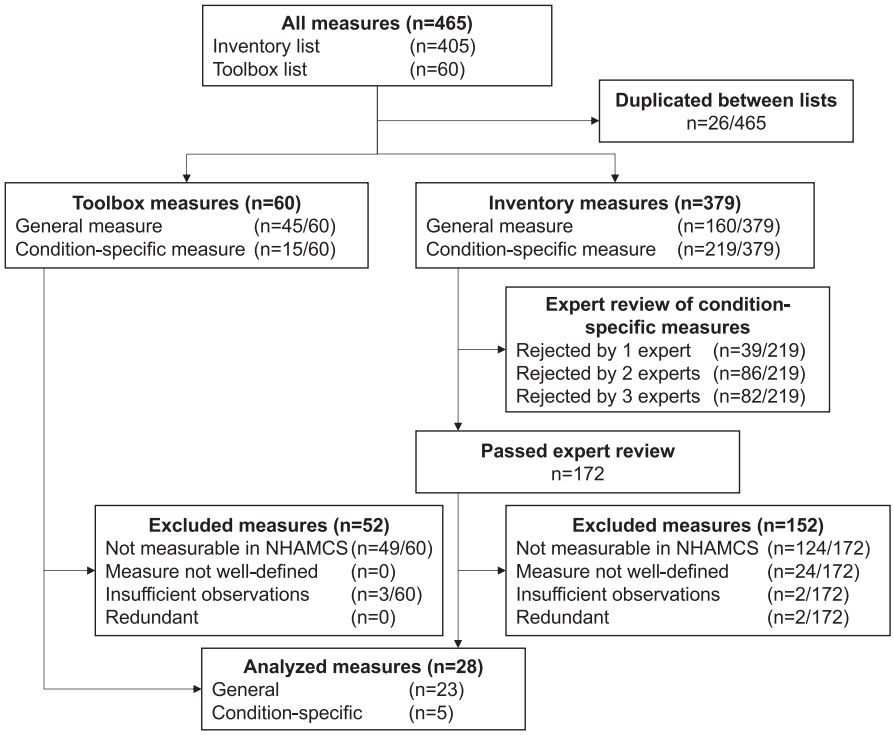

Figure 1. Selection of measures for analysis. Measures were selected from an Inventory of 405 measures[3] and the 60-measure Pediatric Performance Measures Toolbox[4]. Condition-specific inventory measures underwent a local consensus review to determine inclusion, with unanimously accepted measures included. NHAMCS = National Hospital Ambulatory Medical Care Survey.

Data were analyzed using R version 3.4.4 (R Foundation) and survey weighting was performed with the survey package. The institutional review board deemed this study exempt from review.

RESULTS

Identifying Quality Measures

After removing 26 duplicate measures between the Inventory and Toolbox lists, we considered 439 measures for inclusion. After applying review and exclusion criteria, 28 measures remained for analysis (Figure 1 and Table 1). Twenty-two condition-specific measures were excluded despite either being on the Toolbox list or having unanimous support from the expert reviewers because NHAMCS lacked the required variables or sample size. These excluded condition-specific measures included 10 related to timing of an intervention (e.g., beta agonist within 30 minutes of arrival for asthma), three related to measurement of postvisit outcomes (e.g., wound repair infection rate), five because there is no variable that defines the numerator or denominator (e.g., local presence of an evidence-based guideline for bronchiolitis), two for insufficient observations to meet the prespecified power threshold (computed tomography [CT] scans to diagnose appendicitis and antibiotics for children with fever and sickle cell or neutropenia), and two for the need for reassessment data (pain score reduction within 60 minutes for long-bone fractures and improvement in asthma severity over the visit).

Main Analysis

We included 36,430 unweighted NHAMCS observations aged less than 18 years, corresponding to 179.0 million ED visits for children, of which 150.8 million (84.3%) were to general EDs and 28.1 million (15.7%) to pediatric EDs. A total of 3,097 unweighted EDs (2,981 general, 116 pediatric) were analyzed, with each ED contributing one data year. Sex, ethnicity, and triage severity were similar between general and pediatric EDs (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13489/full). A higher proportion of nonwhite, publicly insured, and younger children visited pediatric EDs. General EDs evaluated a higher proportion of children with injury.

General Measures. Compared with pediatric EDs, general EDs discharged and transferred a higher proportion of children, had shorter mean length of

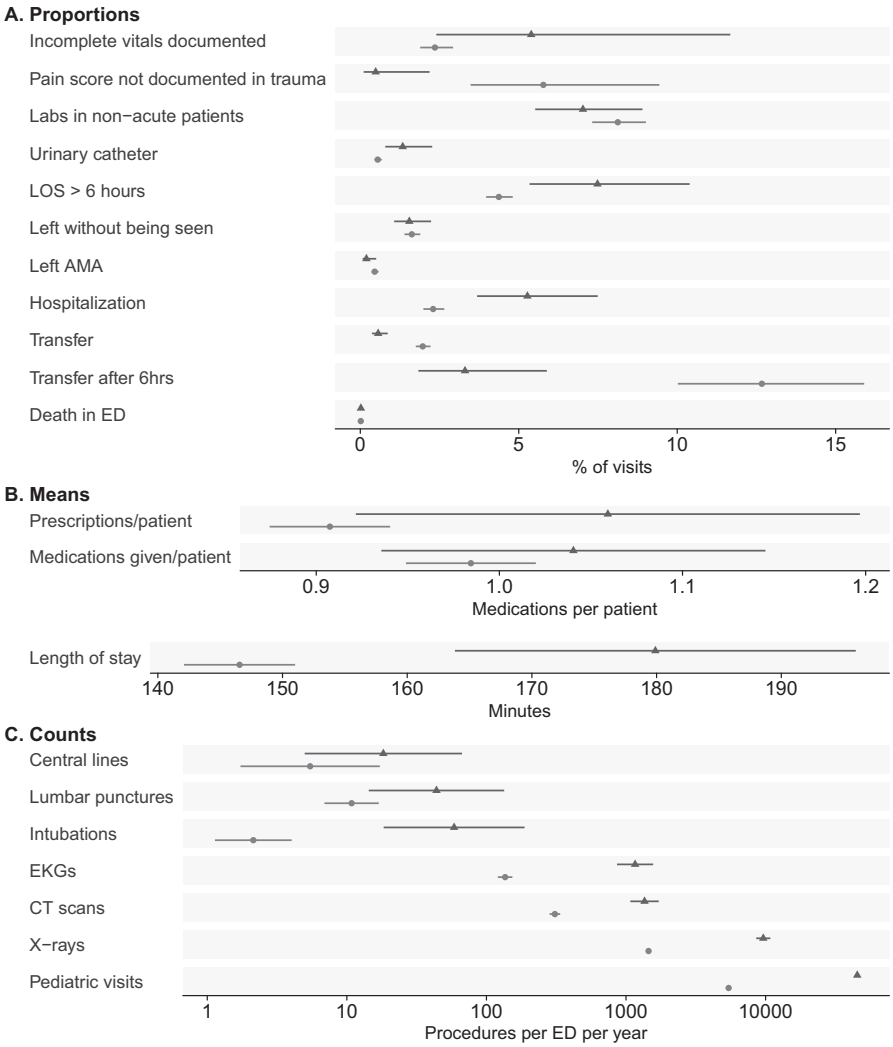

Figure 2. General quality measures included in the final quality report (*blue triangle* = pediatric EDs, *green circle* = general EDs). Point estimates and 95% CIs are shown. The statistical analysis utilized survey-weighted estimates and 95% CIs using (**A**) logistic regression for proportions, (**B**) linear regression for means, and (**C**) Poisson regression for counts. Counts were plotted on a logarithm scale. AMA = against medical advice; LOS = length of stay.

stay among all and discharged patients, and sent patients home with fewer prescriptions (Figure 2). General EDs obtained fewer pain scores for injured children. Pediatric EDs had a lower proportion of visits in which patients left against medical advice (pediatric vs. general EDs, –0.26%, 95% CI = –0.48 to –0.05). No differences were found between general and pediatric EDs in rates of mortality, the rate of patients leaving without being seen, incomplete vital signs, labs in nonacute patients, and numbers of medications given per patient.

Overall, the count measures revealed that pediatric ED experience with procedures was higher than in general EDs, with between 3.3 and 27.4 times the frequency by procedure for central lines and endotracheal intubations, respectively. Pediatric EDs performed significantly more CT scans, X-rays, electrocardiograms, endotracheal intubations, and lumbar punctures and had more pediatric visits per ED per year. ED experience with central lines was infrequent and statistically similar between ED types.

Condition-specific Measures. Condition-specific quality measure performance is shown in Figure 3. Pooled together, pediatric EDs had significantly higher performance on three of seven condition-specific quality measures, including a lower rate of antibiotic administration for viral infections (pediatric vs, general EDs, –6.2%, 95% CI = –10.9 to –1.5), fewer chest X-rays for asthma exacerbations (–18.7%, 95% CI –27.8 to –9.6), and use of topical anesthetics for suturing/stapling wounds (+25.7%, 95% CI = 7.7 to 43.8). No differences in performance between pediatric and general EDs was found for use of oral rehydration for

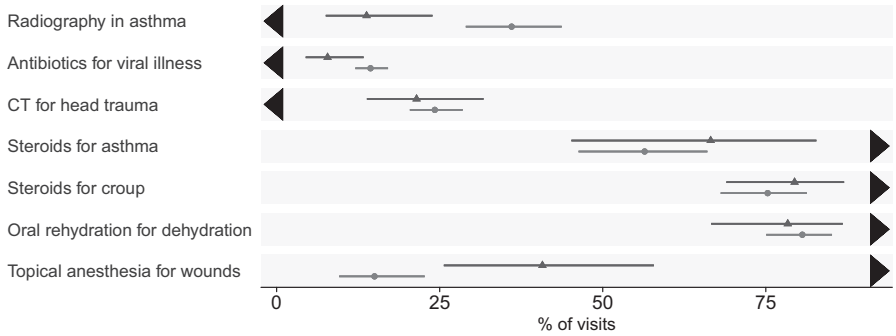

Figure 3. Condition-specific quality measures. Survey-weighted estimates and 95% CIs were calculated using logistic regression. *Arrows* point toward higher performance. Blue triangles denote pediatric EDs; green circles indicate general EDs.

dehydration (–3.5%, 95% CI = –12.5 to 5.6), corticosteroids for asthma exacerbations (+10%, 95% CI = –11.6 to 31.6), corticosteroids for croup (+4.1%, 95% CI = –7.2 to 15.5), and CT for head injury (–2.8%, 95% CI = –12.6 to 7).

DISCUSSION

In a national, representative sample of ED visits for children, we analyzed a spectrum of general and condition-specific quality measures and identified differences between general and pediatric EDs. Among general quality measures, children seen in pediatric EDs had longer lengths of stay, more frequent documentation of pain scores in trauma, higher rates of hospitalization, and higher numbers of prescriptions per patient. Pediatric EDs had lower rates of laboratory testing in nonacute patients. General EDs had higher rates of visits with complete vital signs and transfers. On a per-ED basis, pediatric EDs performed higher numbers of all procedures examined, with the exception of central lines in which there were too few to detect a difference. Among the condition-specific measures, pediatric EDs had higher performance for three measures: lower rates of x-ray utilization in asthma, higher rates of steroids for asthma, and lower rates of antibiotics prescribed for patients diagnosed with viral illness.

Our results have broad implications for clinicians and policymakers focused on providing high-quality emergency care to ill or injured children. First, our data demonstrate the feasibility of using nationally representative survey data for assessment of a wide range of emergency care quality measures across the U.S. health care system. Much of the prior literature on quality in pediatric emergency care has focused on pediatric-specific centers. Because nearly 90% of children seek care in general EDs, adopting quality benchmarks that can reasonably be applied in nonpediatric settings is critical.[11] In addition, this study provides a potential blueprint for the basic clinical data measurement that large health systems could leverage to measure systemwide care quality. Linkage of claims and pharmacy data could regionally or nationally could also allow for measurement of a number of the measures in this study. Second, our study has important implications for measuring quality related to critical care procedures; given the exceedingly low number of these procedures performed in general EDs, future efforts are needed to measure outcomes and ensure competency through ongoing training and simulation. Third, our results provide setting-specific normative data and benchmarks for important, common quality metrics. For instance, a general ED may compare its own pediatric length of stay to the national average general ED pediatric length of stay. Finally, we demonstrate that significant variability continues to exist on important quality measures between pediatric and general EDs in the care of children.

While the purpose of this analysis was not to analyze all condition-specific quality in pediatric emergency care, it did demonstrate significant differences between pediatric and general EDs. General and pediatric EDs had comparable rates of use of oral rehydration for dehydration and CT scan utilization for head injuries. However, pediatric EDs had higher performance across three measures: higher use of steroids and lower chest radiography rates in asthma, and lower rates of antibiotic prescribing in upper respiratory tract infections. These findings are consistent with prior studies that showed rates of radiology studies for children being inversely proportional to pediatric volume[12] and prescribers in pediatric EDs being likely to prescribe systemic corticosteroids in asthma and less

likely to utilize radiography.[13,14] Other differences in care have been documented for pediatric respiratory illnesses, utilization of CT for minor head trauma, and availability of pediatric staffing and equipment.[5,7,12,13,15–18] While important, when measured individually, these components of care quality do not provide a comprehensive view of pediatric emergency care. Such a view would encompass multiple conditions, safety, staffing, equipment, and protocols. Taken together, our findings and those of the prior literature highlight the need for continued measurement, education, and quality improvement to standardize the care that children receive regardless of ED type.

Prior work has shown that pediatric EDs care for a higher proportion of medically complex children, children with technology dependence, and children presenting with medical problems, whereas general EDs care for a higher proportion of children with injuries.[6,11,19,20] These differences in complexity and diagnosis may be responsible, in part, for some of the differences we observed across general quality measures such as longer length of stay and higher hospitalization rates. Medically complex children and children with noninjury complaints are more likely to require longer ED workups, hospitalization, and prescriptions; yet, prescriptions per patient were higher in general EDs. Furthermore, definitive care for many pediatric problems has become increasingly regionalized.[20,21] As fewer general EDs are part of centers with pediatric inpatient or subspecialty care, transfers have become increasingly necessary, resulting in both sicker children and children more likely to require hospital admission being evaluated in pediatric EDs.[22] This may be the cause of the higher rates of transfer we observed at general EDs compared to pediatric EDs.

We found significant differences in ED experience with pediatric examinations and procedures including electrocardiogram (ECG), x-rays, CT scans, lumbar punctures, and endotracheal intubations. Simple counts are useful experience measures, as there is evidence that procedural volume is a key component of quality.[23,24] The utilization and interpretation of diagnostic studies such as ECGs, x-rays, and CT scans vary by patient age. Clinicians caring for acutely ill and injured children must understand the indications, and interpretation of these diagnostic studies in children, which may be aided by experience.[25] Prior evidence also suggests that higher-volume of CT scans is associated with reductions in radiation.[26,27] Perhaps most importantly, we identified a nearly 10-fold difference in rates of critical care procedures including endotracheal intubations. A minimum level of experience with performing these critical care procedures is likely needed to gain competency and mastery.[23,24] While clinicians at general EDs may have more overall experience with many of the critical-care procedures in adults, it is not known how those skills transfer to successful performance in children.

We analyzed only 6% of the Inventory and Toolbox measures.[3,4] The list of 405 Inventory measures was meant to be highly inclusive, meaning many measures were duplicative or vague or had disagreement about whether they were valuable, as reflected by the lack of consensus from our expert panel. As a starting point for measuring pediatric emergency care quality, we favor the 60 Toolbox measures, which have higher face validity and consensus support. Even among these, many could not be measured in NHAMCS data because they were ED-level characteristics (such as the presence of specific personnel, equipment, or guidelines).

Our study must be interpreted in the context of its limitations. First, although NHAMCS data are representative, data are heavily extrapolated, leading to high uncertainty around effect estimates. Additionally, without detailed clinical information, we cannot know if unmeasured clinical patient differences account for observed differences in the quality measures we evaluated. Another effect of this uncertainty was that we were able to report accurate estimates of central tendency, but not of variation or time trends between departments, which would help EDs interpret their own performance.[28] Second, while we chose a set of important quality measures based on predefined criteria, we were also constrained by the data available in NHAMCS. This limited set cannot present a complete picture of the quality of care provided for children in either pediatric or general EDs. Among the 60 Toolbox measures, 15 are designated as having special priority, and we were able to report on only four. This highlights the difficulty in measuring quality with readily available national data sources. However, instead of waiting for the development of more robust data, we believe that useful quality measurement can start with measures for which the data are already widely available. Although available data will vary between systems, we believe that targeting measures that are ascertainable with available data makes sense as a starting point.

CONCLUSION

Using one nationally representative set of sample ED visits we demonstrated the feasibility of using national data to measure important aspects of clinical quality for children cared for in the ED. Differences in care between general and pediatric EDs exist and require further research to understand and target improvement.

We thank Drs. Catherine Perron and Andrew Fine for their thoughtful review of the initial list of condition-specific quality measures.

References

1. Macias CG. Quality improvement in pediatric emergency medicine. Acad Pediatr 2013;13:S61–8.
2. Committee on the Future of Emergency Care in the United States Health System. Emergency Care for Children: Growing Pains. Washington, DC: National Academies Press, 2007.
3. Alessandrini E, Varadarajan K, Alpern ER, et al. Emergency department quality: an analysis of existing pediatric measures. Acad Emerg Med 2011;18:519–26.
4. Pediatric Emergency Care Applied Research Network. Emergency Department Pediatric Performance Measures Toolbox. 2015. Available from: https://emscimprovement.center/resources/toolboxes/emergency-department-pediatric-performance-measures-toolbox/. Accessed Mar 16, 2018.
5. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527.
6. Hudgins JD, Monuteaux MC, Bourgeois FT, et al. Complexity and severity of pediatric patients treated at United States emergency departments. J Pediatr 2017;186: 145–9.e1.
7. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. J Pediatr 2018;194: 225–32.e1.
8. Centers for Disease Control and Prevention. NAMCS/NHAMCS - About the Ambulatory Health Care Surveys. 2017. Available at: https://www.cdc.gov/nchs/ahcd/about_ahcd.htm. Accessed May 16, 2018.
9. Goyal MK, Kuppermann N, Cleary SD, Teach SJ, Chamberlain JM. Racial disparities in pain management of children with appendicitis in emergency departments. JAMA Pediatr 2015;169:1–7.
10. Michelson KA, Hudgins JD, Monuteaux MC, Bachur RG, Finkelstein JA. Cardiac arrest survival in pediatric and general emergency departments. Pediatrics 2018;141.
11. Bourgeois FT, Shannon MW. Emergency care for children in pediatric and general emergency departments. Pediatr Emerg Care 2007;23:94–102.
12. Marin JR, Weaver MD, Barnato AE, Yabes JG, Yealy DM, Roberts MS. Variation in emergency department head computed tomography use for pediatric head trauma. Acad Emerg Med 2014;21:987–95.
13. Bekmezian A, Hersh AL, Maselli JH, Cabana MD. Pediatric emergency departments are more likely than general emergency departments to treat asthma exacerbation with systemic corticosteroids. J Asthma 2011;48:69–74.
14. Knapp JF, Simon SD, Sharma V. Variation and trends in ED use of radiographs for asthma, bronchiolitis, and croup in children. Pediatrics 2013;132:245–52.
15. Chamberlain JM, Teach SJ, Hayes KL, Badolato G, Goyal MK. Practice pattern variation in the care of children with acute asthma. Acad Emerg Med 2016;23:166–70.
16. Knapp JF, Simon SD, Sharma V. Quality of care for common pediatric respiratory illnesses in United States emergency departments: analysis of 2005 National Hospital Ambulatory Medical Care Survey data. Pediatrics 2008;122:1165–70.
17. Principi T, Coates AL, Parkin PC, Stephens D, DaSilva Z, Schuh S. Effect of oxygen desaturations on subsequent medical visits in infants discharged from the emergency department with bronchiolitis. JAMA Pediatr 2016;170:602.
18. Bressan S, Romanato S, Mion T, Zanconato S, Da Dalt L. Implementation of adapted PECARN decision rule for children with minor head injury in the pediatric emergency department. Acad Emerg Med 2012;19:801–7.
19. Murtagh Kurowski E, Byczkowski T, Grupp-Phelan JM. Comparison of emergency care delivered to children and young adults with complex chronic conditions between pediatric and general emergency departments. Acad Emerg Med 2014;21:778–84.
20. França UL, McManus ML. Availability of definitive hospital care for children. JAMA Pediatr 2017;171:e171096.
21. França UL, McManus ML. Trends in regionalization of hospital care for common pediatric conditions. Pediatrics 2018;141:e20171940.
22. Li J, Monuteaux MC, Bachur RG. Interfacility transfers of noncritically ill children to academic pediatric emergency departments. Pediatrics 2012;130:83–92.
23. Wang HE, Balasubramani GK, Cook LJ, Lave JR, Yealy DM. Out-of-hospital endotracheal intubation experience and patient outcomes. Ann Emerg Med 2010;55(527–537):e6.
24. Konrad C, Schüpfer G, Wietlisbach M, Gerber H. Learning manual skills in anesthesiology: is there a recommended number of cases for anesthetic procedures? Anesth Analg 1998;86:635–9.

25. Shrader MW, Campbell MD, Jacofsky DJ. Accuracy of emergency room physicians' interpretation of elbow fractures in children. Orthopedics 2008;31.
26. Hill KD, Frush DP. Image Gently Have-A-Heart Campaign. J Am Coll Radiol 2018;15:372–3.
27. Agarwal S, Jokerst C, Siegel MJ, Hildebolt C. Pediatric emergency CT scans at a children's hospital and at community hospitals: radiation technical factors are an important source of radiation exposure. AJR Am J Roentgenol 2015;205:409–13.
28. Mannix R, Meehan WP, Monuteaux MC, Bachur RG. Computed tomography for minor head injury: variation and trends in major United States pediatric emergency departments. J Pediatr 2012;160: 136–139.e1.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13489/full

Data Supplement S1. Demographic characteristics of children visiting emergency departments, 2010-2015.

Pediatric Emergency Research Canada (PERC): Patient/Family-informed Research Priorities for Pediatric Emergency Medicine

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ABSTRACT

Background: A growing body of literature supports patient and public involvement in the design, prioritization, and dissemination of research and evidence-based medicine. The objectives of this project were to engage patients and families in developing a prioritized list of research topics for pediatric emergency medicine (PEM) and to compare results with prior research prioritization initiatives in the emergency department (ED) setting.

Methods: We utilized a systematic process to combine administrative data on frequency of patient presentations to the ED with multiple stakeholder input including an initial stakeholder survey followed by a modified Delphi consensus methodology consisting of two Web-based surveys and a face-to-face meeting.

Results: The prioritization process resulted in a ranked list of 15 research priorities. The top five priorities were mental health presentations, pain and sedation, practice tools, quality of care delivery, and resource utilization. Mental health, pain and sedation, clinical prediction rules, respiratory illnesses/wheeze, patient safety/medication error, and sepsis were identified as shared priorities with prior initiatives. Topics identified in our process that were not identified in prior work included resource utilization, ED communication, antibiotic stewardship, and patient/family adherence with recommendations.

Conclusions: This work identifies key priorities for research in PEM. Comparing our results with prior initiatives in the ED setting identified shared research priorities and opportunities for collaboration among PEM research networks. This work in particular makes an important contribution to the existing literature by including the patient/family perspective missing from prior work.

A growing body of literature supports patient and public involvement in the design, prioritization, and dissemination of research and evidence-based medicine.[1–7] This is particularly important in research involving children due to the necessary involvement of parents in providing informed consent and participating in the research.[8] The Patient-Centered Outcomes Research Institute (PCORI) defines patient engagement in research as "the meaningful involvement of patients, caregivers, clinicians, and other healthcare

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stakeholders throughout the research process—from topic selection through design and conduct of research to dissemination of results" (https://www.pcori.org/engagement/what-we-mean-engagement).

The objective of this project was to engage patients and families in developing a prioritized list of research topics for pediatric emergency medicine (PEM). A secondary objective was to compare results with prior research prioritization initiatives in the emergency department (ED) setting.[7,9,10] PEM is the branch of medicine concerned with providing acute health care to children, which may include triage, stabilization, diagnosis, treatment, and appropriate follow-up care. In 1995 Canadian PEM physicians created a research network called Pediatric Emergency Research Canada (PERC; http://www.perc-canada.ca/), which brought together tertiary pediatric emergency care institutions throughout Canada to conduct research designed to improve the health of children.[11,12] Similar research networks in the United States (Pediatric Emergency Care Applied Research Network [PECARN]), the United Kingdom (Pediatric Emergency Research in the UK and Ireland [PERUKI]), and Australia and New Zealand (Paediatric Research in Emergency Department International Collaborative [PREDICT]) have published consensus-based research priorities for their networks.[9,10,13] However, these processes focused on clinicians, investigators, and administrators and they did not include patients or families. Thus, our project focused specifically on engaging patients and families in the prioritization process to ensure that patients' and families' views are included in the selection of research topics.[1]

METHODS

We utilized a systematic two-phase process including data collection and a stakeholder survey followed by a modified Delphi consensus methodology[14] consisting of two Web-based surveys and a face-to-face meeting. The modified Delphi method has been used in prior research priority setting initiatives in pediatrics, emergency medicine, and PEM.[9,15,16] Ethics approval was obtained from the Conjoint Health Research Ethics Board of the University of Calgary.

Phase 1: Topic Generation

The objective of Phase 1 was to generate an extensive list of potential research topics for prioritization.

Data Collection. To ensure that the topics reflected the frequency and severity of disease burden and gaps in care, we invited all 15 PERC sites to provide data on the 50 most common chief complaints, admission, and discharge diagnoses, along with deidentified patient complaints and morbidity and mortality round topics. The results of this data collection was combined with topics identified in prior research priority setting initiatives from other pediatric emergency research networks[9,10] to create an initial list of potential topics. We then convened an advisory panel of stakeholders which included parents of children who had received emergency care, emergency physicians, nurses, administrators, educators, and trainees from across Canada ($n = 107$). The parent participants were identified through established patient and parent advisory and engagement groups including: the Patient and Community Engagement Research (PACER; $n = 3$) and the Alberta Children's Hospital Patient and Family Care Center (PFCC; $n = 2$) groups in Calgary; the TRanslating Emergency Knowledge for Kids (TREKK) parent advisory group ($n = 2$) in Winnipeg; the Pediatric Patient Advisory Group (PedPAG) at the University of Alberta ($n = 2$) in Edmonton; and parents participating in the Strengthening Transitions in Care program ($n = 2$) at Dalhousie University.

Survey 1. Utilizing a Web-based survey, participants were asked to rate the degree to which they agree that each topic is a priority for multicenter research in the PERC network. A 5-point Likert scale was used (1 = disagree strongly, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = agree strongly) and participants were also asked to suggest topics that were not included in the original list. It was decided a priori that all topics rated "agree" or "agree strongly" by 70% or more of the respondents would be retained for discussion at the face-to-face meeting. Indeterminate topics (rated 4 or 5 by >50% and < 70% of respondents) and any new topics suggested by respondents of the Phase 1 survey were retained for Phase 2.

Phase 2: Topic Refinement and Prioritization

The objective of Phase 2 was to refine and prioritize the potential research topics. Phase 2 consisted of two further Web-based surveys and a face-to-face meeting of a stakeholder panel. The stakeholder panel consisted of parents ($n = 6$) who had attended a pediatric emergency department with their child/children, the

PERC site lead or designate from each of our 15 PERC sites (including physicians and nurses) and two PERC researchers with experience in patient and family engagement. The parent representatives were purposively sampled from those who participated in Phase 1 to achieve balanced geographic and gender representation.

Survey 2. At the outset of Phase 2 we sent out a second Web-based survey where the stakeholder panel rated the indeterminate (topics rated 4 or 5 by >50% and <70% of respondents) and new topics suggested by respondents from Phase 1, using the same 5-point Likert scale. Similar to the Phase 1 survey all topics that were rated 4 ("agree") or 5 ("strongly agree") by ≥70% of respondents were retained for discussion at the face-to-face meeting.

Face-to-Face Meeting. A face-to-face meeting was held on February 1, 2017, in Banff, Alberta. The meeting was held in conjunction with the PERC Annual Scientific Meeting and parents were invited to attend the entirety of the PERC meeting. The in-person meeting was led by an experienced facilitator using the nominal group technique, an established consensus methodology that has been used in similar prioritization exercises.[10,15] Prior to the meeting, participants were provided with the data collected in Phase 1 (entrance complaints, admission and discharge diagnoses from all sites), a summary of the group ratings for each topic from the premeeting survey, and their individual responses to the survey. The discussion at the meeting was framed in terms of: 1) the potential impact of the research topic (i.e., impact on morbidity, mortality, and health resource utilization); 2) the feasibility of conducting research on the topic in a multicenter research network and; and 3) the degree to which the topic requires knowledge generation versus knowledge translation. Participants discussed each of the topics and were able to clarify meaning/rephrase topics and suggest new topics.

Survey 3. Upon completion of the face-to-face meeting the stakeholder group completed a third, and final, Web-based survey to rate the topics discussed and new topics identified at the meeting using the same 5-point Likert scale. The final list of priorities consisted of those rated 4 ("agree") or 5 ("strongly agree") by 70% of respondents in the third survey.

RESULTS

Project phases and the results of data collection and surveys are outlined in Figure 1

Phase 1: Topic Generation

Data Collection. A total of 12 PERC sites (80%, $n = 15$) contributed data on entrance complaints, admission and discharge diagnoses, deidentified patient complaints (complaints about care received in the ED submitted by patients and families), and morbidity and mortality round topics. Based on the International Statistical Classification of Disease (ICD) nomenclature conditions were combined and the top 50 entrance complaints and admission and discharge diagnoses were retained (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13493/full). These data were combined with the deidentified patient complaints and morbidity and mortality round topics and existing topics from prior research prioritization initiatives.[9,10] After consolidation of data sources and removal of duplicates by the research team, 85 potential research topics were retained (Data Supplement S2, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13493/full) for Survey 1.

Survey 1: Stakeholder Survey. The first online survey of potential research topics had an 86% response rate (92/107). From this survey, a total of 64 topics were identified for further consideration. Sixteen topics were rated 4 or 5 by 70% of the respondents and immediately retained for discussion at the face to face meeting (topics ranked 1 to 16 in Table 1). Thirty-five topics were retained from the initial list of 85 (rated 4 or 5 by at least 50% of the respondents) and 13 new topics/conditions were identified by participants (see Table 1), leaving 48 topics for the Phase 2 survey.

Phase 2: Topic Refinement and Prioritization

Survey 2. During Phase 2 of the priority setting process the stakeholder panel ($n = 23$) participated in a second online survey to rate the 48 topics from the Phase 1 online survey. There was a 100% response rate (23/23) with 19 topics rated 4 or 5 by 70% or more respondents and 15 new topics identified for a

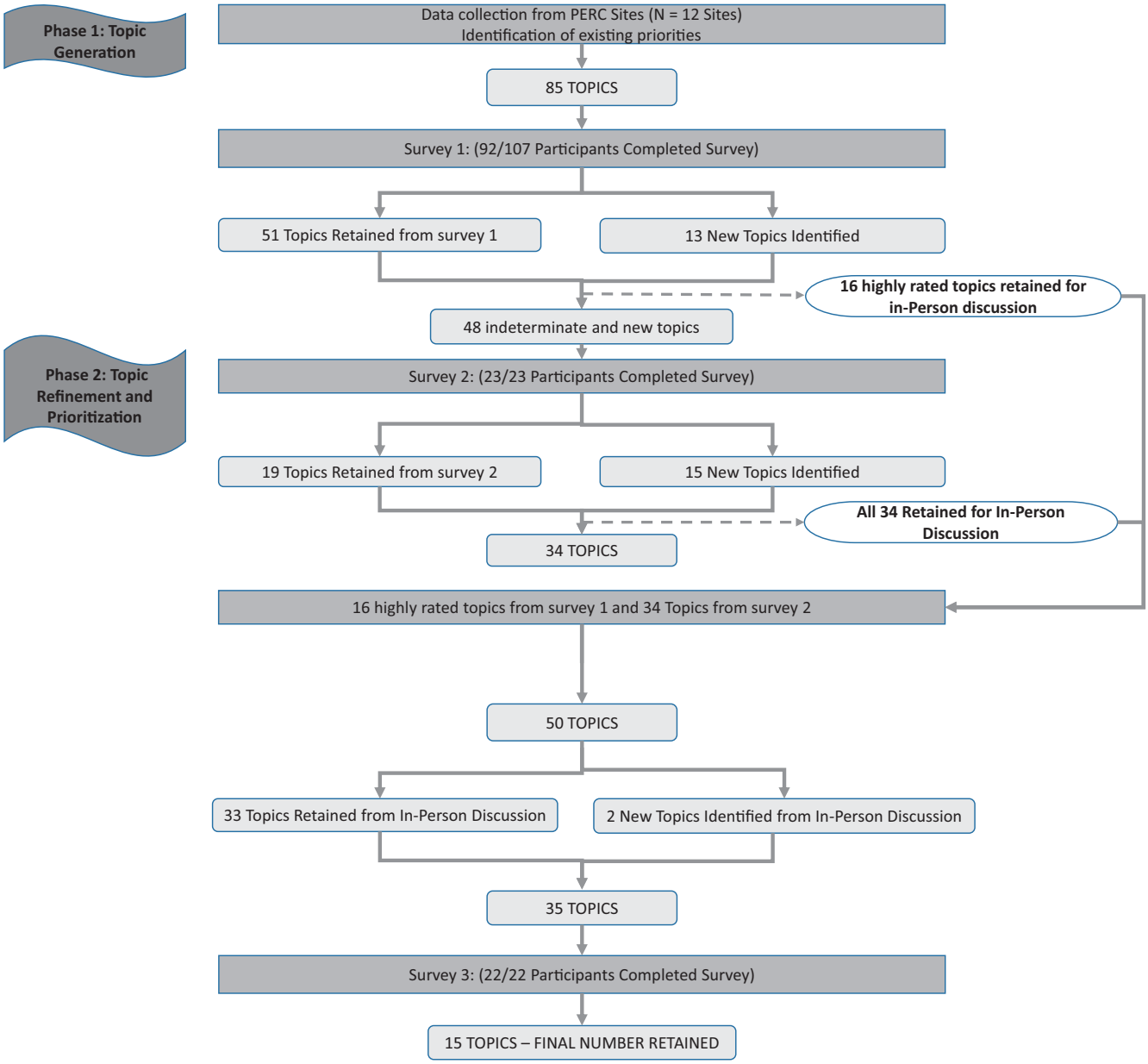

Figure 1. Project phases and the results of data collection and surveys. Note: All topics that were rated "agree" or "agree strongly" by 70% or more of the respondents were retained for discussion at the face-to-face meeting, indeterminate topics (rated 4 or 5 by >50% and <70% of respondents), and new topics suggested by respondents were retained for the next phase. PERC = Pediatric Emergency Research Canada.

total of 34 topics retained for discussion at the face-to-face meeting (Table 2).

Face-to-Face Meeting. A total of 50 topics were discussed at the face-to-face meeting, including 16 highly rated topics retained from Survey 1 and 34 topics from Survey 2. A total of 22 individuals attended the in person meeting, including 14 PERC site leads, two PhD health researchers, and six parents. One clinician from the original stakeholder group was unable to attend the face-to-face meeting. Each of the 50 topics were discussed by the group to ensure a common understanding of each condition and eliminate any redundancies and/or combine topics. At the conclusion of this meeting there were a total of 35 topics. The participants combined the 50 initial topics into 33 and identified two new topics (Table 3).

Survey 3. Five days after the face-to-face meeting the participants were asked to complete a third and final online survey to rate the remaining 35 topics. The final survey had a 100% response rate (22/22) with 15 topics rated 4 or 5 by 70% of the participants

Table 1
Topics Retained From Phase 1 Online Survey

Rank	Topic	% Agree/ Strongly Agree
1	Sepsis/toxic shock syndrome	87
2	Analgesia and sedation	83
3	Concussion	82
4	Safety incidents: events or complications that threatened the safety of patients	80
5	Errors in diagnosis (erroneous, missed, or slow clinical diagnosis)	79
6	Adequacy of resuscitation	78
7	Migraine	77
8	Asthma/status asthmatics	76
9	Discharge planning (referrals, follow-up, discharge instructions)	75
10	Treatment algorithms/practice protocols	74
11	Medication safety/errors	72
12	Communication breakdown (handover between ED staff or staff and patients)	72
13	Practice protocols	72
14	Allergic reaction	71
15	Suicidal ideation/gesture	71
16	Appendicitis	70
17	Delays: delays in admissions or access to treatment	68
18	Prediction rules for high-stakes/low-likelihood diseases	68
19	Major/multiple trauma	68
20	Wheezing/bronchiolitis	67
21	Quality of care: substandard clinical/nursing care	67
22	Pneumonia	65
23	C-spine/back trauma	64
24	Diabetic ketoacidosis	64
25	Cardiac arrest	61
26	Goals of care and resuscitation	60
27	Upper/lower extremity injury/fracture	59
28	Urinary tract infection	59
29	Influenza	58
30	Left without being seen/left against medical advice	58
31	Patient/family expectations (i.e., regarding wait times, admission decisions, test/CT scan ordering)	57
32	Intussusception	57
33	Skin infections/cellulitis/abscess	55
34	Fever	55
35	Neonatal sepsis	55
36	Traumatic intracranial injury (subdural, epidural, subarachnoid)	55
37	Toxic ingestion/poisoning	54
38	Education/training outcomes	53
39	Nonaccidental injury	53
40	Dehydration	53
41	Meningitis/encephalitis	52
42	Depression	52
43	Abdominal pain	52
44	Seizure	51
45	Gastroenteritis (vomiting/diarrhea)	50
46	Respiratory failure	50
47	Cardiac arrhythmia	50

(Continued)

Table 1 (continued)

Rank	Topic	% Agree/ Strongly Agree
48	Myocarditis	50
49	Urgency and acuity scaling	50
50	Burns	50
51	Sickle cell disease	50
New topics identified in Survey 1	Team performance in resuscitation	NA
	Human factors research in PEM	
	Impact of new technology on provider/team performance	
	Orbital cellulitis	
	Role of ED care in mental health care/system	
	Role of point of care ultrasound in PEM	
	ED crowding /flow/efficiency	
	Simulation research	
	Nature of complaints in the ED	
	Patient/family perceptions/experience of ED care	
	Patient/family adherence/compliance with treatment recommendations	
	Impact of parenting culture on ED care	
	Role of social media in health/ED care	

PEM = pediatric emergency medicine.

(Table 4). These 15 topics were identified as the top research priorities for PEM. The top five priorities included mental health presentations, pain and sedation, practice tools, quality of care delivery, and resource utilization.

Comparison With Prior Research Priorities

Table 5 shows the topics and rankings from this process compared to prior research priority setting initiatives in the ED setting.[7,9,10,13]

DISCUSSION

We used a systematic process to combine data on patient presentations with multiple stakeholder input to identify research priorities in PEM. In contrast to prior research priority setting initiatives in PEM[9,10,13] we included parents in the prioritization and used a data-driven process. The top five priorities included mental health presentations, pain and sedation, practice tools, quality of care delivery, and resource utilization.

When comparing our results with prior initiatives in PEM[9,10,13] there is some alignment in research topics. For example, pain and sedation, respiratory illnesses/wheeze, patient safety/medication error, and sepsis were identified as priorities in our work and prior publications.[9,10,13] Major/multisystem trauma were also priorities identified in our work and in the UK and Ireland and Australia and New Zealand.[9,13] Similarly, practice tools and quality of care/best practices in care delivery were also prioritized by the PECARN.[10] These overlapping priorities highlight the need for research in these areas, as well as the potential for collaboration between research networks.

Another recently published prioritization process in the ED setting[7] that included patients/families was not specific to PEM so it is difficult to directly compare results. Many of the identified priorities were focused on the frail elderly, end-of-life care, and adult-specific conditions such as chest pain. However, there was some notable overlap with our work, including the high ranking of mental health presentations. Clearly mental health, which was identified and highly ranked in our work, the prior process that included patients/parents,[7] and in one of the prior PEM initiatives,[10] is a priority for multiple stakeholders. Other areas of overlap with the EM priority-setting partnership included trauma, clinical prediction rules, and sepsis,[10] further highlighting the importance of these research areas.

A key finding from our work is the priorities we identified that were lacking from prior initiatives in PEM that did not include the patient/parent perspective.[9,10,13] These topics include resource utilization, ED communication, antibiotic stewardship, and patient/

Table 2
Topics Retained From Survey 2

Rank	Topic	% Agree/ Strongly Agree
1	Wheezing/bronchiolitis	83
2	Prediction rules for high-stakes/low-likelihood diseases	83
3	Quality of care: substandard clinical/nursing care	83
4	Pneumonia	78
5	C-spine/back trauma	78
6	Delays in admissions or access to treatment	78
7	Role of ED care in mental health care/system	78
8	Role of point-of-care ultrasound in PEM	78
9	Patient/family adherence /compliance with treatment recommendations	78
10	Gastroenteritis (vomiting/diarrhea)	77
11	Traumatic intracranial injury (subdural, epidural, subarachnoid)	74
12	Major/multiple trauma	74
13	Patient/family perceptions/experience of ED care	74
14	Depression	70
15	Neonatal sepsis	70
16	Patient/family expectations (wait times, admission decisions, test/CT scan orders)	70
17	Impact of new technology on provider/team performance	70
18	ED crowding/flow/efficiency	70
19	Nonaccidental injury	70
New topics identified in Survey 2	More help and research in dealing with chronic pain/mental health—currently they seem to be treated as separate issues	NA
	Opioid and nonopioid use in the ED and after discharge. We are in opioid crisis in Canada, why not have PERC be at the forefront of solutions and approach?	
	Headache management (migraine, posttraumatic, etc.; abortive, acute, subacute, chronic, etc.)	
	Tranexamic acid in major trauma	
	Return to play and discharge instructions in concussion	
	Acute pain assessment and management	
	Streptococcal pharyngitis and complications (current epidemiology and optimal diagnostic/treatment strategies)	
	Resource use—the appropriate use of investigations and treatments (i.e., imaging, antibiotics)	
	Impact of communication from pre-hospital providers on ED care	
	Parent education on disease natural history and their role in treatment	
	Immunization and barriers associated with increased reluctance or nonimmunized	
	Barriers or adaptations to care within ED for oral averse children with G/NG-tubes	
	How families/parents make decision to bring child to ED	
	Arthritis	
	Community engagement in health service research in PEM	

PEM = pediatric emergency medicine; PERC = Pediatric Emergency Research Canada.

family adherence with recommendations. The inclusion of parents in this process enabled a rich dialogue about the context and importance of these topics from a health care user's point of view. Similarly, the health care providers were able to provide the parents with insight into the clinical context. Prior work has highlighted that including the patient perspective results in key contributions, including making the patient and caregiver perspectives explicit, and can change the focus of research and result in changes to outcomes, goals, and improvement of measurement tools.[3,17] One of the new topics identified in Survey 2 was community engagement in health services research. At the face-to-face meeting there was unanimous agreement among panel participants that this was not a research priority as such, but instead should be a guiding principle for all research conducted in PEM.

This process resulted in a number of key lessons about community engagement in research. First, given the complexity of the medical context, including

Table 3
Topics Retained from Face-to-Face Meeting

Topics retained
Sepsis
Pain and sedation
Concussion (including return to play and discharge instructions)
Patient safety
Cardiopulmonary resuscitation
Migraine
Asthma
Discharge process (e.g., referrals, follow-up, discharge instructions)
Practice tools (e.g., clinical practice guidelines, order sets, protocols, algorithms)
ED communication (e.g., health care provider/health care provider, staff/patients)
Allergic reaction
Mental health presentations
Appendicitis
Bronchiolitis/preschool wheeze
Clinical prediction rules (high-stakes/low-likelihood diseases)
Quality of care delivery
Pneumonia
C-spine/back trauma
Timely access to care
Point-of-care ultrasound (POCUS)
Patient/family adherence with recommendations
Gastroenteritis (vomiting and/or diarrhea)
Traumatic brain injury (TBI)
Major/multisystem trauma
Patient/family experience
Febrile young infants
Impact of new technology
ED crowding /flow/efficiency
Nonaccidental injury (e.g., neglect, abuse, assault)
Resource utilization
Immunization
How families/parents make decisions to bring child to ED
Community engagement research methodology
New topics identified
Health care provider safety and wellness
Antibiotic stewardship

terminology, and the importance of the patient/family perspective, a face-to-face meeting was a crucial component of this process. This aligns with prior work on including public involvement in setting a national research program in the United Kingdom, which reported that there was the most public input where contributions could be made in an open format.[3] Another key lesson was the importance of including more than one parent, to broaden the perspective provided and to increase the comfort level of the individual participants to provide their perspective. At the end of our face-to-face meeting one of the parent participants stated that they felt that this "had been a genuine and respectful experience." Prior work has also highlighted the importance of continuous and genuine partnerships, strategic selection of stakeholders, and accommodation of stakeholders' practical needs,[4] factors we also considered key to the success of our initiative.

This project had a number of important strengths, most importantly is the inclusion of the patient/parent perspective. Although there were proportionally few parents in the initial survey, we attempted to make sure their perspective was represented by including multiple parents at the face-to-face meeting and enabling participants to add new topics throughout the process. We also had broad stakeholder representation in our initial topic generation phase, with the inclusion of nurses, physicians, administrators, educators, trainees, researchers, and parents. The high response rate to our surveys also contributes to the face validity and generalizability of our results. A final strength was the use of data to identify topics and perceived and unperceived needs. In comparison, prior work depended on brainstorming and expert opinion.[9,10]

LIMITATIONS

With respect to limitations, our process was intentionally focused on research that could be conducted in pediatric EDs, and as such our priorities may not reflect the research needs for all care settings where children are seen, such as prehospital care and care provided in community, rural, and general EDs. Similarly, the data upon which we based our priorities, and our stakeholders, were Canadian, which may limit the generalizability of our results. However, the overlap between our priorities and prior work in the United States, the United Kingdom, and Ireland indicates that many of these priorities are generalizable. As with any priority process, it is possible that individuals' responses reflect their own bias. For example, clinician scientists represented in this group may have been influenced by their own areas of research. However, we utilized a diverse group in identifying initial priorities and anonymous survey responses and required a majority to identify priorities to retain and the face-to-face discussions were

Table 4
Final Research Priorities

Rank	Condition	% Agree/ Strongly Agree
1	Mental health presentations	86
2	Pain and sedation	82
3	Practice tools (e.g., clinical practice guidelines, order sets, protocols, algorithms)	82
4	Quality of care delivery	82
5	Resource utilization (e.g., appropriate use of investigations and treatments)	82
6	Major/multisystem trauma	77
7	Clinical prediction rules (high-stakes/low-likelihood diseases)	77
8	ED communication (e.g., health care provider/health care provider, staff/patients)	77
9	Antibiotic stewardship	73
10	Bronchiolitis/preschool wheeze	73
11	Febrile young infants	73
12	Patient safety	73
13	Patient/family adherence with recommendations	73
14	Sepsis	73
15	Traumatic brain injury	73

Table 5
Comparison of Results With Recent Research Prioritization Initiatives in the ED Setting

Current Process Topic	Rank	Rank (topic)			
		Miller 2008[10]	Hartshorn 2015[9]	Smith 2017[7]	Deane 2018[13]
Mental health presentations	1	7 (mental health)		3 (mental health patients)	
Pain and sedation	2	10 (pain and anxiety management)	11 (procedural sedation), 15 (pain control)		11 (sedation)
Practice tools (e.g., clinical practice guidelines, order sets, protocols, algorithms)	3	12 (treatment algorithms), 14 (practice protocols)			
Quality of care delivery	4	9 (best practices in patient care)			
Resource utilization (e.g., appropriate use of investigations and treatments)	5				
Major/multisystem trauma	6		2 (major trauma), 5 (trauma patients with major hemorrhage), 16 (trauma networks), 20 (abdominal trauma)	10 (trauma patients)	13 (blunt trauma)
Clinical prediction rules (high-stakes/ low-likelihood diseases)	7	2 (prediction rules)	7 (atraumatic limp clinical decision rule), 8 (petechiae clinical decision rule)	6 (chest pain decision rules)	
ED communication (e.g., health care provider/health care provider, staff/patients)	8				
Antibiotic stewardship	9				
Bronchiolitis/ preschool wheeze	10	1 (respiratory illnesses/asthma)	4 (severe asthma), 17 (wheeze)		1, 3, 29 (asthma) 19 (bronchiolitis)
Febrile young infants	11				
Patient safety	12	3 (medication error reduction)	13 (patient safety issues)		30 (cognitive errors)
Patient/family adherence with recommendations	13				
Sepsis	14	8 (infectious diseases)	3 (septic shock), 13 (sepsis)	8 (severe sepsis)	8, 12, 16 (sepsis)
Traumatic brain injury	15		10 (head injury)		

facilitated by an experienced mediator to ensure all voices were heard.

CONCLUSION

This work identifies key priorities for research in pediatric emergency medicine. Comparing our results with prior initiatives in the ED setting identifies shared research priorities and opportunities for collaboration among pediatric emergency medicine research networks. This work in particular makes an important contribution to the existing literature by including the patient/family perspective missing from prior work. Our prioritized list will guide investigators and funding bodies in the development, planning, and funding of research to improve care and outcomes for ill and injured children. Future work will include continuing our partnership with patients and families to generate research questions, identify patient-centered outcomes, and codesign studies in these priority research areas.

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References

1. Gooberman-Hill R, Burston A, Clark E, et al. Involving patients in research: considering good practice. Musculoskeletal Care 2013;11:187–90.
2. Lander J, Hainz T, Hirschberg I, Strech D. Current practice of public involvement activities in biomedical research and innovation: a systematic qualitative review. PLoS One 2014;9:e113274.
3. Oliver S, Armes DG, Gyte G. Public involvement in setting a national research agenda: a mixed methods evaluation. Patient 2009;2:179–90.
4. Frank L, Forsythe L, Ellis L, et al. Conceptual and practical foundations of patient engagement in research at the patient-centered outcomes research institute. Qual Life Res 2015;24:1033–41.
5. Hirst E, Irving A, Goodacre S. Patient and public involvement in emergency care research. Emerg Med J 2016;33:665–70.
6. Partridge N, Scadding J. The James Lind Alliance: patients and clinicians should jointly identify their priorities for clinical trials. Lancet 2004;364:1923–4.
7. Smith J, Keating L, Flowerdew L, et al. An emergency medicine research priority setting partnership to establish the top 10 research priorities in emergency medicine. Emerg Med J 2017;34:454–6.
8. Zylke JW, Rivara FP, Bauchner H. Challenges to excellence in child health research: call for papers. JAMA 2012;308:1040–1.
9. Hartshorn S, O'Sullivan R, Maconochie IK, et al. Establishing the research priorities of paediatric emergency medicine clinicians in the UK and Ireland. Emerg Med J 2015;32:864–8.
10. Miller SZ, Rincon HKuppermann N. Pediatric Emergency Care Applied Research Network. Revisiting the emergency medicine services for children research agenda: priorities for multicenter research in pediatric emergency care. Acad Emerg Med 2008;15:377–83.
11. Bialy L, Plint A, Zemek R, et al. Pediatric Emergency Research Canada: origins and evolution. Pediatr Emerg Care 2018;34:138–44.
12. Kelsall D. Celebrating top achievements in health research 2011. CMAJ 2012;184:189–91.
13. Deane HC, Wilson CL, Babl FE, et al. PREDICT prioritisation study: establishing the research priorities of paediatric emergency medicine physicians in Australia and New Zealand. Emerg Med J 2018;35:39–45.
14. Jones J, Hunter D. Consensus methods for medical and health services research. BMJ 1995;311:376–80.
15. Plint AC, Stang AS, Calder LA. Priorities in Patient Safety Research in Emergency Medicine Consensus Panel. Establishing research priorities for patient safety in emergency medicine: a multidisciplinary consensus panel. Int J Emerg Med 2015;8:1.
16. Rudolph S, Hiscock H, Price A, et al. What research questions matter to Australian paediatricians? National Delphi Study. J Paediatr Child Health 2009;45:704–10.
17. Forsythe LP, Ellis LE, Edmundson L, et al. Patient and stakeholder engagement in the PCORI pilot projects: description and lessons learned. J Gen Intern Med 2016;31:13–21.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13493/full

Data Supplement S1. Top 50 entrance complaints and admission and discharge diagnoses.

Data Supplement S2. List of combined conditions.

Reliability of HEARTSMAP as a Tool for Evaluating Psychosocial Assessment Documentation Practices in Emergency Departments for Pediatric Mental Health Complaints

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Related articles appear on pages 1471 and 1473.

ABSTRACT

Objectives: The goal of this study was to assess the reliability of HEARTSMAP as a standardized tool for evaluating the quality of psychosocial assessment documentation of pediatric mental health (MH) presentations to the emergency department (ED). In addition, we report on current documentation practices.

Methods: We conducted a retrospective cross-sectional study of pediatric (up to age 17) MH-related visits to four EDs between April 1, 2013, and March 31, 2014. The primary outcome was the inter-rater agreement when evaluating the completeness of pediatric emergency psychosocial assessments using the HEARTSMAP tool. The secondary outcome was to describe the adequacy of documentation of emergency pediatric MH assessments, using HEARTSMAP as a guide for a complete assessment.

Results: A total of 400 medical records (100 from each site) were reviewed. We observed near-perfect inter-rater agreement (κ = 0.99–1.00) regarding the presence of documentation and good-to-perfect agreement (κ = 0.71–1.00) regarding whether sufficient information was documented to score a severity level for every component of an emergency psychosocial assessment. Inter-rater agreement regarding whether referrals or resources were documented for identified needs was observed to be good to very good (κ = 0.62–0.98). Current psychosocial documentation practices were found to be inconsistent with significant variability in the presence of documentation pertaining to HEARTSMAP sections between medical centers and initial clinician assessor and whether specialized MH services were involved prior to discharge.

Conclusions: The HEARTSMAP tool can be reliably used to assess pediatric psychosocial assessment documentation across a diverse range of EDs. Current documentation practices are variable and often inadequate, and the HEARTSMAP tool can aid in quality improvement initiatives to standardize and optimize care for the growing burden of pediatric mental illness.

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Mental illness represents a significant and growing health burden for children and adolescents globally.[1] Approximately one in every five youth currently suffer from a diagnosable mental illness in North America.[2,3] However, in the face of increasing shortages and mounting barriers,[4,5] only a fraction of these individuals are able to access adequate care in the community.[6–8] As a result, families are turning to emergency departments (EDs) for care, especially under crisis circumstances.[9,10] Indeed, the incidence of mental health (MH)-related visits to EDs has dramatically increased across North America over the past decade,[11–16] with this setting often serving as patients' first, and sometimes only, point of access for care.[6,17,18]

Emergency programs have not kept pace with the increasing demand for pediatric MH-related care due to insufficient funding, support, and training.[9,19,20] Many EDs are poorly equipped to manage MH complaints and often lack standardized assessment methods to guide clinical decision making.[19,21] As a result, EDs vary considerably in their MH care practices, most of which are not evidence based,[18] while expected assessments (i.e., physical abuse assessments for suspicious injuries or suicidality assessments for self-harm presentations) are often inadequate or entirely absent from ED medical records.[22–24] Furthermore, documentation of psychosocial assessments for MH-related presentations to the ED frequently contain gaps,[24–26] and given the concordance between documentation in medical records and actual clinical performance,[27,28] poor psychosocial documentation has significant clinical and medicolegal implications.[29]

The American Academy of Pediatrics and American College of Emergency Physicians have acknowledged these deficits and prioritized the expansion of resources and research to standardize and improve MH assessments in EDs.[5,19] In response, the HEARTSMAP tool, modified from the well known "HEADSS" mnemonic used for adolescent psychosocial history taking,[30] was designed and recently validated to support ED clinicians with the assessment, management, and documentation of children and youth presenting with MH concerns.[31] Specifically, the tool facilitates a comprehensive psychosocial evaluation and guides an appropriate disposition process by offering acuity-specific service recommendations for families. In addition, the tool generates a customized report that summarizes the clinical encounter and can be added directly to patients' medical records to satisfy documentation requirements.

The objectives of this study were to assess the reliability of HEARTSMAP as a standardized tool for evaluating psychosocial assessment documentation, as well as report on the completeness of current documentation practices, of pediatric MH-related presentations to a diverse range of EDs. Doing so will elicit critical information regarding current ED practices given the heterogeneity of care[18] and MH presentations[13,32] in children and youth associated with ED locale (e.g., urban vs. rural, general vs. pediatric ED) and aid in standardizing and optimizing future care for the growing burden of pediatric mental illness.

METHODS

Study Design

We conducted a retrospective cross-sectional study of pediatric MH-related visits to EDs between April 1, 2013, and March 31, 2014, at one pediatric center and three regional centers. We determined the interrater agreement in using HEARTSMAP as a standardized tool for evaluating the quality of current psychosocial documentation practices. Ethical approval was obtained from the University of British Columbia Clinical Research Ethics Board.

Study Setting and Population

We evaluated a random sample of pediatric MH-related ED visits at four medical centers from three health authorities in British Columbia, Canada. Two centers are regional tertiary care centers with general EDs from the same health authority that serve approximately 1,850 pediatric MH-related patients annually combined. The third center is a regional tertiary care center with a specialized pediatric ED that serves approximately 1,250 pediatric MH-related patients annually. The fourth center is an urban quaternary care and provincial pediatric referral center with a pediatric ED that serves approximately 1,000 pediatric MH-related patients annually.

The study population consisted of children and adolescents up to 17 years of age seeking care for a MH-related complaint at one of the study centers. The National Ambulatory Care Reporting System was used to identify MH-related ED visits through each local health authority according to the presenting complaint (Canadian Emergency Department Information

System codes) and/or discharge diagnosis (International Classification of Disease 10th Revision codes), which included terms related to MH disorders and their variations (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13506/full).[33] Visits whereby the patient left without being seen by the ED clinician or against medical advice, and those registering to the ED only to be directly admitted to psychiatry without an ED clinician assessment, were excluded. A simple random sample (using a random number generator from Microsoft Excel) of 400 records, 100 from each center, was included for review.

Study Protocol

The HEARTSMAP Tool. The HEARTSMAP tool is an online algorithmic instrument that supports clinicians in the collection of pertinent psychosocial information relating to 10 sections: Home, Education and activities, Alcohol and drugs, Relationships and bullying, Thoughts and anxiety, Safety, Sexual health, Mood and behavior, Abuse, and Professional resources (http://heartsmap.ca).[34] Specific question and scoring guidelines allow clinicians to assess the severity of a patient's condition on a scale of 0 to 3, scoring a 0 (no concern), 1 (mild), 2 (moderate), or 3 (severe) for each section of the HEARTSMAP tool. Clinicians also record whether each section of concern within the HEARTSMAP tool is currently being addressed, to assess the urgency or need for care.

Scores from each HEARTSMAP section map to one or more of the following domains: social, function, youth health, psychiatry, and abuse. Each domain is associated with recommendations for relevant services with several degrees of acuity based on a composite of sectional scores and what resources youth already have in place. Specific recommendations include psychiatric assessment, crisis response teams, social workers, youth health specialists, substance abuse/detoxification programs, or redirection to an established care team if applicable.

The HEARTSMAP tool has been validated[31] and found to be reliable when used among a diverse range of ED clinicians and settings, including at small community-based, rural/remote, large regional, and urban academic centers.[35] Furthermore, the tool has been implemented as the criterion standard at an urban quaternary care academic center, with experienced ED clinicians taking approximately 15 to 20 minutes to complete an assessment using it.

Data Abstraction and Evaluation. This retrospective chart review was conducted according to published standards.[36,37] Five reviewers completed extensive training in chart abstraction to a standardized online collection form created using the secure Research Electronic Data Capture (REDCap) Web application (https://projectredcap.org).[38] In addition, the senior principal investigator reviewed the first five entries completed by each reviewer to ensure quality of data abstraction. Documentation relevant to each section of the HEARTSMAP tool was abstracted verbatim, with care taken to avoid including any personal identifiers and allow for blinding, and with one minor variation: the thoughts and anxiety section was considered as two separate entities (i.e., thoughts *and* anxiety), for a total of 11 sections.

Two reviewers who did not perform the original data abstraction for a given medical record subsequently applied the HEARTSMAP tool to evaluate the abstracted psychosocial documentation. Reviewers were trained to use HEARTSMAP by using a sample of clinical vignettes and were monitored by the principal investigators. Reviewers first evaluated medical records for the 1) *presence* of any information explicitly documented pertaining to each section of HEARTSMAP (i.e., home environment for Home, school or activities outside of school for Education and activities, alcohol or drug use for Alcohol and drugs). If documentation for a section was present, then it was evaluated for whether 2) *sufficient* information from the clinical assessment was documented to score a severity level or not using HEARTSMAP. For example, Safety was considered scorable if there was documentation detailing no suicidal/homicidal ideations (0 = no concern), passive suicidal/homicidal ideations with no plan or intent (1 = mild), suicidal/homicidal plans that are unrealistic or unfeasible with nonlethal gestures (2 = moderate), or an active suicidal/homicidal attempt (3 = severe). If the available documentation was ambiguous or incomplete, despite being present, then it was considered insufficient to score a severity level. Finally, if information for a given section was present, then it was evaluated for whether 3) *referrals or resources* already accessed were explicitly documented if applicable (i.e., if a patient presenting with anxiety is followed by a primary care physician in the community). Interrater reliability was calculated, and subsequently,

discrepancies between reviewers were resolved by an independent third reviewer to allow for outcome measure calculations.

Outcome Measures

The primary outcome measure was the inter-rater agreement in reviewers' assessments of the documentation of pediatric emergency psychosocial assessments, for each section of HEARTSMAP with regard to 1) *presence* of documentation, 2) *sufficiency* of documented details to evaluate severity of concerns, and 3) documentation of *MH resources* in place for identified needs. Secondary outcome measures included the completeness of psychosocial assessment documentation as measured by the proportion of cases with adequate documentation for each HEARTSMAP section, stratified according to the medical center, type of initial clinician assessor (e.g., general ED physician, pediatric ED physician, resident physician, or psychiatric liaison), and involvement of specialized MH services (i.e., psychiatric liaison) in the ED prior to disposition.

Data Analysis

We used descriptive statistics to summarize patient demographics and visit characteristics. Patient age, as a continuous variable, is presented as a median and interquartile range. Patient sex, triage acuity level using the Canadian Triage and Acuity Scale (CTAS),[39] time of presentation, visit day of the week, presenting complaint, discharge diagnosis, and disposition (admitted vs. discharged) are presented with proportion percentages.

We reported the proportion of medical records with documentation present, sufficient to score, and with referrals or resources accessed for each HEARTSMAP section as percentages with 95% confidence intervals (CIs) and applied the chi-square test, and Fisher's exact test where appropriate, at significance level of <0.05 to compare between medical center, type of initial clinician assessor, and involvement of specialized MH services in the ED prior to disposition. No correction was included for multiple comparisons; therefore, results should be interpreted accordingly.

Data analyses were conducted using Stata 15/SE (StataCorp, College Station, TX). Kappa statistics were computed using Cohen's method to measure the inter-rater agreement among reviewers and presented with 95% CIs.[40] Inter-rater agreement was interpreted according to guidelines described by Altman to differentiate between poor ($\kappa \leq 0.20$), fair ($\kappa = 0.21$–0.40), moderate ($\kappa = 0.41$–0.60), good ($\kappa = 0.61$–0.80), and very good ($\kappa = 0.81$–1.00) agreement.[41] The sample size required to determine with 95% confidence and 5% precision that 50% (a conservative estimate that would require the largest sample size) of records would have documentation of all HEARTSMAP sections was estimated to be approximately 400 medical records in total.

RESULTS

We reviewed a total of 400 records, 100 from each medical center, using HEARTSMAP to standardize our evaluation. Patient demographics and visit characteristics are summarized in Table 1.

Inter-rater agreement across all 11 sections included for the HEARTSMAP tool is summarized in Table 2. We observed near perfect inter-rater agreement ($\kappa = 0.99$–1.00) regarding the presence of documentation and good to very good agreement regarding whether sufficient information was documented to score a severity level ($\kappa = 0.71$–1.00) and whether referrals or resources were documented for identified needs ($\kappa = 0.62$–0.98), for every HEARTSMAP section.

The overall proportion of ED psychosocial assessments with HEARTSMAP section documentation present and sufficient to assign a severity score, as well as those with documented resources in place for identified needs, are summarized and stratified by medical center (Table 3) and initial clinician assessor (Table 4) and whether specialized MH services were involved during a general ED visit prior to disposition (Table 5). Among medical centers, documentation presence was significantly variable for 10/11 sections ($p < 0.05$; Table 3). Overall, Safety was consistently the most well documented section with information present and sufficient to score a severity level for 95% (95% CI = 92%–96%) and 93% (95% CI = 90%–96%) of clinical assessments, respectively (Table 3). Sexual health and Abuse were the most poorly documented sections with information present for only 24% (95% CI = 20%–29%) and 31% (95% CI = 26%–35%) of clinical assessments, respectively. There was significant variability in the presence of documentation for each section among initial clinician assessors ($p < 0.001$; Table 4) and whether MH services were involved in the ED or not prior to disposition ($p < 0.04$; Table 5). Among initial clinician assessors, psychiatric liaisons had the highest proportion of

Table 1
Patient Demographics and Visit Characteristics (N = 400)

Demographics	Number (% or IQR)
Age (years), median (IQR); range	15 (14–16); 4–17
Female	269 (67.2)
Male	131 (32.8)
CTAS	
1	0 (0)
2	145 (36.2)
3	240 (60.0)
4	14 (3.5)
5	1 (0.3)
Day of arrival	
Weekday	308 (77.0)
Weekend	88 (22.0)
Holiday	4 (1.0)
Time of presentation	
00:00–07:59	46 (11.5)
08:00–15:59	165 (41.2)
16:00–23:59	189 (47.3)
Presenting complaint	
Suicidal/homicidal ideation	171 (42.8)
Mood or anxiety	66 (16.5)
Behavioral concern/aggression	51 (12.8)
Substance misuse/intoxication/overdose	40 (10.0)
Situational crisis (social issues)	20 (5.0)
Psychosis/hallucinations	16 (4.0)
Self-harm	15 (3.8)
Suicide attempt	10 (2.5)
Other diagnoses	9 (2.3)
None documented	2 (0.5)
Discharge diagnosis	
Mood or anxiety	110 (27.5)
Suicidal/homicidal ideation	78 (19.5)
Situational crisis (social issues)	58 (14.5)
Substance misuse/intoxication/overdose	44 (11.0)
Behavioral concern/aggression	40 (10.0)
None documented	21 (5.3)
Self-harm	18 (4.5)
Psychosis/hallucinations	14 (3.5)
Suicide attempt	8 (2.0)
Other	9 (2.3)
Disposition	
Discharged home	287 (71.7)
With documented discharge plan/recommendations	237 (82.6)
No discharge plan documented	50 (17.4)
Admitted	113 (28.3)
Psychiatry	99 (87.6)
Pediatrics	14 (12.4)

CTAS = Canadian Triage and Acuity Scale; IQR = interquartile range.

clinical documentation present and sufficient to score for 10/11 and 9/11 sections, respectively (Table 4). Furthermore, documentation was consistently more comprehensive when specialized MH services (i.e., psychiatric liaison) were involved in general EDs prior to patient disposition, with a higher proportion of clinical documentation present and sufficient to score for 11/11 and 10/11 sections, respectively (Table 5).

DISCUSSION

Standardizing and improving MH assessments in the ED is an active area of research, with evidence historically limited by methodologic shortcomings.[21] This study assessed the reliability and feasibility of using HEARTSMAP as a standardized tool for evaluating pediatric psychosocial assessment documentation in the ED to ultimately aid in quality improvement. Strong evidence was demonstrated for the tool's inter-rater reliability, with good to perfect agreement in evaluating the presence and sufficiency of documentation, as well as good to very good agreement in evaluating referral and resource documentation, pertaining to each HEARTSMAP section. Furthermore, the tool provides a practical framework with clearly delineated psychosocial domains (i.e., HEARTSMAP sections) and scoring guidelines to ensure a straightforward and reproducible approach in abstracting and evaluating clinical assessment documentation adequacy.

In applying HEARTSMAP, current documentation practices for pediatric MH-related presentations to four separate EDs were found to vary based on geographic locale (Table 3), clinician assessors (Table 4), and specialized MH resource involvement (Table 5), with several evident gaps and opportunities for improvement. Notably, "Sexual health" and "Abuse" assessments were scarcely documented, and although, "Safety" was consistently the most well-documented section overall, documentation of MH resources in place for identified safety concerns (i.e., a safety plan) was severely lacking (22% [95% CI = 18%–27%]; Table 3). Furthermore, although a disposition plan was consistently well-documented (Table 3, "Professionals"), there were no follow-up plans or recommendations documented for almost one-fifth (17.4%) of patients discharged home (Table 1). This lack of documented follow-up plan recommendations upon discharge may either represent a

Table 2
Inter-rater Agreement (κ = Cohen's Kappa Coefficient) in Applying HEARTSMAP as a Standardized Tool for Evaluating Psychosocial Assessment Documentation for Pediatric Patients Presenting With MH-related Complaints to EDs

	Present			Severity			Resources		
Section	*N*	κ	95% CI	*n*	κ	95% CI	*n*	κ	95% CI
Home	400	1.00	—	324	0.79	0.72–0.86	324	0.85	0.79–0.91
Education	400	1.00	—	270	0.86	0.80–0.92	270	0.88	0.82–0.95
Alcohol/drugs	400	1.00	—	312	0.85	0.77–0.93	312	0.95	0.92–0.99
Relationships	400	0.99	0.98–1.0	246	0.78	0.70–0.86	246	0.62	0.50–0.74
Thoughts	400	1.00	—	306	0.82	0.71–0.92	306	0.84	0.75–0.92
Anxiety	400	1.00	—	242	0.83	0.75–0.90	242	0.91	0.86–0.96
Safety	400	1.00	—	378	0.75	0.61–0.88	378	0.80	0.73–0.88
Sexual health	400	0.99	0.98–1.0	97	1.00	—	97	0.98	0.94–1.0
Mood	400	1.00	—	350	0.79	0.73–0.86	350	0.81	0.75–0.87
Abuse	400	1.00	—	122	0.74	0.61–0.86	122	0.92	0.85–0.99
Professionals*	400	1.00	—	351	0.71	0.44–0.98	—	—	—

*Professionals refers to disposition plan, with current resources already accounted for in other sections; therefore, "Resources" not applicable.

failure to record the information or a true absence of any actual treatment recommendations being provided.[24,42] In addition to obvious medicolegal implications, these examples highlight the potential impact current assessment and documentation practices in the ED may have on patient care, especially given that return visits are rising and estimated to represent one third of annual MH presentations to the ED.[2,12] This study also revealed geographic disparities (Table 3), a well-known obstacle to accessing MH services,[43] and found documentation of clinical assessments to be consistently more comprehensive when a psychiatric liaison was involved (Table 4), irrespective of the initial clinician assessor (Table 5). These findings underscore the need for increased standardization in MH care, broadly applicable across geographic jurisdictions and clinical practitioners.

Numerous studies have described pediatric patients presenting to the ED with MH concerns according to basic demographic and clinical data (e.g., age, sex, presenting complaint, discharge diagnosis) from health care databases. Although these studies highlight similar gaps in psychosocial documentation, such as information relating to abuse[26] and discharge recommendations,[25] few have actually examined ED clinician assessments and their documentation.[42] Indeed, we identified only two retrospective reviews evaluating ED physician assessment documentation for pediatric MH presentations. Newton et al.[24] explored whether documentation of a subset of psychosocial assessments (e.g., suicidality, homicidality, mood, anxiety/stress, reality testing) were present or not in the clinical record and identified similar shortcomings to those found in our study at both pediatric and general EDs. More recently, Cappelli et al.[42] used the Child and Adolescent Needs and Strengths Tool (CANS-MH 3.0), a communimetric measure similar to HEARTSMAP, with good inter-rater reliability (κ = 0.71) to assess for the presence of documentation pertaining to a broad range of MH symptoms and risk behaviors, as well as rate their severity in an effort to predict patient disposition. The study revealed that despite some gaps, the clinical information documented by pediatric ED physicians was generally good and useful for appraising risk. However, unlike HEARTSMAP, the CANS-MH tool does not identify MH resources in place for identified areas of concern or provide acuity-specific service recommendations for clinicians.

Given that MH encompasses a clinically heterogeneous array of conditions such as psychological, behavioral, neurodevelopmental, and addictive disorders, a thorough history and psychosocial assessment of patients is essential.[44] Furthermore, documentation of psychosocial features of the patient such as socioeconomic status, evidence of abuse, emotional stability, and social relationships is imperative to facilitate his or her current and future care. The results of this study indicate that HEARTSMAP is a reliable and effective tool to evaluate psychosocial assessment documentation practices for quality improvement initiatives and is an important addition to previously described

Table 3
Proportion of Psychosocial Assessments With Documentation of HEARTSMAP Sections Present, Sufficient to Score a Severity Level, and With Related Referrals or Resources, During Pediatric and General ED Evaluations of Pediatric Patients Presenting With MH-related Complaints Stratified by Hospital Site and Overall

	% Information Present						% Information Sufficient to Score Severity						% Resources Documented					
Section	All (95% CI)	BCH	SMH	RIH	KGH	p-value	All (95% CI)	BCH	SMH	RIH	KGH	p-value	All (95% CI)	BCH	SMH	RIH	KGH	p-value
Home	81 (77–85)	80	88	71	85	0.013	52 (47–58)	45	50	58	56	0.344	31 (26–36)	29	38	27	29	0.453
Education	68 (63–72)	72	79	47	72	<0.001	47 (41–53)	43	33	40	69	<0.001	25 (20–31)	26	27	17	28	0.561
Alcohol/drugs	78 (74–82)	71	87	70	84	0.004	83 (79–87)	80	89	77	86	0.219	56 (50–62)	69	64	53	39	0.001
Relationships	62 (57–66)	57	70	47	72	0.001	46 (40–52)	40	49	47	47	0.808	19 (14–24)	18	37	6	10	<0.001
Thoughts	77 (72–80)	84	88	62	72	<0.001	89 (85–92)	87	91	77	99	0.001	82 (77–86)	86	81	71	89	0.04
Anxiety	61 (56–65)	45	72	46	79	<0.001	33 (27–39)	9	36	30	44	<0.001	48 (42–55)	60	53	39	43	0.14
Safety	95 (92–96)	94	97	95	92	0.502	93 (90–96)	96	95	92	91	0.513	22 (18–27)	9	26	29	25	0.003
Sexual health	24 (20–29)	54	11	14	18	<0.001	56 (46–65)	85	27	29	6	<0.001	38 (29–48)	61	27	7	0	<0.001
Mood	88 (84–90)	91	94	77	88	0.002	65 (60–70)	58	73	56	72	0.026	47 (42–52)	51	50	55	33	0.023
Abuse	31 (26–35)	20	32	20	50	<0.001	65 (56–73)	75	69	65	58	0.543	46 (37–55)	45	56	40	42	0.578
Professionals*	88 (84–91)	75	89	96	91	<0.001	98 (96–99)	100	99	97	98	0.59	—	—	—	—	—	—

BCH = Pediatric ED (n = 100); SMH = pediatric ED (n = 100); RIH = general ED (n = 100); KGH = general ED (n = 100); all = overall (N = 400).
*Professionals refers to disposition plan, with current resources already accounted for in other sections; therefore, "% resources documented" not applicable.

assessment tools.[45] In addition, the deficits in current documentation practices elucidated in this study are similar to those previously described[24–26,42] and affirm the need for standardized assessment tools in the ED to facilitate individualized and optimal patient care. This includes a safe and effective transition between emergency and community settings, with EDs increasingly serving as the first point of contact for children and youth with MH concerns.[6,17] Indeed, given that pediatric MH presentations to the ED are time[12,46] and resource[47] intensive, efforts to decrease the burden imposed on EDs for patients seeking MH care must be sought; the utility of a tool such as HEARTSMAP in facilitating an efficient assessment and providing acuity-specific recommendations represents a potential solution in this regard.

LIMITATIONS

The main limitations of this study stem from its retrospective design and the quality of data abstracted. In particular, our study is limited by the inability to detect if an assessment and disposition plan was completed by the clinician and not documented in the patient's chart, or worse, the assessment and disposition plan did not happen at all. Furthermore, the retrospective nature also limits our ability to clearly delineate a relationship between MH assessment quality and the effect it has on patient- and system-based outcomes, such as ED return visits, ED flow parameters, patient compliance with care plan, and patient satisfaction. In addition, although our study was multicentered, it took place within a single provincial health jurisdiction and thus does not offer insights into national trends and practices. Finally, chart evaluators were not blinded to the study objectives or hypotheses, nor were they blinded to which medical center's charts they were reviewing. This may introduce observer bias to the study, but as evaluators were not clinicians involved in the clinical care of pediatric emergency patients nor were associated with the MH teams at any site, the magnitude of the impact from this concern is likely minimal.

CONCLUSIONS

The HEARTSMAP tool is a useful and reliable instrument for evaluating the quality of psychosocial documentation in the ED. It allows for the assessment of both the amount of information included for all

Table 4
Proportion of Psychosocial Assessments With Documentation of HEARTSMAP Sections Present, Sufficient to Score a Severity Level, and With Related Referrals or Resources, During Pediatric and General ED Evaluations of Pediatric Patients Presenting With MH-related Complaints Stratified by the Initial Clinician Assessor

	% Information Present					% Information Sufficient to Score Severity					% Resources Documented				
Section	PED	ED	R	PL	p-value	PED	ED	R	PL	p-value	PED	ED	R	PL	p-value
Home	79	68	73	92	<0.001	57	50	30	57	0.051	41	24	17	33	0.069
Education	62	44	78	83	<0.001	42	37	44	51	0.379	25	14	19	30	0.102
Alcohol/drugs	69	64	71	95	<0.001	75	77	86	90	0.028	53	50	83	53	0.018
Relationships	62	44	56	78	<0.001	39	35	48	53	0.128	31	12	9	19	0.104
Thoughts	71	49	88	95	<0.001	88	88	81	93	0.191	78	77	89	84	0.353
Anxiety	57	52	46	75	<0.001	27	20	16	45	0.002	45	28	74	56	0.001
Safety	93	89	95	100	<0.001	93	85	97	99	<0.001	11	23	10	31	0.004
Sex	36	11	56	17	<0.001	90	23	74	12	<0.001	71	8	52	4	<0.001
Mood	86	73	93	99	<0.001	48	54	66	77	<0.001	34	37	61	51	0.015
Abuse	24	18	22	47	<0.001	86	71	78	58	0.180	64	62	56	40	0.167
Professionals*	72	90	88	95	<0.001	98	97	100	99	0.415	—	—	—	—	—

PED = pediatric emergency physician (n = 58); ED = general emergency physician (n = 115); R = resident physician (n = 41); PL = psychiatric liaison (i.e., MH emergency services; n = 154).
*Professionals refers to disposition plan, with current resources already accounted for in other sections; therefore, "% resources documented" not applicable.

Table 5
Proportion of Psychosocial Assessments With Documentation of HEARTSMAP Sections Present, Sufficient to Score a Severity Level, and With Related Referrals or Resources, During General ED Evaluations of Pediatric Patients Presenting With MH-related Complaints Stratified by Whether Specialized MH Services Were Involved Prior to Disposition

	% Information Present			% Information Sufficient to Score Severity			% Resources Documented		
Section	No MHES	MHES	p-value	No MHES	MHES	p-value	No MHES	MHES	p-value
Home	61	92	<0.001	36	68	<0.001	18	34	0.040
Education	36	79	<0.001	25	70	<0.001	9	29	0.029
Alcohol/drugs	57	94	<0.001	71	87	0.011	51	43	0.333
Relationships	33	81	<0.001	20	56	0.001	0	11	0.064
Thoughts	34	94	<0.001	77	92	0.022	68	85	0.039
Anxiety	46	76	<0.001	10	54	<0.001	17	54	<0.001
Safety	86	100	<0.001	81	99	<0.001	21	32	0.095
Sex	10	21	0.036	33	9	0.121	11	0	0.281
Mood	62	99	<0.001	43	75	<0.001	36	47	0.174
Abuse	8	57	<0.001	57	60	1.000	43	41	1.000
Professionals*	87	99	0.001	95	99	0.163	—	—	—

No MHES = no mental health emergency services involved during presentation to ED (n = 90); MHES = mental health emergency services involved during presentation to ED irrespective of who the initial clinician assessor was (n = 110).
*Professionals refers to disposition plan, with current resources already accounted for in other sections; therefore, "% resources documented" not applicable.

applicable aspects of a MH-related presentation and the degree to which this information allows a third party to assess severity. Future directions include using HEARTSMAP to prospectively evaluate MH presentations to investigate the tool's effect on patient care, department flow, and return visits. This study highlights the need for standardized clinical assessment tools in the ED, such as HEARTSMAP, to optimize resource utilization and care for the growing burden of mental illness in children and youth.

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References

1. Patel V, Flisher AJ, Hetrick S, McGorry P. Mental health of young people: a global public-health challenge. Lancet 2007;369:1302–13.
2. Canadian Institute for Health Information. Care for children and youth with mental disorders. May 2015. Available at: https://secure.cihi.ca/free_products/CIHI%20CYMH%20Final%20for%20pubs_EN_web.pdf. Accessed Feb 15, 2018.
3. Report of the surgeon general's conference on children's mental health: A National Action Agenda. Washington, DC: US Department of Health and Human Services, 2000
4. Baren JM, Mace SE, Hendry PL, Dietrich AM, Grupp-Phelan J, Mullin J. Children's mental health emergencies-part 1. Challenges in care: definition of the problem, barriers to care, screening, advocacy, and resources. Pediatr Emerg Care 2008;24:399–408.
5. Dolan MA, Mace SE. Pediatric mental health emergencies in the emergency medical services system. Pediatrics 2006;118:1764–7.
6. Gill PJ, Saunders N, Gandhi S, et al. Emergency department as a first contact for mental health problems in children and youth. J Am Acad Child Adolesc Psychiatry 2017;56:475–82.
7. Offord DR, Boyle MH, Fleming JE, Blum HM, Grant NI. Ontario Child Health Study. Summary of selected results. Can J Psychiatry 1989;34:483–91.
8. Stephenson J. Children with mental problems not getting the care they need. JAMA 2000;284:2043–4.
9. Chun TH, Katz ER, Duffy SJ, Gerson RS. Challenges of managing pediatric mental health crises in the emergency department. Child Adolesc Psychiatr Clin N Am 2015;24:21–40.
10. Hamm MP, Osmond M, Curran J, et al. A systematic review of crisis interventions used in the emergency department: recommendations for pediatric care and research. Pediatr Emerg Care 2010;26:952–62.
11. Gandhi S, Chiu M, Lam K, Cairney JC, Guttmann A, Kurdyak P. Mental health service use among children and youth in Ontario: population-based trends over time. Can J Psychiatry 2016;6:119–24.
12. Mapelli E, Black T, Doan Q. Trends in pediatric emergency department utilization for mental health-related visits. J Pediatr 2015;167:905–10.
13. Newton AS, Ali S, Johnson DW, et al. A 4-year review of pediatric mental health emergencies in Alberta. CJEM 2009;11:447–54.
14. Pittsenbarger ZE, Mannix R. Trends in pediatric visits to the emergency department for psychiatric illnesses. Acad Emerg Med 2014;21:25–30.
15. Rogers SC, Mulvey CH, Divietro S, Sturm J. Escalating mental health care in pediatric emergency departments. Clin Pediatr (Phila) 2017;56:488–91.
16. Sheridan DC, Spiro DM, Fu R, et al. Mental health utilization in a pediatric emergency department. Pediatr Emerg Care 2015;31:555–9.
17. Cloutier P, Kennedy A, Maysenhoelder H, Glennie EJ, Cappelli M, Gray C. Pediatric mental health concerns in the emergency department: caregiver and youth perceptions and expectations. Pediatr Emerg Care 2010;26:99–106.
18. Leon SL, Cappelli M, Ali S, et al. The current state of mental health services in Canada's paediatric emergency departments. Paediatr Child Health 2013;18:81–5.
19. Dolan MA, Fein JA. Pediatric and adolescent mental health emergencies in the emergency medical services system. Pediatrics 2011;127:1356–66.
20. Zun L. Care of psychiatric patients: the challenge to emergency physicians. West J Emerg Med 2016;17:173–6.
21. Newton AS, Hartling L, Soleimani A, Kirkland S, Dyson MP, Cappelli M. A systematic review of management strategies for children's mental health care in the emergency department: update on evidence and recommendations for clinical practice and research. Emerg Med J 2017;34:376–84.
22. Boyce MC, Melhorn KJ, Vargo G. Pediatric trauma documentation. Adequacy for assessment of child abuse. Arch Pediatr Adolesc Med 1996;150:730–2.
23. Limbos MA, Berkowitz CD. Documentation of child physical abuse: how far have we come? Pediatrics 1998;102:53–8.
24. Newton AS, Ali S, Hamm MP, et al. Exploring differences in the clinical management of pediatric mental health in the emergency department. Pediatr Emerg Care 2011;27:275–83.
25. Stewart C, Spicer M, Babl FE. Caring for adolescents with mental health problems: challenges in the emergency department. J Paediatr Child Health 2006;42:726–30.
26. Starling J, Bridgland K, Rose D. Psychiatric emergencies in children and adolescents: an emergency department audit. Australas Psychiatry 2006;14:403–7.
27. Stange KC, Zyzanski SJ, Smith TF, et al. How valid are medical records and patient questionnaires for physician profiling and health services research? A comparison with direct observation of patients visits. Med Care 1998;36:851–67.
28. McDermott MF, Lenhardt RO, Catrambone CD, Walter J, Weiss KB. Adequacy of medical chart review to characterize emergency care for asthma: findings from the Illinois Emergency Department Asthma Collaborative. Acad Emerg Med 2006;13:345–8.

29. Simpson S, Stacy M. Avoiding the malpractice snare: documenting suicide risk assessment. J Psychiatr Pract 2004;10:185–9.
30. Cohen E, Mackenzie RG, Yates GL. HEADSS, a psychosocial risk assessment instrument: implications for designing effective intervention programs for runaway youth. J Adolesc Health 1991;12:539–44.
31. Lee A, Deevska M, Stillwell K, et al. A psychosocial assessment and management tool for children and youth in crisis. CJEM 2018:1–10.
32. Sills MR, Bland SD. Summary statistics for pediatric psychiatric visits to US emergency departments, 1993-1999. Pediatrics 2002;110:e40.
33. Data Quality Documentation, National Ambulatory Care Reporting System—Multi-Year Information. Ottawa: Canadian Institute for Health Information, 2012.
34. Doan Q, Black T. HEARTSMAP. 2015. Available at: http://heartsmap.ca/. Accessed Mar 10, 2018.
35. Virk P, Stenstrom R, Doan Q. Reliability testing of the HEARTSMAP psychosocial assessment tool for multidisciplinary use and in diverse emergency settings. Paediatr Child Health 2018;pxy017. https://doi.org/10.1093/pch/pxy017
36. Gilbert EH, Lowenstein SR, Koziol-McLain J, Barta DC, Steiner J. Chart reviews in emergency medicine research: where are the methods? Ann Emerg Med 1996;27:305–8.
37. Kaji AH, Schriger D, Green S. Looking through the retrospectoscope: reducing bias in emergency medicine chart review studies. Ann Emerg Med 2014;64:292–8.
38. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42:377–81.
39. Bullard MJ, Chan T, Brayman C, Warren D, Musgrave E, Unger B. Revisions to the Canadian Emergency Department Triage and Acuity Scale (CTAS) guidelines. CJEM 2014;16:485–9.
40. McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb) 2012;22:276–82.
41. Altman DG. Practical Statistics for Medical Research. London: Chapman and Hall, 1991.
42. Cappelli M, Glennie JE, Cloutier P, et al. Physician management of pediatric mental health patients in the emergency department: assessment, charting, and disposition. Pediatr Emerg Care 2012;28:835–41.
43. Caxaj CS. A review of mental health approaches for rural communities: complexities and opportunities in the Canadian context. Can J Commun Mental Health 2015;35:29–45.
44. Doan Q, Black TR. Behavioral disorders in children. In: Tintinalli JE, Stapczynski JS, Ma OJ, Yealy DM, Meckler GD, Cline DM, editors. Tintinalli's Emergency Medicine: A Comprehensive Study Guide. 8th ed. New York, NY: McGraw-Hill Education, 2016.
45. Newton AS, Soleimani A, Kirkland SW, Gokiert RJ, Cloutier R. A systematic review of instruments to identify mental health and substance use problems among children in the emergency department. Acad Emerg Med 2017;24:552–68.
46. Santiago LI, Tunik MG, Foltin GL, Mojica MA. Children requiring psychiatric consultation in the pediatric emergency department: epidemiology, resource utilization, and complications. Pediatr Emerg Care 2006;22:85–9.
47. Grupp-Phelan J, Mahajan P, Foltin GL, et al. Referral and resource use patterns for psychiatric-related visits to pediatric emergency departments. Pediatr Emerg Care 2009;25:217–20.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13506/full

Data Supplement S1. Mental health-related presenting complaints and discharge diagnoses identified through the National Ambulatory Care Reporting System (NACRS).

Providers' Perceptions of Caring for Pediatric Patients in Community Hospital Emergency Departments: A Mixed-methods Analysis

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ABSTRACT

Background: Approximately 90% of pediatric emergency care is provided in community emergency departments (CEDs) that care for both adults and children. Paradoxically, the majority of pediatric emergency medicine knowledge generation, quality improvement work, and clinical training occurs in children's hospitals. There is a paucity of information of perceptions on pediatric care from CED providers. This information is needed to guide the development of strategies to improve CED pediatric readiness.

Objective: The objective was to explore interprofessional CED providers' perceptions of caring for pediatric patients.

Methods: A preparticipation survey collected data on demographics, experience, and comfort in caring for children. Emergency pediatric simulations were then utilized to prime interprofessional teams for debriefings. These discussions underwent qualitative analysis by three blinded authors who coded transcripts into themes through an inductive method derived from grounded theory. The other authors participated in confirmability and dependability checks.

Results: A total of 171 community hospital providers from six CEDs completed surveys (49% nurses, 22% physicians, 23% technicians). The majority were PALS trained (70%) and experienced fewer than five pediatric resuscitations in their careers (61%). Most self-reported comfort in caring for acutely ill and injured children. From the debriefings, three major challenge themes emerged: 1) knowledge and skill limitations attributed to infrequency of training and actual clinical events, 2) the emotional toll of caring for a sick child, and 3) acknowledgment of pediatric specific quality and safety deficits. Subthemes focused on causes and potential

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mitigating factors contributing to these challenges. A solution theme highlighted novel partnering opportunities with local children's hospitals.

Conclusion: Interprofessional CED providers perceive that caring for pediatric patients is challenging due to case infrequency, the emotional toll of caring for sick children, and pediatric quality and safety deficits in their systems. These areas of focus can be used to generate specific strategies for improving CED pediatric readiness.

Children comprise a substantial portion of emergency department (ED) visits in the United States, encompassing 34% of the 141.1 million ED visits in 2014.[1] Of these children, most are cared for in community EDs (CEDs) closest to their homes that care for both adults and children.[2–4] CEDs often serve a smaller volume of pediatric patients, which, among other factors, is negatively associated with pediatric readiness as measured by the Emergency Medical Service for Children's (EMSC) weighted pediatric readiness score.[5] Addressing deficiencies in pediatric readiness supports ongoing efforts to improve the quality of patient care across the continuum of health care delivery.[6] As such, programs to identify barriers and inform pediatric specific improvement initiatives are ongoing at both local and national levels.[2,6–8] The perspectives of CED providers are needed to inform these initiatives.

In-situ simulations involve the presentation of a patient to an interdisciplinary team of frontline providers in their actual clinical work space using real equipment. These simulations can be used to train providers and teams (especially around low-frequency, high-stakes cases) and to probe systems for latent safety threats.[9–22] Debriefings involve teams self-reflecting on the simulation experience and provoke participants to express their cognitive and emotional frames.[23–26] As such, these discussions can be used to explore CED providers' perceptions of pediatric care in their ED, specifically probing their comfort with medical management, navigation of systems issues and resource limitations, and discovery of latent safety hazards. Additionally, debriefings can be used to explore providers' perspectives to inform possible solutions for encountered obstacles.

This study aims to explore interprofessional CED providers' perceptions of caring for pediatric patients. While each CED is unique, we hypothesized that survey data combined with qualitative analysis of a simulation primed debrief would offer new insights to guide pediatric improvement strategies tailored to CEDs.

METHODS

Study Design

We used a mixed-methods design[27] combining data from preparticipation surveys with the qualitative analysis of the debriefings. We anticipated the qualitative component to balance the underlying perceptions related to emergency pediatrics with "primed" reactions from a realistic in situ pediatric simulation.[28–30] Through semistructured open-ended questions related to pediatric care in their ED, participants were encouraged to share their perspectives on the group's comfort with the medical management, navigation of systems issues and resource limitations, and discovery of latent safety hazards (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13509/full). Three blinded authors coded debriefing transcripts into themes through an inductive method derived from grounded theory.[31,32] Our study team utilized the Standards for Reporting of Qualitative Research and the 32-item consolidated criteria for reporting qualitative research (COREQ) and consulted best practice guidelines from Choo and Ranney to generate and report our findings.[30,32–34]

This study was approved by the institutional review board of Brown University/Hasbro Children's Hospital. Study protocol was funded through a grant from the Agency for Healthcare Research and Quality with members of the authorship team receiving support from the R Baby Foundation.

Study Setting and Population

We report data from a statewide initiative from 2011 to 2014 that used in situ simulation, semistructured debriefing, and follow-up learning and planning sessions to address and assist in improving each participating CED's pediatric practices. Due to its size and the relative accessibility of its community hospitals, Rhode Island served as an ideal initial state for such an intervention. The state's health care network is comprised of one major children's hospital and nine

community centers. The basic demographics and pediatric volumes of each CED are included in Table 1.

Each simulation and debriefing occurred in the respective resuscitation bay inclusive of the full interdisciplinary team. Teams taking care of the simulated patients mirrored the actual staffing teams (composed of physicians, nurses, physician assistants, nurse practitioners, and technicians).

Study Protocol

A research team led by a pediatric emergency medicine physician solicited all state CEDs to participate. At the start of the session CED participants completed a presurvey of their attitudes and experience with emergency pediatric care. Thereafter, teams partook in a series of three infant and one child in situ simulations (upper airway obstruction from a foreign body, septic shock, febrile status epilepticus, and cardiopulmonary arrest from drowning). Immediately following completion of the four simulations a semistructured debriefing was facilitated by the same physician with expertise in this skill.[30] Transcripts were audio recorded and thence professionally transcribed.[30]

Measurements

Descriptive data were collected from each participating CED. Quantitative data from the preintervention surveys provided participants' demographics and self-reported pediatric training and experience. Likert scales were used to assess attitudes and comfort with pediatric emergency care. Qualitative analysis of the debriefing transcripts generated themes of challenges and potential solutions to CED's care of pediatric patients.

Data Analysis

Quantitative data analyses were performed with SPSS version 22.0. Preintervention questionnaire Likert scales were reported as medians with interquartile ranges. These data were then analyzed using bivariate analyses examining for differences by provider type and pediatric volume using the Kruskal-Wallis test.

A three-member team (MG, AHW, and AB) used Dedoose software (version 7.5.15; SocioCultural Research Consultants) for qualitative data analysis.[32] An inductive approach was first used through an initial round of independent open coding.[32] Next, we completed an iterative analysis process fine tuning our codebook as a group and then applying it to reach consensus on major themes, a practice derived from grounded theory.[31,32,35] The rest of the research team (BLE, LLB, MAA) participated by reviewing the generated themes ensuring that the analytic process was valid.[36] Finally, we synthesized findings from the quantitative and qualitative components looking for concordance and discordance.[29]

RESULTS

Demographics

From 2012 to 2013, seven of the nine CEDs in Rhode Island were enrolled. Data were analyzed from six CEDs as one visit had limited attendance and did not represent the full care team. Key characteristics of the 171 participants enrolled are provided in Table 2. Notably, most providers were PALS trained (70%) although many (61%) experienced fewer than five pediatric resuscitations in their careers.

Table 1
Rhode Island CEDs: Individual Census and Staffing Information, 2012

			Physicians FTE			
Hospital	Census	Pediatrics	Full Time	Part Time	Midlevel FTE	Nursing FTE
1*	61,000	16%	16	4	8	101
2*	30,000	2%	7	5	6	40
3*	32,000	13%	9	1	2.5	27
4*	45,700	4%	11	17	0	76
5*	32,000	30%	7	2	2	21
6*	35,000	5%	8	2	5	43
7	27,000	3.3%	5	7	10	35
8	45,000	13%	6	1	14	72
9	25,541	17%	5	3	6	24

CED = community ED; FTE = full-time equivalent.
*Participant sites.

Table 2
Key Characteristics of Our Participants (N = 171)

Sex	
Female	114 (66.7)
Male	47 (27.5)
Age (years)	39.5 (31.3–49.5)
Training	
MD/DO	38 (22.2)
RN	84 (49.1)
CNA	13 (7.6)
Other	24 (14.0)
Number of hours worked/week	36.0 (33.0–40.0)
Number of years at this training	8.0 (3.0–15.8)
Number of years working at this hospital	6.0 (3.0–12.0)
Number of pediatric resuscitations participated in	
<5	105 (61.4)
5–15	29 (17.0)
16–30	18 (10.5)
>30	5 (2.9)
Number of adult resuscitations participated in	
<5	8 (4.7)
5–15	25 (14.6)
16–30	28 (16.4)
31–50	18 (10.5)
>50	76 (44.4)
PALS training	
No	36 (21.1)
Yes	120 (70.2)
Participation in simulation-based training in the past	
No	70 (40.9)
Yes	94 (55.0)
System uses length-based system for pediatric resuscitations	
No	4 (2.4)
Yes	148 (86.5)
Provider has used length-based system for pediatric resuscitations	
No	29 (17.0)
Yes	121 (70.8)

Data are reported as n (%) or median (IQR). Please note that not all column cells add to 100% due to missing data.
IQR = interquartile range.

Quantitative Results

Table 3 reports "attitudes and comfort with pediatric emergency care" as medians with interquartile ranges (IQRs) on a five-point Likert scale. Participants were "neutral" (3; IQR = 2–4) to "feeling comfortable taking care of acutely ill children" and "agreed" (4; IQR = 3–4) with "pediatric equipment is easy to locate in our ED," "our resuscitation bay is well-equipped for pediatric resuscitation," and "I am extremely stressed during a pediatric resuscitation."

Physicians and advanced practitioners reported greater agreement than their nursing colleagues in "receiving adequate training in the care of acutely ill children" (3.5 [IQR = 2.8–4] vs. 3 [IQR = 3–4]; p = 0.002). Further, the CED with the highest pediatric volume in the state reported greater "comfort taking care of acutely ill children" when compared to the other community hospitals involved in this work (4 [IQR = 3–4]; p < 0.001). Assessing survey responses by prior simulation experience, PALS certification status or years on the job did not reveal any significant differences.

Qualitative Results

Three major themes emerged as challenges to pediatric care in the CED: 1) knowledge and skills limitations due to event infrequency, 2) the emotional toll of caring for a sick child, and 3) acknowledgment of pediatric specific quality and safety deficits. As highlighted below, discussions of each perceived challenge naturally guided participants toward brainstorming potential mitigating solutions. The most common solution theme was the potential for partnering roles with local children's hospitals (Table 4).

Knowledge and Skills Limitations Attributed to Event Infrequency. In response to the prompt, "What was challenging about that scenario?" the most common reply focused around the issue of infrequency of pediatric cases contributing to both an individual's and the team's lack of confidence in their abilities to care for critically ill children. This concept was further delineated into deficits in medical knowledge and procedural competencies attributed to low pediatric census and infrequent competency trainings (Table 4, quotes 1.1.a–1.2.c). Additionally, participants noted that while proximity to a children's hospital was a potential contributor to event infrequency, as children were more likely to be directly transported to the major pediatric center, those working nearby major pediatric centers felt more comfortable collaborating with their local pediatric colleagues (Table 4, quotes 1.3.a–1.3.c).

Frequently, participants offered solutions to the issue of pediatric emergency care infrequency. The prominent idea of forming professional partnerships with local children's hospitals to provide needs assessments and competency trainings through in situ simulation and other modalities were widely supported. This was favored over relying on current curricula that

Table 3
Providers' Reported Attitudes and Comfort With Pediatric Emergency Care

	Likert score, median (IQR)
I feel comfortable taking care of acutely ill children	3 (2–4)
Pediatric equipment is easy to locate in our ED	4 (3–4)
I am unsure of my responsibilities during a pediatric resuscitation	2 (2–3)
I am comfortable reporting a medical error or "near miss"	4 (4–4.5)
We have easy access to pediatric transport to a children's hospital	4 (4–5)
Our resuscitation bay is well equipped for pediatric resuscitations	4 (3–4)
I feel comfortable taking care of acutely ill adults	5 (4–5)
I have received adequate training in the care of acutely ill children	3 (2.5–4)
I am extremely stressed during an adult resuscitation	2 (1–3)
I am successful at my tasks during an adult resuscitation	4 (4–5)
We have medical equipment for all ages and sizes of pediatric patients	4 (3–4)
My hospital has an easy to use medical error reporting system	4 (4–5)
I am successful at my tasks during a pediatric resuscitation	3 (3–4)
I am extremely stressed during a pediatric resuscitation	4 (3–4)

was deemed outdated or too infrequently delivered to provide adequate training. Additional ideas highlighting pediatric acute care telemedicine and patient follow-up processes were also postulated solutions to event infrequency (Table 4, quotes 1.3.b–1.3.c). Further, working with the children's hospital to share and adapt cognitive aids and clinical care guidelines to the CED setting was yet another benefit anticipated to emerge from forming such partnerships.

The Emotional Toll of Caring for a Sick Child. A second major theme that participants viewed as challenging to their pediatric emergency care was how a sick child creates an emotional toll on providers that differs from adult practice. Similar to comments above, providers shared that infrequency of emergency pediatric cases, lack of familiarity with pediatric specific equipment, and lack of available cognitive resources made them more anxious during acute management and at times feel unsure of their decisions (Table 4, quote 2.1.a). In addition, multiple providers spoke to the emotional challenge of caring for a sick child alongside nervous caregivers, creating additional stress in an already anxiety provoking situation (Table 4, quotes 2.2.a–c).

Further, simply acknowledging the fact that their patient was an acutely ill child triggered shared reactions of emotional distress by our participants (Table 4, quote 2.3.a). While any patient loss remains a sharp reminder of the gravity of our work, CED providers shared the concern that their typical coping strategies employed for adult critical care and loss often did not suffice when applied to pediatric cases (Table 4, quote 2.3.b).

Equally as important to emphasize with respect to this "emotional toll," however, was that the CED participants were steadfast in their ability to lean on their internal colleagues as close-knit teammates to get through both the stressful acute resuscitation and the subsequent emotions endured (Table 4, quotes 2.4.a–c).

In addition to relying on established colleagues, again the potential role of the local children's hospital emerged as a resource to help mitigate some of these emotional issues. Acknowledging that the coping mechanisms of a CED provider after a pediatric emergency may be less refined than their pediatric ED colleagues, CED providers brainstormed roles for pediatric ED personnel to assist in their emotional processing. Providing follow-up and feedback on pediatric transfer patients was highly desired and already an informal practice of many participants (Table 4, quote 2.5.a). Additionally, asking a pediatric ED provider to participate in the debrief of an acute case with the referring CED team was suggested to have value for CED personnel to learn pediatric specific coping mechanisms.

Acknowledgment of Pediatric Specific Quality and Safety Deficits. Finally, there were multiple instances when the simulation identified gaps in pediatric specific quality and safety practices. Here CED providers recognized that infrequency of pediatric events was not a suitable explanation for the

Table 4
Summary of Qualitative Analysis With Exemplary Quotations

Theme: Explanation	Subtheme	Exemplary Quotes	Derived Recommendations
1. Knowledge and skills limitations attributed to event infrequency	Medical knowledge deficits	1.1.a—"Last time I was in a code for an infant, the baby was 3 months and that was 25 years ago." 1.1.b—"Biggest challenge is that we don't see that many critically ill kids, and so it's a familiarity issue." 1.1.c—"Dr. S may want to do an [In-Situ SIM] with us every few months just to keep us fresh!"	• Connect with local children's hospitals to provide in situ simulation and other training modalities to address pediatric competencies. • Adapt children's hospital care protocols to the community setting. • Update and centrally locate key pediatric cognitive aids. • Create a culture of collaboration between the children's hospital and community hospital teams.
	Discomfort with pediatric procedures	1.2.a—"I've been here 16 years, probably had a half-dozen pediatric intubations." 1.2.b—"It's a question of memory and a question of habit, habit plays into the whole sense of how much you have to think about what to do next." 1.2.c—"We have our peds competencies once every other year . . . that's as much peds resuscitation as I get . . . minimal hands on." 1.2.d—". . . I open that [pedi] cart and I'm like boom boom boom boom! It's not a familiar thing for me and it scares the hell out of me!"	
	Proximity to children's hospitals	1.3.a—"These days I would call [Hasbro] and just talk to the [PEM] physician . . . call it collaborating, not cheating!" 1.3.b—"I wonder if we could [install] a speakerphone . . . get a Hasbro attending on the line to help out with a community hospital code." 1.3.c—"[The transport team] nurses are awesome, and they know their stuff . . . Now that we have a system in place, it's much more cohesive and it's the same people who know what's going on . . . its reassuring."	
2. The emotional toll of caring for a sick child	The infrequency of the event	2.1.a— ". . . Fear, everyone is scared to death when a kid comes in. . .because we don't see a lot of it and we don't feel comfortable with it."	• Specific to children, address how the reactions may be different for providers experiencing unique emotions after a pediatric resuscitation. • Build upon the tightknit nature of the community hospital team. • Use structured debriefings after pediatric cases that incorporates all team members. Address how a team functions differently when outside of their comfort zones. • Create systems to connect referring providers with the local children's hospital to provide patient follow-up with positive and constructive feedback on their pediatric transfers.
	The caregiver factor	2.2.a—"The families are feeling our anxiety." 2.2.b—"I've seen parents stand there stoically . . . and not say a word. I've seen others go the other way when they're actually becoming another patient for you." 2.2.c—"That last one was horrible for me when the family was not accepting that the child had expired."	
	The child factor	2.3.a- "I think it's just such an emotional impact with children. . .I really do. I think all of us feel that way." 2.3.b- ". . .I've been thinking of that child with the child abuse head injuries."	
	The tightknit community team	2.4.a—"[A pediatric resuscitation] really brings our department together. We don't see it much so when we do, it really mobilizes the whole department." 2.4.b—"There were enough hands, enough equipment . . . we had two physicians as well as six nurses . . . the communication was working well." 2.4.c—"I think everyone here in the department works well together . . . it seems like a group that has been here a while." ". . . yeah we have that continuity."	
	The role of the local children's hospital	2.5.a—"What do you use as a resource [for follow-up] as a physician?" ". . . I call whoever is up in the ER at Hasbro, talk to them since they know what happened."	

(Continued)

Table 4 (continued)

Theme: Explanation	Subtheme	Exemplary Quotes	Derived Recommendations
3. Acknowledgement of pediatric specific quality and safety deficits	Infrequency is not a valid excuse anymore	3.1.a—"… It's five percent of our patient population. It's not nothing! It's like this very steady, small but predictable percentage that we get, so there is no reason that we don't need policies." 3.1.b—"… just because [the pediatric population] is so small we think, eh, [and so] we kind of make it up as we go along. But that means that five percent [of our cases] are predictably painful."	• Designate individuals as pediatric champions to work with children's hospitals to create pediatric specific triage, transfer, clinical care, and equipment stocking policies and protocols. • Create a reliable medication dosing safety mechanism with pharmacy personnel which does not rely on their physical presence for safe utilization. • Raise funds or solicit donations for child friendly distraction tools and/or personnel.
	Lack of pediatric equipment policies and protocols	3.2.a—"It's hard when you don't have that many patients to keep stock up to date [because] its expensive …" 3.2.b—"If a pedi child comes in, like the last time, I couldn't even get a pulse Ox 'cuz I couldn't even find the equipment for it." 3.2.c—"We used to have a chart for normal VS for babies … I liked that … but that's gone, too." 3.2.d—"Nobody checks the cart?" "Not the Pedi cart, there is not a designated person to check that cart." "Why not?" "I don't know, there should be!"	
	Medication safety issues	3.3.a—"You can fudge with adult dosing … you just can't do that with kids, the dosing changes like every 5 kilos!" 3.3.b—"You need two RNs to do a med of any kind, even if its Tylenol!" 3.3.c—"[Our] pharmacist does everything … and that's actually a good thing, but when they are not there, when things happen in the middle of the night, we are left to figure it out all on our own because they literally just do it [all]."	
	Unsafe clinical environment for children	3.4.a—"… I had a child stick their arm down the needle disposal box!"	
	Child friendliness deficits	3.5.a—"Even just having coloring books and stickers that are easily accessible to keep them distracted and happy while they are here … We don't even really have much of that."	

quality and safety issues uncovered (Table 4, quotes 3.1.a–b).

Specific deficiencies that emerged focused around a need for enhanced protocols related to the triage process (e.g., appropriate patient weight in kilograms rather than pounds and the need for help identifying age specific abnormal vital signs), clinical care guidelines, and equipment stocking practices (Table 4, quotes 3.2.a–d).

Nearly all participants shared concerns related to medication dosing safety, specifically focusing on their fear of weight-based dosing errors (Table 4, quotes 3.3.a and b). Many facilities reconciled this concern through reliance on pharmacy personnel. However, lack of around the clock pharmacy coverage and variation in their physical presence during acute care forced many to acknowledge their current medication practices were ripe for error with children (Table 4, quote 3.3.c).

Finally, the groups shared several stories on how they desired a safer and more child friendly clinical environment. In our debriefs, participants frequently shared pediatric-specific "near-miss" stories (Table 4, quote 3.4.a) while others expressed the desire for increased child friendliness efforts to help with distraction during challenging examinations or procedures (Table 4, quote 3.5.a).

The CED groups again brainstormed potential solutions to many of these uncovered pediatric-specific quality and safety deficits. Organically, participants derived the concept of a local CED "pediatric champion" or one who takes ownership for the responsibility of creating or carrying out pediatric-specific policies and procedures.[2] Further, strategizing with pharmacy

personnel to develop after-hours medication safety protocols was also commonly discussed.

Finally, a partnering role with the local children's hospital surfaced again. CED providers thought that seeking outside expertise around pediatric specific quality and safety practices, as long as pediatric ED colleagues were willing to work to adapt their protocols to the CED setting, would be highly beneficial.

DISCUSSION

Through preintervention surveys and a deeper qualitative analysis of the debriefings from a series of simulation-primed experiences, we offer themes to help focus hypothesis generation for future pediatric-specific interventions as we collectively aim to improve CED pediatric care. Interventions through partnership with local children's hospitals may help address the challenges of pediatric event infrequency, the emotional toll of caring for children in the CED and CED pediatric quality and safety deficits (Figure 1). These results foster a deeper understanding of CED training, teamwork, and systems of care, uncovering both benefits and potential shortcomings to consider as we aim to advance emergency care of pediatrics, regardless of where it is provided.

Of note, some of the qualitative themes that emerged contrasted participants' perceptions of pediatric readiness as demonstrated by the preparticipation survey. It seems that the simulation stimulus helped uncover aspects of pediatric readiness not previously considered by CED providers. This likely reflected a gap between their own perceived individual level of comfort and their system's true level of readiness for emergency pediatric care.

A prior publication focused on comparing differences in the care pediatric patients receive between pediatric only and pediatric/adult mixed EDs. This article noted that care can be quite heterogeneous with respect to adherence to clinical guidelines, in comfort with pediatric-specific equipment and medication dosing, in approaches and the composition of care teams and in the active use of cognitive aids and algorithms during acute care.[37] This work and that of others outline both advantages and potential limitations to pediatric acute care between settings.[13,37,38]

To our knowledge, our approach and the themes derived is the first to focus specifically on interprofessional CED teams. This offered the ability for the CED to both identify their own challenges and, importantly, organically derive their own solutions increasing the likelihood of implementing meaningful and sustainable local change.[39,40]

As we look ahead, the most commonly derived "solution" to the aforementioned challenges facing the CED focused on novel partnering opportunities with local children hospitals. This partnership, built on mutual respect, could focus on advocating for pediatric care to be thought of as a continuum of care, similar to ongoing efforts to best address ischemic heart disease, stroke, and cardiac arrest by the American Heart Association and more familiar to our pediatric colleagues, how neonatal intensive care and pediatric trauma services are regionally organized.[41–43]

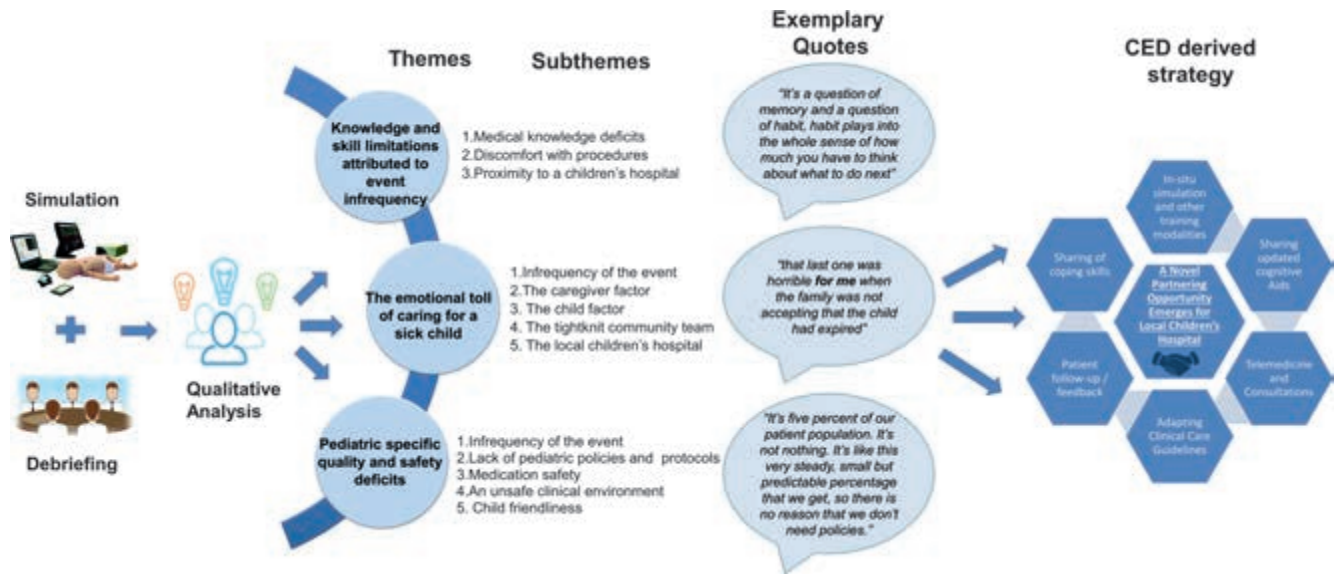

Figure 1. Schematic for our study protocol, key results, and conclusions. CED = community ED.

Consistent with these models, our participants desired children's hospitals to play a central role in training, sharing, and adapting clinical care guidelines; consulting with CEDs to help with equipment stocking practices; and assisting in the development of robust quality improvement initiatives around pediatric triage, transfer, medication administration, and safety protocols.

Thus, the door has been opened by our CED colleagues for pediatric ED providers to create meaningful working partnerships. Our results suggest that focusing initially on relationship building may cultivate success in CED pediatric improvement efforts. This is consistent with published recommendations from EMSC, which promotes the model of connecting CEDs to pediatric centers through local "pediatric champions" who can liaise between the facilities to identify and implement local improvements.[2] However, it should be noted that a single champion may not be sufficient. The work needed to achieve sustainable improvements requires support from both CED and children's hospital administrators and academicians alike as it will take time and resources to achieve our shared mission of excellence in pediatric emergency care regardless of where it occurs. To this notion, one must acknowledge that many of the suggestions generated by CED providers, especially the strategies that involve partnering with local children's hospitals, may be logistically and or financially difficult to implement. To this issue, we again encourage readers to consider the themes identified in this study as a means to focus future hypothesis generation for meaningful interventions. Future work to improve pediatric emergency care across the continuum will require creative and innovative solutions to navigate these obstacles.

LIMITATIONS

This work has important limitations to review. First, Rhode Island is a small state with a pediatric health care infrastructure of one centrally located children's hospital. These favorable logistics may limit our report's generalizability to larger states with multiple children's hospitals or those where geographic restrictions may inhibit working partnerships with local children's hospitals.[4] CED providers were astute to this issue and called on technologies like telemedicine to address this barrier. Further, we were encouraged to recently learn of similar themes generated in the state of Wisconsin, supporting our work's generalizability.[44] Second, as is a standard limitation of qualitative work, our results and messages reflect the opinions of our protocol's participants. We are, however, confident that the themes generated through this work have validity as we analyzed several variable CEDs and interviewed a wide array of clinical providers. Third, the possibility exists that since the primary author (MPG) and simulation debrief facilitator (LLB) are both pediatric emergency medicine providers, our understanding of the thoughts and feelings expressed by the participants may be influenced by how we ourselves practice. We attempted to limit this bias by ensuring that LLB received proper training in debriefing,[45] had independent transcriptions of the debriefings, and included a blinded general emergency medicine provider (AHW) and a research assistant (AB) in the qualitative analysis. Unfortunately, we did not have a registered nurse on our research team, which may have influenced our transcript coding. Finally, it is important to mention that perceptions of care delivered during simulation versus actual patient care may differ as one can never fully replicate the real patient experience.

CONCLUSIONS

Interprofessional community ED providers perceived pediatric knowledge and skill limitations due to event infrequency, reported a unique emotional toll when caring for sick children and identified quality and safety deficits related to their community ED's care of pediatric patients. This information should be used to guide the development of community ED pediatric improvement strategies. As a potential solution, our participants proposed thoughtful partnering opportunities with local children's hospitals to collaboratively work toward the aim of improving national pediatric readiness.

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References

1. National Hospital Ambulatory Medical Care Survey: 2014 Emergency Department Summary Tables. Atlanta: National Center for Health Statistics, 2015.

2. American Academy of Pediatrics; Committee on Pediatric Emergency Medicine; American College of Emergency Physicians; Pediatric Committee; Emergency Nurses Association Pediatric Committee. Joint Policy Statement—guidelines for care of children in the emergency department. Pediatrics 2009;124:1233–43.
3. Brown AM, Decker SL, Selck FW. Emergency department visits and proximity to patients' residences, 2009-2010. NCHS Data Brief 2015;192:1–8.
4. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. J Pediatr 2018;194:225–32:e1.
5. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
6. Emergency Care for Children Growing Pains. Washington, DC: Institute of Medicine, 2006.
7. Cichon ME, Fuchs S, Lyons E, Leonard D. A statewide model program to improve emergency department readiness for pediatric care. Ann Emerg Med 2009;54:198–204.
8. Hohenhaus SM, Lyons E, Phillippi RG. Emergency departments and pediatric categorization, approval, and recognition: a review of two states. J Emerg Nurs 2008;34:236–7.
9. Petrosoniak A, Auerbach M, Wong AH, Hicks CM. In situ simulation in emergency medicine: moving beyond the simulation lab. Emerg Med Australas 2017;29:83–8.
10. Stone KP, Patterson MD, Reid JR, Geis GL, Auerbach M. Simulation to improve patient safety in pediatric emergency medicine. Clin Pediatr Emerg Med 2016;17:185–92.
11. Auerbach M, Stone K, Patterson M. The role of simulation in improving patient safety. In: Comprehensive Healthcare Simulation Pediatrics. Basel: Springer, 2016. p. 55–66. https://www.springer.com/us/book/9783319241852#aboutAuthors
12. Auerbach M, Kessler DO, Patterson M. The use of in situ simulation to detect latent safety threats in paediatrics: a cross-sectional survey. BMJ Simul Technol Enhanc Learn 2015;(1):bmjstel-2015-000037.
13. Whitfill T, Gawel M, Auerbach M. A simulation-based quality improvement initiative improves pediatric readiness in community hospitals. Pediatr Emerg Care 2018;34:431–5.
14. Hamman WR, Beaudin-Seiler BM, Beaubien JM, et al. Using simulation to identify and resolve threats to patient safety. Am J Manag Care 2010;16:e145–50.
15. Block EF, Lottenberg L, Flint L, Jakobsen J, Liebnitzky D. Use of a human patient simulator for the advanced trauma life support course. Am Surg 2002;68:648–51.
16. Donoghue AJ, Durbin DR, Nadel FM, Stryjewski GR, Kost SI, Nadkarni VM. Effect of high-fidelity simulation on pediatric advanced life support training in pediatric house staff: a randomized trial. Pediatr Emerg Care 2009;25:139–44.
17. Jiang J, Zou Y, Shi W, et al. Two-thumb-encircling hands technique is more advisable than 2-finger technique when lone rescuer performs cardiopulmonary resuscitation on infant manikin. Am J Emerg Med 2015;33:531–4.
18. Rosenthal ME, Adachi M, Ribaudo V, Tristan Mueck J, Schneider RF, Mayo PH. Achieving housestaff competence in emergency airway management using scenario based simulation training: comparison of attending vs housestaff trainers. Chest 2006;129:1453–8.
19. Happel CS, Lease MA, Nishisaki A, Braga MS. Evaluating simulation education via electronic surveys immediately following live critical events: a pilot study. Hosp Pediatr 2015;5:96–100.
20. Kessler D, Pusic M, Chang TP, et al. Impact of just-in-time and just-in-place simulation on intern success with infant lumbar puncture. Pediatrics 2015;135:e1237–46.
21. Issenberg SB, McGaghie WC, Petrusa ER, Gordon DL, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach 2005;27:10–28.
22. Cheng A, Kessler D, Mackinnon R, et al. Reporting guidelines for health care simulation research: extensions to the CONSORT and STROBE statements. Adv Simul 2016;1:25.
23. Sawyer T, Eppich W, Brett-Fleegler M, Grant V, Cheng A. More than one way to debrief: a critical review of healthcare simulation debriefing methods. Simul Healthc 2016;11:209–17.
24. Eppich W, Cheng A. Promoting excellence and reflective learning in simulation (PEARLS): development and rationale for a blended approach to health care simulation debriefing. Simul Healthc 2015;10:106–15.
25. Wong AH, Tiyyagura GK, Dodington JM, Hawkins B, Hersey D, Auerbach MA. Facilitating tough conversations: using an innovative simulation-primed qualitative inquiry in pediatric research. Acad Pediatr 2017;17:807–13.
26. Arafeh JM, Hansen SS, Nichols A. Debriefing in simulated-based learning: facilitating a reflective discussion. J Perinat Neonatal Nurs 2010;24:302–9.
27. Curry L, Nunez-Smith M. Mixed Methods in Health Sciences Research: A Practical Primer. Thousand Oaks (CA): SAGE Publications, 2015. https://us.sagepub.com/en-us/nam/mixed-methods-in-health-sciences-research/book241457
28. Creswell JW. Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. Boston: Pearson Education Inc, 2015. https://eric.ed.gov/?id=ED556110
29. Curry LA, Nembhard IM, Bradley EH. Qualitative and mixed methods provide unique contributions to outcomes research. Circulation 2009;119:1442–52.

30. Choo EK, Garro AC, Ranney ML, Meisel ZF, Morrow Guthrie K. Qualitative research in emergency care part I: research principles and common applications. Acad Emerg Med 2015;22:1096–102.
31. Starks H, Trinidad SB. Choose your method: a comparison of phenomenology, discourse analysis, and grounded theory. Qual Health Res 2007;17:1372–80.
32. Ranney ML, Meisel ZF, Choo EK, Garro AC, Sasson C, Morrow Guthrie K. Interview-based qualitative research in emergency care part II: data collection, analysis and results reporting. Acad Emerg Med 2015;22:1103–12.
33. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research. Acad Med 2014;89:1245–51.
34. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Heal Care 2007;19:349–57.
35. Watling CJ, Lingard L. Grounded theory in medical education research: AMEE Guide No. 70. Med Teach 2012;34:850–61.
36. Sargeant J. Qualitative research part II: participants, analysis, and quality assurance. J Grad Med Educ 2012;4:1–3.
37. Gangadharan S, Tiyyagura G, Gawel M, et al. A grounded theory qualitative analysis of interprofessional providers' perceptions on caring for critically ill infants and children in pediatric and general emergency departments. Pediatr Emerg Care 2016 [Epub ahead of print]. https://journals.lww.com/pec-online/Abstract/publishahead/A_Grounded_Theory_Qualitative_Analysis_of.98890.aspx
38. Chime NO, Katznelson J, Gangadharan S, et al. Comparing practice patterns between pediatric and general emergency medicine physicians: a scoping review. Pediatr Emerg Care 2017;33:278–86.
39. Fleiszer AR, Semenic SE, Ritchie JA, Richer MC, Denis JL. The sustainability of healthcare innovations: a concept analysis. J Adv Nurs 2015;71:1484–98.
40. Stumbo SP, Ford JH, Green CA. Factors influencing the long-term sustainment of quality improvements made in addiction treatment facilities: a qualitative study. Addict Sci Clin Pract 2017;12:26.
41. Highlights of the 2015 American Heart Association Guideline. Highlights 2015 Am Hear Assoc Guidel Updat CPR ECC. Dallas: American Heart Association, 2015. pp. 1–36.
42. Guidelines for the Early Management of Patients with Acute Ischemic Stroke: A Guideline for Healthcare Professionals from the American Heart Association/American Stroke Association. Dallas: American Heart Association, 2013.
43. Lorch S a, Myers S, Carr B. The regionalization of pediatric health care. Pediatrics 2010;126:1182–90.
44. Query LA, Olson KR, Meyer MT, Drendel AL. Minding the Gap: Understanding Emergency Medicine Clinician Experiences to Optimize Care for Critically Ill Children in the General Emergency Department. Abstract Presented at the Society for Academic Emergency Medicine Meeting, May 2018.
45. Nederhof AJ. Methods of coping with social desirability bias: a review. Eur J Soc Psychol 1985;15:263–80.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13509/full

Data Supplement S1. Agenda for Community ED Clinician Interviews.

Adherence to Pediatric Cardiac Arrest Guidelines Across a Spectrum of Fifty Emergency Departments: A Prospective, In Situ, Simulation-based Study

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ABSTRACT

Background and Objectives: Pediatric out-of-hospital cardiac arrest survival outcomes are dismal (<10%). Care that is provided in adherence to established guidelines has been associated with improved survival. Lower mortality rates have been reported in higher-volume hospitals, teaching hospitals, and trauma centers. The primary objective of this article was to explore the relationship of hospital characteristics, such as annual pediatric patient volume, to adherence to pediatric cardiac arrest guidelines during an in situ simulation. Secondary objectives included comparing adherence to other team, provider, and system factors.

Methods: This prospective, multicenter, observational study evaluated interprofessional teams in their native emergency department (ED) resuscitation bays caring for a simulated 5-year-old child presenting in cardiac arrest. The primary outcome, adherence to the American Heart Association pediatric guidelines, was assessed using a 14-item tool including three component domains: basic life support (BLS), pulseless electrical activity (PEA), and ventricular fibrillation (VF). Provider, team, and hospital-level data were collected as independent data. EDs were evaluated in four pediatric volume groups (low < 1,800/year; medium 1,800–4,999; medium-high 5,000–9,999; high > 10,000). Cardiac arrest adherence and domains were evaluated by pediatric patient volume and other

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team and hospital-level characteristics, and path analyses were performed to evaluate the contribution of patient volume, systems readiness, and teamwork on BLS, PEA, and VF adherence.

Results: A total of 101 teams from a spectrum of 50 EDs participated including nine low pediatric volume (<1,800/year), 36 medium volume (1,800–4,999/year), 24 medium-high (5,000–9,999/year), and 32 high volume (≥10000/year). The median total adherence score was 57.1 (interquartile range = 50.0–78.6). This was not significantly different across the four volume groups. The highest level of adherence for BLS and PEA domains was noted in the medium-high–volume sites, while no difference was noted for the VF domain. The lowest level of BLS adherence was noted in the lowest-volume EDs. Improved adherence was not directly associated with higher pediatric readiness survey (PRS) score provider experience, simulation teamwork performance, or more providers with Pediatric Advanced Life Support (PALS) training. EDs in teaching hospitals with a trauma center designation that served only children demonstrated higher adherence compared to nonteaching hospitals (64.3 vs 57.1), nontrauma centers (64.3 vs. 57.1), and mixed pediatric and adult departments (67.9 vs. 57.1), respectively. The overall effect sizes for total cardiac adherence score are ED type $\gamma = 0.47$ and pediatric volume (low and medium vs. medium-high and high) $\gamma = 0.41$. A series of path analyses models was conducted that indicated that overall pediatric ED volume predicted significantly better guideline adherence, but the effect of volume on performance was only mediated by the PRS for the VF domain.

Conclusions: This study demonstrated variable adherence to pediatric cardiac arrest guidelines across a spectrum of EDs. Overall adherence was not associated with ED pediatric volume. Medium-high–volume EDs demonstrated the highest levels of adherence for BLS and PEA. Lower-volume EDs were noted to have lower adherence to BLS guidelines. Improved adherence was not directly associated with higher PRS score provider experience, simulation teamwork performance, or more providers with PALS training. This study demonstrates that current approaches optimizing the care of children in cardiac arrest in the ED (provider training, teamwork training, environmental preparation) are insufficient.

Pediatric out-of-hospital cardiac arrest (p-OHCA) survival rates to hospital discharge with favorable neurologic outcomes range from 10% to 20%.[1–7] Outcomes are affected by a variety of factors including bystander cardiopulmonary resuscitation (CPR), the quality of prehospital care provided, and the arrest and postarrest care these children subsequently receive in the emergency department (ED) and intensive care unit. In the United States, ED care is provided to these children across a spectrum of over 5,000 hospitals.[8] Survival rates for nontraumatic p-OHCA are higher in EDs that care for children only compared to EDs that care for a mix of adults and children (odds ratio [OR] = 2.2, 95% confidence interval [CI] = 1.7–2.8).[9] Improved survival has also been noted when children are cared for in EDs classified as teaching hospitals (OR = 0.57, 95% CI = 0.50–0.66) or trauma centers (OR = 0.76, 95% CI = 067–0.86).[10] This study noted a difference in survival based on total annual ED volume, but was not able to comment on the association with annual pediatric volume. Another recent pediatric study across 108 centers found wide variability in mortality but did not find higher annual pediatric volumes to be associated with outcomes.[11] For adult patients, EDs with higher patient volumes have improved survival rates, supporting the volume–outcome relationship.[12,13]

Paradoxically, the majority of emergency care for children is not provided in high-volume or pediatric-only EDs.[8] Instead, most children in cardiac arrest are cared for in the ED closest to their home that likely cares for both children and adults.[8,14] These community EDs vary in terms of the total volume of pediatric patients, and many children present to EDs that care for fewer than five children per day.[15] These lower-pediatric-volume EDs have been noted to be less "pediatric ready" when measured by a national survey.[8] A recent report noted that 30% of U.S. children do not live within a 30-minute drive time to an ED with high pediatric readiness.[16]

To provide equitable care to children in cardiac arrest, all EDs should be expected to provide care that is adherent to evidence-based guidelines. Adherence to the current American Heart Association (AHA) life support guidelines has been associated with improved survival.[17–20] Registries have been developed to measure adherence, explore the association of adherence and survival, and identify gaps in adherence as targets for improvement interventions.[21–23] Adherence to AHA guidelines in EDs has been described in adult patients; however, there are limited data on adherence to AHA guidelines in pediatric patients.[21,24,25] There are few detailed descriptions of adherence to pediatric cardiac arrest guidelines across the spectrum of EDs. Understanding factors that explain variations in adherence could help to identify modifiable factors at the provider or institutional level. Examination of these mediating factors is increasing in clinical research and

may be an effective approach to identify pathways of modification and thus direct resources to effect change in the measured outcome.[26]

The low frequency of pediatric cardiac arrest events in children, and particularly in lower-volume community EDs, necessitates novel approaches to research. Simulation-based research allows for the "on-demand" presentation of a patient with identical characteristics and preprogrammed responses to interventions. In situ simulation allows for measurement of interprofessional healthcare teams caring for this simulated patient in their own setting utilizing their own equipment and resources.[27,28] This approach has been increasingly used to evaluate clinical settings and systems to help optimize emergency care.[29,30]

The primary objective of this article was to utilize in situ simulation to explore the relationship of hospital characteristics, particularly patient volume, to adherence to pediatric cardiac arrest guidelines. Secondary objectives included comparing adherence to other hospital, team, and provider factors. We hypothesized that the percent adherence to cardiac arrest guidelines would be associated with the annual pediatric patient volume of the ED (that EDs that care for more children would provide higher-quality care).

METHODS

Study Setting and Population

A group of investigators within INSPIRE[31] (International Network for Simulation-based Pediatric Innovation, Research, & Education) recruited teams of providers from their institutions' ED and other EDs in their geographic region. A spectrum of EDs was purposefully sampled to include various sizes, geographic locations, and staffing models across seven states. Each study session involved a series of simulations in an ED resuscitation room using local equipment, policies, and procedures. Individual providers were recruited to participate, with the goal of replicating an interprofessional team consistent with actual practice, including a minimum one physician or physician's assistant, three nurses, and two certified nursing assistants or emergency medical technicians. EDs staffed by a pharmacist or respiratory therapist included these individuals in recruitment. Each ED director recruited participants over a 1-month period by populating a sign-up sheet on a first-come, first-served basis. Institutional review board approval was obtained from each of the collaborating academic medical centers for this project with the coordinating site and data center located at Yale University School of Medicine.

Study Protocol

This prospective, multicenter, cohort study evaluated interprofessional teams in their native ED resuscitation bays caring for a simulated 5-year-old child presenting in cardiac arrest. After informed consent was obtained, participants completed an anonymous survey on basic demographic information, professional length of clinical experience, and Pediatric Advanced Life Support (PALS) training. The cardiac arrest case was the fourth and final case at all sites and was preceded by three cases: foreign body aspiration, sepsis, and seizure. Each case was followed by a 30-minute scripted debriefing led by investigators (Data Supplements S1 and S2, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13564/full). The debriefings of the first three cases did not discuss cardiac arrest guidelines or management.

Standardization of Simulation Scenarios and Environment

The teams were given a brief scripted introduction to the simulation including the functionality of the child-sized mannequin (Laerdal MegaCode Kid) and familiarization of the simulated medication drawer (Demodose, PocketNurse). Participants were instructed on how to place the patient on a monitor, insert an intravenous line, place pads, and administer medications. Teams were instructed to use their own local EDs real equipment and resources (cognitive aids, policies, protocols). They were informed that a monitor would display the vital signs and that point-of-care laboratory testing was available upon request. Finally, the participants were introduced to the parent actor, who could verbally supply patient history, and the facilitator, who could verbally provide additional clinical information to the team. The case initiated with an "EMS call" that reported the impending arrival of a 5-year-old drowning victim presenting in cardiac arrest and unfolded in real time dependent on the teams' interventions. The preprogrammed scenario and checklist were created for a prior study and iteratively refined for use in this study. A priori management goals for the successful completion of the case included the appropriate initial management of the

presenting rhythm of pulseless electrical activity (PEA). After two doses of epinephrine the rhythm changed to ventricular fibrillation (VF) requiring defibrillation and resulting in a return of spontaneous circulation (Data Supplements S1 and S2).

Measures

Cardiac Arrest Adherence Score. The adherence score was derived from the AHA 2010 PALS and basic life support (BLS) guidelines and consisted of 14 components across three domains (Table 1).[32] Each component was scored dichotomously as absent or present. Data were collected by a trained researcher at each site in real time during the simulation. All simulations were videotaped from two standardized camera angles (above the mannequin head and a panoramic of the room) with integrated multidirectional microphones and device to extract the monitor output using B-Line Live Capture Ultraportable (B-Line Medical).[33] This allowed for data capture of specific timing and task completion through video review of performance. Videos were scored by two investigators to collect data on quantitative factors including the rate of compressions and rate of ventilations and recorded the duration of pauses in CPR using the Counter+ iPhone application.[34] Discrepancies in scoring were discussed until consensus was achieved upon rereview of the videos.

Provider Variables. Participants provided demographic and baseline data via an online data collection instrument (Data Supplements S1 and S2).[35] An MD composition variable was calculated for each team as the percentage of physicians on each team. This variable was calculated as the ratio of physician team members divided by nonphysician team members such as nurses and techs. Each team had a minimum of one MD and two RNs. The number of team members in each of the teams was not standardized in an effort to match the actual clinical staffing in each ED. Experience level of the team was calculated as the median number of years of experience for each team. Providers reported prior PALS training, and this was calculated as the percentage of team members who had prior PALS training.

Table 1
Adherence Score With Subcomponents

Subcomponent	Elements (Yes/No)
BLS	Compression rate 100–120/min Ventilation rate 8–10/min Backboard used Compressor change every 120 sec Interruptions other than preshock pause > 10 sec CPR fraction > 80% (time on chest/time off chest)
PEA	Pulse check < 120 sec after start Verbalize PEA rhythm Epinephrine first correct dose (1.6–2.4 mL) Epinephrine second correct dose (1.6–2.4 ml) 3–5 min after first
VF	Preshock pause > 10 sec Verbalize VF rhythm Defibrillation 1–4 J/kg Resume compressions < 10 sec after defib + continue 120 sec

BLS = basic life support; PEA = pulseless electrical activity; VF = ventricular fibrillation.

Team Variables. Team performance was measured using the Simulation Team Assessment Tool (STAT).[36] The STAT is a published assessment tool with validity evidence for the case used in this project across four domains of pediatric emergency care including basic assessment, airway/breathing, circulation, and human factors/teamwork. The human factors/teamwork element of the STAT consists of 26 variables measuring three domains of teamwork including teamwork, leadership, and team management. These variables were scored on a trichotomous scale as 2 points (complete and timely), 1 point (incomplete), and 0 (needed and not done). Each team's STAT performance was scored through an additional retrospective video review by an attending physician, a nurse, and a resident physician (separate from the medical management scoring review). These three raters all completed 2 hours of rater training and 2 hours of rater calibration with the team who developed this tool.

Hospital/System Variables. Systems-level factors were measured using the Emergency Medical Services for Children (EMSC) National Pediatric Readiness Survey (PRS). This survey was completed at each site by nursing or physician leadership. This survey collects information regarding the pediatric preparedness of each institution including details on pediatric equipment, medications, and supplies; staff with pediatric expertise; and pediatric-specific policies, procedures, and protocols.[8] The survey elements were from the guidelines created by the American Academy of Pediatrics, The American College of Emergency Physicians, and Emergency Nurses Association in 2009.[37] PRS score of 100 indicates meeting the essential elements

for pediatric readiness. The research team obtained permission to use this instrument from its developers for this study.

Data Analysis

Adherence data were gathered as described above and manually entered into Microsoft Excel version 14.0 (Microsoft Corp.) and transferred into SAS Version 9.2 (SAS Institute) for analysis. All data were examined for missing values. We determined a priori that teams with missing data related to the primary outcome would be excluded from analysis. None of the teams had missing data for the primary outcome. Some teams lacked teamwork score data owing to either lack of consent for videotaping or technical issues involving difficulty in hearing the audio feed to evaluate communication. Imputed scores versus scores deleted did not render any difference in outcome analyses. After these sensitivity analyses, we treated the data points as missing at random and used imputed scores to replace missing data. Analysis of data distribution and homogeneity of variance were conducted and informed the selection of appropriate statistical tests.

The primary outcome variable was the total 14-component AHA adherence score divided into three cardiac arrest domains scores (BLS, PEA, VF). Each element was scored dichotomously (1 = adherent, 0 = not) and summed. A review of the distribution of total adherence score and three subscores demonstrated that all scores showed significant deviations from normality. Descriptive analyses were conducted, and team and hospital characteristics were reported by ED volume category by Pearson's chi-square tests or Mann-Whitney U-tests. The total adherence and subscores were examined by ED characteristics and assessed by Mann-Whitney U-tests. We examined differences in median cardiac adherence score by pediatric volume using the Wilcoxon test with the Dwass, Steel, Critchlow-Fligner method for pairwise comparisons. We report on differences in the cardiac arrest scores by sites and ED types with appropriate 95% CIs.

To examine the relationship between variables to predict the adherence subscores, we conducted a path analysis. This analysis used structural equation modeling examining the effect various variables (annual volume of pediatric patients treated, PRS score, STAT score, site team's experience in years, ratio of team members with PALS training, and the ratio of physicians to total team membership) had on the adherence subscores. For ease of interpretation, the predictor variables were centered on the median scores across the teams with the exception of pediatric volume size which was categorized by annual pediatric volume. We report the effect size difference in cardiac adherence by ED type and pediatric volume size using the Hedges and Olkin gamma index, which returns an effect size estimator based on the proportional difference between groups in values above the overall median adherence scores (using an alpha of 0.05).

These predictors were used in individual path analyses models predicting the three cardiac arrest domains using a PROC CALIS procedure in SAS software version 9.4 (SAS Institute, Inc.). For these models, we utilized full information maximum likelihood estimation to any response sets with missing data. Statistical significance of paths was evaluated using an a priori alpha level of 0.05, two-tailed, and the overall fit of models was judged well-fitting with comparative fit index (goodness of fit $\geq$ 0.05; Bentler comparative fit index $\geq$ 0.95), and root mean square error of approximation ($\leq$0.05). We also used the Barron and Kenny test (1986) of the joint significance of the mediation paths (a and b; see Figure 1) to indicate that full mediation has occurred and the product of the paths (a $\times$ b) to assess the amount of mediation accounted for,[38] and the tests of significance of the products of the paths were conducted using the Sobel test.[39]

RESULTS

In total, 50 EDs with 101 individual teams were assessed: 16 teams were from PEDs and the remainder from GEDs. The teams and EDs varied in pediatric patient volumes; with 45 (44.5%) teams categorized as low to medium pediatric volume (<5,000 annual census) and 56 as medium-high to high (5,000 to >10,000 annual census). Table 2 shows the demographic characteristics of the sites and teams within these sites categorized by annual pediatric volume. There were significant differences in the pediatric patient volume, PRS scores, teaching hospital status, the presence of inpatient pediatrics, trauma center status, ED type, team MD composition, median PRS scores, and experience of teams.

Adherence Scores

Teams with higher levels of provider experience or percentages of providers with current PALS training did not demonstrate improved adherence. Neither teams with improved teamwork as measured by the

Table 2
Team and Hospital Characteristics by Pediatric ED Volume

	Volume Category				
	Low Pediatric Volume (<1,800 Patients)	Medium Pediatric Volume (1,800–4,999 Patients)	Medium-high Pediatric Volume (5,000–9,999 Patients)	High Pediatric Volume (≥10,000 Patients)	p-value
Teams, *n*	9	36	24	32	
Hospital characteristics					
Total patient volume/year	31,000 (26,000–36,000)	40,000 (37,000–56,500)	50,000 (44,000–88,000)	55,000 (48,000–80,000)	<0.001
PRS score	61.1 (49.3–72.9)	57.0 (44.8–79.6)	60.4 (54.0–81.5)	95.8 (92.7–97.6)	<0.001
Rural/urban					0.080
Rural	1 (11)	9 (25)	5 (21)	1 (3)	
Urban	8 (89)	27 (75)	19 (79)	31 (97)	
Teaching hospital					
No	7 (78)	28 (78)	18 (75)	2 (6)	<0.001
Yes	2 (22)	8 (22)	6 (25)	30 (94)	
Inpatient pediatrics					<0.001
No	8 (89)	32 (89)	15 (63)	1 (3)	
Yes	1 (11)	4 (11)	9 (38)	31 (97)	
Trauma center					<0.001
No	7 (78)	36 (100)	21 (88)	2 (6)	
Yes	2 (22)	0 (0)	3 (13)	30 (94)	
ED type					<0.001
General ED	9 (100)	36 (100)	24 (100)	16 (50)	
Pediatric ED	0 (0)	0 (0)	0 (0)	16 (50)	
Team characteristics					
STAT teamwork score	75.0 (71.6–85.2)	81.8 (79.6–88.)	71.4 (62.5–80.7)	84.1 (73.9–92.1)	0.266
% MD composition	17 (14–21)	15 (12–17)	14 (11–17)	33 (20–43)	<0.001
% with PALS training	67 (59–83)	64 (32–88)	83 (71–89)	92 (82–100)	0.076
Team composite experience in years	18.1 (15.9–21.3)	10.4 (8.5–17.2)	8.9 (7.5–13.1)	11.0 (8.6–16.7)	<0.001

Data are reported as median (IQR) or *n* (%).
IQR = interquartile range; PALS = Pediatric Advance Life Support; PRS = pediatric readiness survey; STAT = Simulation Team Assessment Tool.

STAT tool nor hospitals with higher PRS as measured by the EMSC survey. demonstrated improved adherence.

Table 3 presents the mean score for the total adherence score and medians for the three subscores by ED type. While the total cardiac arrest score was not significantly different by annual pediatric patient volume, there was a trend by volume, whereby the low-volume EDs had the lowest cardiac arrest adherence (median = 50, 95% interquartile range [IQR] = 36–79) and the medium-high–volume EDs had the highest cardiac arrest adherence (median = 71, IQR = 52–79). We conducted pairwise comparison across the four pediatric volume groups; there were no significant pairwise differences in the total cardiac adherence scores. There were significant differences in BLS subscores by pediatric volume, with again the low-volume EDs scoring the lowest (median = 33, IQR = 17–67) and the medium-high–volume EDs scoring highest (median = 67, IQR = 50–67). The overall effect sizes for total cardiac adherence score are ED type $\gamma = 0.47$ and pediatric volume (low and medium vs. medium-high and high) $\gamma = 0.41$.

Table 4 presents the percent adherence for all components by hospital volume. For the BLS domain, the ventilation rate, changing compressors and CPR fraction were all different across volume groups. For the PEA domain, the higher-volume departments were more likely to check a pulse prior to initiating CPR; however, the other variables were similar across

Table 3
Guideline Adherence by Annual ED Pediatric Volume

	All Sites $N = 100$	Pediatric patient volume			
		Low $n = 9$	Medium $n = 35$	Medium-high $n = 24$	High $n = 32$
BLS					
Compression rate 100–120/min	73.7	66.7	65.7	75.0	83.9
Ventilation rate 8–10/min	44.0	11.1	25.7	62.5	59.4
Backboard used	35.0	33.3	28.6	33.3	43.8
Compressor change	33.0	22.2	25.7	58.3	25.0
Interruption other than preshock	30.0	22.2	37.1	29.2	25.0
CPR fraction > 80%	84.0	77.8	71.4	87.5	96.9
PEA					
Pulse check < 120 sec	58.0	44.4	40.0	83.3	62.5
Verbalize PEA rhythm	83.0	88.9	77.1	83.3	87.5
Epinephrine first	78.0	66.7	77.1	70.8	87.5
Epinephrine second	70.7	77.8	71.4	70.8	67.7
VF					
Preshock pause	60.0	77.8	51.4	75.0	53.1
Recognize/verbalize fibrillation	78.8	77.8	82.9	65.2	84.4
Defibrillation correct	70.0	55.6	71.4	79.2	65.6
Resume compression after defib	53.0	33.3	51.4	58.3	56.3

BLS = Basic Life Support; CPR = cardiopulmonary resuscitation; ETT = endotracheal tube; PALS = Pediatric Advanced Life Support; PEA = pulseless electrical activity; VF = ventricular fibrillation.

Table 4
Cardiac Arrest Guideline Adherence Elements by Hospital Factors

	Score			
Element	Total Adherence Score	BLS Subscore	PEA Subscore	VF Subscore
Pediatric patient volume	57.1 (50.0–78.6)	50 (33–67)	75 (50–100)	75 (50–75)
Low	50.0 (35.7–78.6)	33 (17–67)	75 (38–100)	75 (25–88)
Medium	57.1 (45.8–71.4)	33 (17–67)	75 (50–75)	75 (50–100)
Medium-high	71.4 (51.8–78.6)	67 (50–67)	88 (50–100)	75 (50–75)
High	60.7 (51.8–76.8)	50 (33–67)	75 (50–100)	75 (50–75)
Rural/urban				
Rural	57.1 (35.7–71.4)	50 (17–50)	75 (50–94)	63 (25–75)
Urban	57.1 (50.0–78.6)	50 (33–67)	75 (50–100)	75 (50–75)
Teaching hospital				
No	57.1 (35.7–71.4)	50 (17–67)	75 (50–75)	75 (50–75)
Yes	64.3 (50.0–78.6)	58 (33–67)	75 (50–100)	75 (50–100)
Inpatient pediatrics				
No	57.1 (35.7–71.4)	50 (17–67)	75 (50–100)	75 (50–75)
Yes	57.1 (50–78.6)	50 (33–67)	75 (50–100)	75 (50–100)
Trauma center				
No	57.1 (41.1–85.7)	50 (17–67)	75 (50–100)	75 (43.8–75)
Yes	64.3 (57.1–78.6)	67 (33–67)	75 (50–100)	75 (50–75)
ED type				
General ED	57.1 (42.9–75.0)	50 (33–67)	75. (50–100)	75 (50–75)
Pediatric ED	67.9 (57.1–83.9)	67 (33–67)	88 (56–100)	75 (50–94)

Data are reported as median (IQR).
PALS = Pediatric Advanced Life Support; BLS = basic life support; PEA = pulseless electrical activity; VF = ventricular fibrillation.

groups. For the VF domain no difference was noted across the volume groups in any of the domains.

There were significant differences in total cardiac arrest scores by teaching hospital status, trauma center status, and ED type (pediatric or general). Teaching hospitals, trauma centers, and pediatric EDs had higher cardiac arrest adherence compared to nonteaching hospitals (64.3% vs 57.1%, Δ = 7.2%, 95% CI = 2.2–12.2), nontrauma centers (64.3 vs. 57.1, Δ = 7.3%, 95% CI = 2.3–12.3), and general EDs (67.9 vs. 57.1, Δ = 10.8%, 95% CI = 4.7–16.9), respectively.

Path Analysis of Factors Contributing to Three Cardiac Arrest Domain Scores

Figure 1 shows the results of the structural equation modeling ("path analyses") with each cardiac arrest subscore—BLS, PEA, and VF—modeled separately (see Figure 1, Models 1, 2, and 3, respectively). For clarity of presentation only those variables with significant path coefficients were displayed in Figure 1 and presented in Table 5. Table 5 shows the results of the path analysis with all three models having acceptable fit statics indicating that the model was well specified. There was a significant direct path between

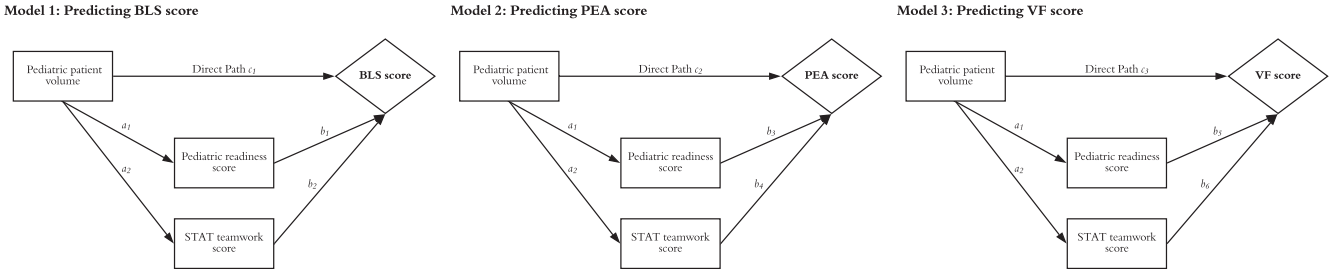

Figure 1. Results of the structural equation modeling ("path analyses") with each cardiac arrest subscore—BLS, PEA, and VF—modeled separately. BLS = basic life support; PEA = pulseless electrical activity; VF = ventricular fibrillation.

Table 5
Path Coefficients for Direct and Mediational Paths Between Median Pediatric Volume and Performance and the Three Cardiac Arrest Domain Scores

Path	β	SE	Model Fit Statistics
Model 1			
Pediatric volume to BLS score C1	0.34**	0.10	χ^2 (2) = 1.59, p = 0.45 GFI = 0.99 BCFI = 0.99 RMSEA = 0.06
Pediatric volume to PRS score a1	0.50***	0.08	
Pediatric volume to STAT score a2	0.24*		
PRS to BLS score b1	–0.01	0.11	
STAT to BLS score b2	0.05	0.10	
Model 2			
Pediatric volume to PEA score C2	0.23*	0.11	χ^2 (2) = 1.46; p = 0.22 GFI = 0.99 BCFI = 0.99 RMSEA = 0.05
PRS to PEA score b3	–0.08	0.12	
STAT to PEA score b4	0.03	0.11	
Model 3			
Pediatric volume to VF score C3	0.13	0.12	χ^2 (2) = 1.12; p = 0.18 GFI = 0.97 BCFI = 0.99 RMSEA = 0.04
PRS to VF score b5	0.22*	0.11	
STAT to VF score b6	0.05	0.11	

BLS = Basic Life Support; GFI = goodness of fit; BCFI = Bentler comparative fit index; PEA = pulseless electrical activity; RMSEA = root mean square error of approximation; STAT = Simulation Team Assessment Tool; VF = ventricular fibrillation.
*p < 0.05; **p > 0.01; ***p < 0.001.

median pediatric volume and the BLS and PEA cardiac arrest domain scores, which indicated that teams whose pediatric volume was higher than the median (adjusted for type—PED vs. GED) had a significantly better cardiac arrest domain score. Pediatric patient volume directly predicted both STAT and PRS scores, but the effects of PRS scores on the cardiac arrest domains was only evident for VF. The Sobel tests indicates that the mediation of pediatric patient volume on VF domain performance through teamwork was significant ($t = 2.08$, $p = 0.04$).

DISCUSSION

Our study demonstrates significant variability in adherence to pediatric cardiac arrest guidelines across a spectrum of EDs. Contrary to our hypothesis, EDs with higher pediatric volumes did not have higher total cardiac adherence scores when we used pairwise comparisons. However, higher adherence was noted for the BLS domain. This finding contrasts with recent clinical data demonstrating improved survival in children presenting to higher-pediatric-volume EDs and academic medical centers.[9–13]

Related to provider and team factors, all sites had comparable percentages of PALS-trained individuals, numbers of MDs in each team and reported team experience, suggesting that these factors did not affect adherence. Most study participants were current in their PALS certification, suggesting that the current training every 2 years may not be sufficient to ensure the provision of care in adherence to guidelines.

We conducted the mediation analyses to try to explain differences in team performance from the perspective of potentially modifiable factors that could be addressed at an ED site. Although pediatric volume had a direct effect on performance for the PEA and BLS cardiac domain scores, this in itself is not a modifiable factor, but we felt that it was important to understand the mechanism by which pediatric volume could operate on team performance across the cardiac skills we measured. Across all of the mediation models tested, pediatric volume did predict better teamwork and pediatric emergency preparedness. However, the only complete mediation path that was significant was the effect of PRS on VF performance as a significant explanation of why EDs with larger volumes performed better on this domain. As the PRS measures systems-level factors indicating pediatric emergency preparedness (such as details on pediatric equipment, medications, and supplies; staff with pediatric expertise; and pediatric-specific policies, procedures, and protocols), this suggests that the effect of the site ability for pediatric emergency preparedness is driving the performance of these teams.[8]

The differences noted in BLS guideline adherence based on volume could be related to the differences in guidelines for children and adults. EDs that less frequently care for children may be more likely to hyperventilate due to stress or a lack of the requisite knowledge and skills. The lower adherence to the BLS component of changing compressors every 2 minutes may be associated with the more frequent use of smaller teams in these lower-volume EDs that are often in underresourced community settings (although our team size was standardized). This could result in a team member being more accustomed to continuing CPR without changing compressors, potentially leading to provider fatigue. Additionally, providers who generally care for adults may perceive the physical demands of pediatric CPR as "easy" compared to what is required for CPR in an adult, thus not requiring changes in compressors due to fatigue. Unfortunately, many teams had multiple interruptions of greater than 10 seconds during the care of this child in cardiac arrest. These interruptions have been associated with worse outcomes in clinical studies.[40] Although we did not collect quantitative data related to the etiology pauses, the study team noted the following elements of care resulting in pauses: 1) intubation procedure, 2) application of pads/preshock, 3) postshock delays, 4) rhythm checks, 5) changes in compressors, and 6) placement of the backboard. The use of a backboard was rare across all groups, in the debriefings, EDs reported that EMS would typically arrive with the patient on a board. The patient did not arrive on a board in our simulation and this may have differed from the actual care provided by EMS in these EDs; however, many pediatric patients are not brought into the ED by EMS and therefore would not have a backboard. The difference in pulse check between EDs in the PEA domain could be explained by the prototypical adult arrest victim has suffered a fibrillation arrest and is less likely to have a pulse upon presentation This could also be attributed to discomfort of the low-pediatric-volume providers in assessing pulses in children.

For the PEA domain, the majority of teams rapidly recognized and verbalized PEA and administered two doses of epinephrine. For the VF domain, it was surprising that the higher-pediatric-volume centers, which

care for few adults, did not demonstrate inferior adherence. We expected that the mixed EDs who care for more adult patients would be more likely to be accustomed to using a defibrillator and applying the correct dose of epinephrine and energy. Half of all of the EDs did not continue CPR immediately after defibrillation; rather, they immediately checked the patient's pulse, leading to a delay in CPR or unnecessary postshock pause.

The variation in survival in different ED types is impacted by adherence to guidelines in the ED. The variation noted during ED care in this study does not fully explain the differences in survival from cardiac arrest noted in other studies. This is because survival from cardiac arrest is dependent on care across the chain of survival. Prior to the hospital, this includes the recognition of arrest, activation of EMS, bystander CPR, access to and application of electricity by bystanders, and basic/advanced EMS skills by EMS. These factors directly impact the patients state upon entering the ED. After the patient's arrival to the ED, the quality of postresuscitation care in the hospital (e.g., access to PICU or ECMO) and in rehabilitation centers also impact outcomes. Additional research is needed across these environments to understand the impact of each element. While many children with cardiac arrest initially present to a lower-volume ED, these patients will often be transferred to a higher-volume ED. Efforts to improve outcomes in the prehospital setting include CPR training for public and access to defibrillators.

Our study findings support recent literature showing variability in adherence to resuscitation guidelines and provide more granular data based on our use of simulation for measurement. These data could be used to inform the development of improvement interventions. Recent publications have reported improved adherence to guidelines with the use of bedside skills refreshers, simulation-based CPR curricula, formalized debriefing of real CPR events, and real-time CPR feedback.[41–45] Multiple studies have demonstrated that the skills acquired during advanced life support training programs deteriorate rapidly, within 3 to 12 months postcourse.[46–48] Brief, focused, and frequent retraining sessions improve skills retention and show promise as a new standard for training of ED providers.[49–51]

LIMITATIONS

Limitations of our study include our use of simulated resuscitation scenarios to measure guideline adherence. Our recruitment methods likely led to selection bias with individuals agreeing to participate being more or less skilled than other staff; however, this bias would be present in all EDs. The involvement of providers without other clinical duties at a scheduled announced time may limit generalizability. This approach was required to maximize participation and to minimize the impact on real patient care. The scheduling of the simulation sessions may have resulted in providers and/or the EDs preparing for the day. The three preceding simulations may have led to a training effect. Reviewers in our study were not blinded to ED type and this may have impacted their ratings. The initial study protocol planned to use blinded reviewers; however, after conducting the first series of simulations, we recognized that collecting the quantitative data for cases required both in-person and video-based data collection. To ensure consistency, in addition to the in-person ratings, two investigators scored all cases independently using video-based review. True blinding was not feasible due to the presence of hospital names on signage and participants' clothing. Additionally, the context of this study was limited to the ED care of these patients. Future work is needed to study the care provided across the chain of survival including prehospital (recognition and activation of EMS, bystander CPR [time to and quality of], access to and application of electricity by bystanders, and basic and advanced EMS) and postresuscitation care (in hospital and rehabilitation). Strengths of our study include our use of in situ methodology, allowing providers to respond to a cardiac arrest in their actual work environment, utilizing real equipment, resources, and personnel unique to their location.

CONCLUSIONS

This study demonstrated variable adherence to pediatric cardiac arrest guidelines across a spectrum of EDs. Overall adherence to cardiac arrest guidelines was not associated with ED pediatric volume. Medium-high–volume EDs demonstrated the highest levels of adherence for basic life support and pulseless electrical activity. Lower-volume EDs were noted to have lower adherence to basic life support guidelines. Improved adherence was not directly associated with higher pediatric readiness survey scores provider experience or simulation teamwork performance or more providers with Pediatric Advanced Life Support training. This study demonstrates that current approaches

to optimizing the care of children in cardiac arrest in the ED (provider training, teamwork training, environmental preparation) are insufficient.

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References

1. Bardai A, Berdowski J, van der Werf C, et al. Incidence, causes, and outcomes of out-of-hospital cardiac arrest in children. A comprehensive, prospective, population-based study in the Netherlands. J Am Coll Cardiol 2011;57:1822–8.
2. Atkins DL, Everson-Stewart S, Sears GK, et al. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. Circulation 2009;119:1484–91.
3. Donoghue AJ, Nadkarni V, Berg RA, et al. Out-of-hospital pediatric cardiac arrest: an epidemiologic review and assessment of current knowledge. Ann Emerg Med 2005;46:512–22.
4. Go AS, Mozaffarian D, Roger VL, et al. Heart disease and stroke statistics–2014 update: a report from the American Heart Association. Circulation 2014;129:e28–e292.
5. Kogaki S. Outcomes of pediatric out-of-hospital cardiac arrest. Circ J 2014;78:595–6.
6. Michiels EA, Dumas F, Quan L, Selby L, Copass M, Rea T. Long-term outcomes following pediatric out-of-hospital cardiac arrest*. Pediatr Crit Care Med 2013;14:755–60.
7. Young KD, Gausche-Hill M, McClung CD, Lewis RJ. A prospective, population-based study of the epidemiology and outcome of out-of-hospital pediatric cardiopulmonary arrest. Pediatrics 2004;114:157–64.
8. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
9. Michelson KA, Hudgins JD, Monuteaux MC, Bachur RG, Finkelstein JA. Cardiac arrest survival in pediatric and general emergency departments. Pediatrics 2018;141. pii: e20172741.
10. Hansen M, Fleischman R, Meckler G, Newgard CD. The association between hospital type and mortality among critically ill children in US EDs. Resuscitation 2013;84:488–91.
11. Gupta P, Tang X, Gall CM, Lauer C, Rice TB, Wetzel RC. Epidemiology and outcomes of in-hospital cardiac arrest in critically ill children across hospitals of varied center volume: a multi-center analysis. Resuscitation 2014;85:1473–9.
12. Johnson NJ, Salhi RA, Abella BS, Neumar RW, Gaieski DF, Carr BG. Emergency department factors associated with survival after sudden cardiac arrest. Resuscitation 2013;84:292–7.
13. Kocher KE, Haggins AN, Sabbatini AK, Sauser K, Sharp AL. Emergency department hospitalization volume and mortality in the United States. Ann Emerg Med 2014;64:446–57.e446.
14. Sullivan AF, Rudders SA, Gonsalves AL, Steptoe AP, Espinola JA, Camargo CA Jr. National survey of pediatric services available in US emergency departments. Int J Emerg Med 2013;6:13.
15. Whitfill T, Auerbach M, Scherzer D, Shi J, Xiang H, Stanley RM. Emergency care for children in the U.S.: epidemiology and trends over time. J Emerg Med 2018;55:423–34.
16. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. J Pediatr 2018;194:225–32.e221.
17. Aufderheide TP, Yannopoulos D, Lick CJ, et al. Implementing the 2005 American Heart Association Guidelines improves outcomes after out-of-hospital cardiac arrest. Heart Rhythm 2010;7:1357–62.
18. Christenson J, Andrusiek D, Everson-Stewart S, et al. Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation. Circulation 2009;120:1241–7.
19. Idris AH, Guffey D, Aufderheide TP, et al. Relationship between chest compression rates and outcomes from cardiac arrest. Circulation 2012;125:3004–12.
20. Sutton RM, French B, Niles DE, et al. 2010 American Heart Association recommended compression depths during pediatric in-hospital resuscitations are associated with survival. Resuscitation 2014;85:1179–84.
21. Chen Z, Freedman MS. CD16+ gammadelta T cells mediate antibody dependent cellular cytotoxicity: potential mechanism in the pathogenesis of multiple sclerosis. Clin Immunol 2008;128:219–27.
22. American Heart Association. Resuscitation Patient Management Tool. 2014. http://www.heart.org/idc/groups/heart-public/@private/@wcm/@hcm/@gwtg/documents/downloadable/ucm_457481.pdf. Accessed Apr 2, 2018.
23. American Heart Association. Resuscitation Fact Sheet. 2017. http://www.heart.org/idc/groups/heart-public/@private/@wcm/@hcm/@gwtg/documents/downloadable/ucm_434082.pdf. Accessed mmm dd, yyyy.
24. Losert H, Sterz F, Kohler K, et al. Quality of cardiopulmonary resuscitation among highly trained staff in an emergency department setting. Arc Intern Med 2006;166:2375–80.

25. Wik L, Kramer-Johansen J, Myklebust H, et al. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. JAMA 2005;293:299–304.
26. Corraini P, Olsen M, Pedersen L, Dekkers OM, Vandenbroucke JP. Effect modification, interaction and mediation: an overview of theoretical insights for clinical investigators. Clin Epidemiol 2017;9:331–8.
27. Auerbach M, Roney L, Aysseh A, et al. In situ pediatric trauma simulation: assessing the impact and feasibility of an interdisciplinary pediatric in situ trauma care quality improvement simulation program. Pediatr Emerg Care 2014;30:884–91.
28. Miller D, Crandall C, Washington C 3rd, McLaughlin S. Improving teamwork and communication in trauma care through in situ simulations. Acad Emerg Med 2012;19:608–12.
29. Kobayashi L, Shapiro MJ, Sucov A, et al. Portable advanced medical simulation for new emergency department testing and orientation. Acad Emerg Med 2006; 13:691–5.
30. Lighthall GK, Poon T, Harrison TK. Using in situ simulation to improve in-hospital cardiopulmonary resuscitation. Jt Comm J Qual Patient Saf 2010;36:209–16.
31. Cheng A, Auerbach M, Calhoun A, et al. Building a community of practice for researchers: the International Network for Simulation-Based Pediatric Innovation, Research and Education. Simul Healthc 2018;13(3S Suppl 1):S28–34.
32. de Caen AR, Kleinman ME, Chameides L, et al. Part 10: Paediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation 2010;81 Suppl 1:e213–59.
33. Bitoun E, Micheloni A, Lamant L, et al. LEKTI proteolytic processing in human primary keratinocytes, tissue distribution and defective expression in Netherton syndrome. Hum Mol Genet 2003;12:2417–30.
34. Apple I. Counter+. Available at: https://itunes.apple.com/us/app/counter-+/id478557426?mt=8. Accessed July 14, 2015.
35. Fortugno P, Bresciani A, Paolini C, et al. Proteolytic activation cascade of the Netherton syndrome-defective protein, LEKTI, in the epidermis: implications for skin homeostasis. J Invest Dermatol 2011;131:2223–32.
36. Reid J, Stone K, Brown J, et al. The Simulation Team Assessment Tool (STAT): development, reliability and validation. Resuscitation 2012;83:879–86.
37. American Academy of Pediatrics Committee on Pediatric Emergency Medicine, American College of Emergency Physicians Pediatric Committee, Emergency Nurses Association Pediatric Committee. Joint policy statement–guidelines for care of children in the emergency department. Ann Emerg Med 2009;54:543–52.
38. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J Pers Soc Psychol 1986;51:1173–82.
39. Sobel M. Asymptotic confidence intervals for indirect effects in structural equation models. Sociol Method 1982;13:290–312.
40. Brouwer TF, Walker RG, Chapman FW, Koster RW. Association between chest compression interruptions and clinical outcomes of ventricular fibrillation out-of-hospital cardiac arrest. Circulation 2015;132:1030–7.
41. Kramer-Johansen J, Myklebust H, Wik L, et al. Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: a prospective interventional study. Resuscitation 2006;71:283–92.
42. Niles D, Sutton RM, Donoghue A, et al. "Rolling refreshers": a novel approach to maintain CPR psychomotor skill competence. Resuscitation 2009;80:909–12.
43. Sutton RM, Niles D, Meaney PA, et al. "Booster" training: evaluation of instructor-led bedside cardiopulmonary resuscitation skill training and automated corrective feedback to improve cardiopulmonary resuscitation compliance of Pediatric Basic Life Support providers during simulated cardiac arrest. Pediatr Crit Care Med 2011;12:e116–21.
44. Wayne DB, Didwania A, Feinglass J, Fudala MJ, Barsuk JH, McGaghie WC. Simulation-based education improves quality of care during cardiac arrest team responses at an academic teaching hospital: a case-control study. Chest 2008;133:56–61.
45. Wayne DB, McGaghie WC. Use of simulation-based medical education to improve patient care quality. Resuscitation 2010;81:1455–6.
46. Roppolo LP, Pepe PE, Campbell L, et al. Prospective, randomized trial of the effectiveness and retention of 30-min layperson training for cardiopulmonary resuscitation and automated external defibrillators.: the American Airlines study. Resuscitation 2007;74:276–85.
47. Smith KK, Gilcreast D, Pierce K. Evaluation of staff's retention of ACLS and BLS skills. Resuscitation 2008;78:59–65.
48. Yang CW, Yen ZS, McGowan JE, et al. A systematic review of retention of adult advanced life support knowledge and skills in healthcare providers. Resuscitation 2012;83:1055–60.
49. Meaney PA, Bobrow BJ, Mancini ME, et al. Cardiopulmonary resuscitation quality: [corrected] improving cardiac resuscitation outcomes both inside and outside the hospital: a consensus statement from the American Heart Association. Circulation 2013;128:417–35.
50. Oermann MH, Kardong-Edgren SE, Odom-Maryon T, Roberts CJ. Effects of practice on competency in single-rescuer cardiopulmonary resuscitation. Medsurg Nurs 2014; 23:22–8.

51. Sutton RM, Niles D, Meaney PA, et al. Low-dose, high-frequency CPR training improves skill retention of in-hospital pediatric providers. Pediatrics 2011;128:e145–51.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13564/full

Data Supplement S1. Case file.

Data Supplement S2. Simulation Scenario Program File for Laerdal Software.

Consensus-based Criterion Standard for the Identification of Pediatric Patients Who Need Emergency Medical Services Transport to a Hospital with Higher-level Pediatric Resources

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ABSTRACT

Background: Emergency medical services (EMS) providers must be able to identify the most appropriate destination facility when treating children with potentially severe medical illnesses. Currently, no validated tool exists to assist EMS providers in identifying children who need transport to a hospital with higher-level pediatric care. For such a tool to be developed, a criterion standard needs to be defined that identifies children who received higher-level pediatric medical care.

Objective: The objective was to develop a consensus-based criterion standard for children with a medical complaint who need a hospital with higher-level pediatric resources.

Methods: Eleven local and national experts in EMS, emergency medicine (EM), and pediatric EM were recruited. Initial discussions identified themes for potential criteria. These themes were used to develop specific criteria that were included in a modified Delphi survey, which was electronically delivered. The criteria were refined iteratively based on participant responses. To be included, a criterion required at least 80% agreement among participants. If an item had less than 50% agreement, it was removed. A criterion with 50% to 79% agreement was modified based on participant suggestions and included on the next survey, along with any new suggested criteria. Voting continued until no new criteria were suggested and all criteria received at least 80% agreement.

Results: All 11 recruited experts participated in all seven voting rounds. After the seventh vote, there was agreement on each item and no new criteria were suggested. The recommended criterion standard included 13 items that apply to patients 14 years old or younger. They included IV antibiotics for suspicion of sepsis or a

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seizure treated with two different classes of anticonvulsive medications within 2 hours, airway management, blood product administration, cardiopulmonary resuscitation, electrical therapy, administration of specific IV/IO drugs or respiratory assistance within 4 hours, interventional radiology or surgery within 6 hours, intensive care unit admission, specific comorbid conditions with two or more abnormal vital signs, and technology-assisted children seen for device malfunction.

Conclusion: We developed a 13-item consensus-based criterion standard definition for identifying children with medical complaints who need the resources of a hospital equipped to provide higher-level pediatric services. This criterion standard will allow us to create a tool to improve pediatric patient care by assisting EMS providers in identifying the most appropriate destination facility for ill children.

Prehospital care providers not only deliver lifesaving treatments to their patients, but they also play a role in helping to identify the most appropriate destination facility for their patients. Although hospital destination is often determined by patient or family choice, we cannot underestimate the role prehospital providers can have in helping to guide patients and their families in making this choice. This role is especially important when the patient is a child who may need specialty care. Currently, a triage tool exists for helping providers identify injured patients who are likely to need the resources of a trauma center,[1] but there is no complementary tool for children with medical complaints.

A pediatric prehospital triage tool for use when evaluating children with medical complaints would assist emergency medical services (EMS) providers in making destination decisions. Prehospital identification of ill children who require specialized resources has the potential to improve patient outcomes by ensuring that children have timely access to those resources. While all emergency departments (ED) must be ready to manage children, it has been shown that variability exists in the availability of necessary resources among EDs and low pediatric patient volumes may create a challenge in maintaining competence.[2–6] Further, initial transport to the appropriate destination can decrease the need for interfacility transfer later in a patient's care. Currently, no such tool exists to augment EMS providers' clinical gestalt and guide them in identifying the most appropriate destination for pediatric patients with medical complaints. It is important to note that simply taking all children to hospitals with higher-level pediatric services is likely not necessary and may lead to overcrowding and inefficient use of this valuable resource.[7,8] Identifying and validating a pediatric destination decision-making tool for ill children has been identified as a prehospital research priority.[9]

Prior to developing a triage tool for pediatric patients with medical complaints for EMS providers, a criterion standard definition needs to be established that defines a child who required higher-level pediatric care. The absence of a defined criterion standard serves as an impediment to the development of a pediatric prehospital triage tool, because without it there is no way to establish the "right" answer when validating the tool. The overall goal of this project was to develop the criterion standard for children with medical complaints who need the resources of a hospital with higher-level pediatric resources so that future work can derive and validate a decision support tool. Therefore, the specific objective for this study was to develop a consensus-based criterion standard for children with a medical complaint who need a hospital with higher-level pediatric resources.

METHODS

This study replicated the methods used in three prior projects that developed criterion standard definitions for various triage tools in the prehospital setting using a modified-Delphi technique.[10–12] This project was conducted by the Charlotte, Houston, and Milwaukee Prehospital (CHaMP) Node of the Pediatric Emergency Care Applied Research Network (PECARN). The institutional review board (IRB) at the Medical College of Wisconsin determined that these types of investigations did not require IRB review or approval.

An expert panel was recruited through PECARN as well as through personal contacts known to the authors. The goal was to recruit a broad range of emergency physicians, some of whom were subspecialists in pediatrics and EMS. We also attempted to recruit physicians from geographically diverse settings. All physicians were contacted by e-mail and invited to participate. Those who participated in the Delphi process were offered the opportunity to also participate as

manuscript authors. No other incentives were offered for participation.

As part of another project, an informal group used an e-mail process to develop a list of criteria that warranted transport to a hospital with higher-level pediatric resources. This list was used to develop the initial Delphi survey for this project (Table 1). The panelists were instructed to vote on whether each of the criteria identified a child whom they believed needed the resources of a hospital with higher level of pediatric resources. They were also instructed to suggest a time frame in which the service had to occur for it to be considered to have met the criterion. At the end of the survey, panelists were asked to suggest additional criteria that should be considered for inclusion. The surveys were distributed to each panelist using Survey Monkey and panelists provided their name on each survey so that response rates could be tracked and any clarifications to answers could be requested.

Two authors (JRS and EBL) reviewed the responses to each survey, but they did not participate in the voting. The methods described below for assessing consensus were determined a priori by the two authors responsible for reviewing each survey, following methodologies set forth in prior studies conducted in the prehospital setting.[10–12] If an individual criterion received fewer than 50% of the panelists' votes during a voting round, it was removed from consideration in subsequent voting rounds. If a criterion received at least 80% of the panelists' votes for inclusion, it was considered to have achieved consensus and no further voting was required on that criterion. If a criterion received between 50 and 80% of the panelists' votes for inclusion, it was revised based on the comments of the panelists and was included in the next voting round. A new survey was then created with the modified criteria and any newly suggested criteria. Criteria that had been approved were listed at the end of each survey for each panelists' reference.

This process was repeated for each subsequent voting round, but in later rounds participants were asked to provide a reason for their vote. These reasons were compiled and provided in an anonymous pros and cons format in the survey to assist panelists in reaching consensus. Voting rounds were conducted until consensus was achieved as indicated by all remaining criteria receiving at least 80% approval and no new criteria being suggested by panelists.

Table 1
Initial List of Criteria to Seed the Consensus-building Process

Airway management or respiratory assistance in the ED
≥40 ml/kg IV fluid bolus(es) given within 2 hours of arrival
Cardiopulmonary resuscitation in the ED
Pacing, cardioversion, or defibrillation in the ED
Three or more treatments or continuous treatment of an inhaled medication in the ED
IV drug administration in the ED (excluding analgesics, antiemetics, antacids)
Nontraumatic blood product administration in the ED
Surgery within 4 hours of ED arrival
Seizures treated with two different classes of anticonvulsant medications
Two or more abnormal age-adjusted vital signs upon ED in a child with immunocompromise, history of marrow or solid organ transplant, or prior cardiac surgery

RESULTS

A total of 11 panelists were recruited to participate in the project (Table 2). There were a total of seven voting rounds. All panelists participated in all voting rounds. After the fourth voting round, no new items were added to the list of criteria for consideration, although the opportunity to suggest new criteria was offered in all voting rounds. During the survey process, it was suggested by several participants that the age of the patients to whom these criteria apply needed to be reconsidered. This question was added to the fourth-round survey and, after clarification in the fifth-round survey, consensus was reached that the criteria being developed applied to pediatric patients 14 years old or younger. The final list of criteria included 13 items (Table 3).

DISCUSSION

This study defined a criterion standard for children with a medical illness who would have needed the resources of a hospital with higher-level pediatric resources. This criterion standard can now be used to develop tools that predict which children with a medical illness need the services of a hospital with higher-level pediatric resources because it will allow investigators to determine the accuracy of any developed prediction tools. It is important to note that these criteria are not for use at the time of prehospital decision making since most of them will not occur until after the prehospital phase of care is completed.

The development of any clinical decision tool requires a criterion standard against which to judge

Table 2
Expert Panel Participants: All Panelist Voted in All Seven Rounds of the Survey

Name	Specialty	Institution	Location
David C. Brousseau, MD, MS	Pediatric emergency medicine	Medical College of Wisconsin	Milwaukee, WI
Jeremy T. Cushman, MD, MS, EMT-P	Emergency Medicine, EMS	University of Rochester	Rochester, NY
Peter S. Dayan, MD, MSc	Pediatric emergency medicine	Columbia University	New York, NY
Patrick C. Drayna, MD	Pediatric emergency medicine	Medical College of Wisconsin	Milwaukee, WI
Amy L. Drendel, DO, MS	Pediatric emergency medicine	Medical College of Wisconsin	Milwaukee, WI
Matthew P. Gray, MD, MS	Pediatric emergency medicine	Medical College of Wisconsin	Milwaukee, WI
Christopher Kahn, MD, MPH	Emergency medicine, EMS	University of California at San Diego	San Diego, CA
Michael T. Meyer, MD	Pediatric critical care	Medical College of Wisconsin	Milwaukee, WI
Manish I. Shah, MD, MS	Pediatric emergency medicine	Baylor College of Medicine	Houston, TX
Manish N. Shah, MD, MPH	Emergency medicine, EMS	University of Wisconsin–Madison	Madison, WI
Rachel M. Stanley, MD, MHSA	Pediatric emergency medicine	Nationwide Children's Hospital	Columbus, OH

Table 3
Consensus-based Criterion Standard for Children Who Need the Resources of Hospital Equipped to Provide Higher-level Pediatric Resources

Criteria	Time Frame
Received IV antibiotics for suspicion of sepsis within 2 hours of ED arrival	Within 2 hours of ED arrival
First-time or unknown prior seizure treated with two different classes of anticonvulsive medications (e.g., benzodiazepine and levetiracetam) or if known to have seizure disorder, treated with two different classes of anticonvulsive medications in addition to usually prescribed treatment, within 2 hours of ED arrival	
Non–trauma-related blood product administration within 4 hours of ED arrival	Within 4 hours of ED arrival
Airway management of any type (e.g., endotracheal, oral, supraglottic device), prior to or within 4 hours of ED arrival	Prior to or within 4 hours of ED arrival
Respiratory assistance (i.e., bag-valve mask, continuous positive airway pressure, high-flow nasal cannula)—excluding oxygen therapy, prior to or within 4 hours of ED arrival	
Electrical therapy (i.e., pacing or cardioversion), prior to or within 4 hours of ED arrival	
Use of one of the following IV/IO medications listed in the 2015 version of the Pediatric Advanced Life Support resuscitation guidelines: adenosine, albumin, amiodarone, atropine, calcium, dopamine, dobutamine, epinephrine, IV lidocaine, norepinephrine, procainamide, prostaglandin E, sodium bicarbonate, or terbutaline; prior to or within 4 hours of ED arrival	
Any surgery within 6 hours of ED arrival	Within 6 hours of ED arrival
Utilized interventional radiology within 6 hours of ED arrival	
Patients who receive prehospital or in-hospital CPR, excluding patients who had resuscitation terminated upon arrival at the ED, prior to or within 6 hours of ED arrival	Prior to or within 6 hours of ED arrival
Intensive care unit admission from the ED	None
Two or more abnormal vital signs for age on arrival at the ED (i.e., first vital signs taken in the ED) in a child who has history of immunocompromise, marrow or solid organ transplant, or cardiac surgery	
Technology-assisted children whose chief complaint involves a malfunction of their technology, excluding those with gastrostomy tubes	

the tool. This has also been referred to as a gold standard but is now more commonly referred to as a criterion standard, since there are very few standards that do not have the potential for some error. However, it is important that the criterion standard be as accurate as possible, since any tool that is developed can only be as good as the criterion standard to which it is compared.

While we have focused on using the developed criterion standard to validate a tool developed for EMS providers to use in pediatric destination decision making, it may also have implications for quality improvement in EMS. If pediatric patients with medical conditions that need a hospital with higher-level pediatric resources can be identified, it may also inform who requires special prearrival notifications to be made, who requires rapid transport, or who may benefit from other specialty care, in addition it may also help to define which patients should be interfacility transferred. Communities could use the defined

criterion standard to identify those cases that should be more carefully reviewed or have their outcomes monitored. Assuring that these children arrive at the most appropriate hospital is the first step in evaluating the overall process of care and its impact on outcome.

For a criterion standard to be usable either in a research or in a clinical context, the presence or absence of the criteria must be easily assessed. The criteria identified in Table 3 can all be determined through a hospital-based medical record review. The criteria defined by our experts largely included treatments rather than specific diagnoses or patient presentations. This makes obtaining these data from a patient's medical record less complicated and likely more reliable, but these definitions will need to be operationalized and identified through a medical record review to ensure its usability. This process has been used previously for the study of field triage and mass casualty triage guidelines.[10–12] Those guidelines have since been operationalized and used in real world analyses.[13–16]

Of the 13 identified criteria, only three were not treatment interventions: admission to the intensive care unit (ICU), specific comorbid conditions with two or more abnormal vital signs, and technology-assisted child with a malfunction. Of these three criteria, all are likely to be documented and easily identified by chart review. However, many of these criteria may be difficult to abstract through an electronic database query and likely will require an actual record review. It does seem likely that a trained research assistant could abstract this information from a patient's chart with physician oversight. Studies that use this technique will need to make the assumption that because an intervention was provided to a patient it was "needed," and this could be a limitation for those studies. For example, admission to an ICU could be a subjective decision that is based on factors other than patient needed such as hospital protocol, bed availability, or physician preference.

LIMITATIONS

There are several limitations to this study. While every effort was made to recruit a wide variety of clinicians from diverse geographic locations, the panel was mostly composed of physicians who work in or near hospitals equipped to provide higher-level pediatric resources. Panel selection is a common limitation of the modified Delphi process, but we attempted to mitigate this bias as much as possible through our expert selection methodology. A broad range of specialty expertise was obtained, although geographic diversity was not as high as anticipated. This may have introduced some bias into the results, but no more so than one would expect to find in a qualitative consensus-building process. As this criterion standard is applied for research and other practical applications, feedback from other diverse practice settings will be needed to best refine these criteria. The defined criteria have also not yet been collected for use in research or quality improvement and, while these data seem to be easily identifiable in the patient record, that assumption requires further testing.

CONCLUSION

We developed a 13-item consensus-based criterion standard definition for identifying children with medical complaints who need the resources of a hospital equipped to provide higher-level pediatric resources. This criterion standard will allow us to create a tool to improve pediatric patient care by assisting prehospital providers in identifying the most appropriate destination facility for ill children.

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References

1. Sasser SM, Hunt RC, Faul M, et al. Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage, 2011. MMWR Recomm Rep 2012;61:1–20.
2. Middleton KR, Burt CW. Availability of pediatric services and equipment in emergency departments: United States, 2002–03. Adv Data 2006:1–16.
3. Schappert SM, Bhuiya F. Availability of pediatric services and equipment in emergency departments: United States, 2006. Natl Health Stat Rep 2012;47:1–21.
4. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
5. Athey J, Dean JM, Ball J, Wiebe R, Melese-d'Hospital I. Ability of hospitals to care for pediatric emergency patients. Pediatr Emerg Care 2001;17:170–174.
6. Michelson KA, Lyons TW, Bachur RG, Monuteaux MC, Finkelstein JA. Timing and location of emergency department revisits. Pediatrics 2018;141. pii: e20174087.
7. Meyer MT, Gourlay DM, Weitze KC, et al. Helicopter interfacility transport of pediatric trauma patients: are we overusing a costly resource? J Trauma Acute Care Surg 2016;80:313–7.

8. Li J, Monuteaux MC, Bachur RG. Interfacility transfers of noncritically ill children to academic pediatric emergency departments. Pediatrics 2012;130:83–92.
9. Browne LR, Shah MI, Studnek JR, et al. 2015 Pediatric research priorities in prehospital care. Prehosp Emerg Care 2016;20:311–6.
10. Lerner EB, Willenbring BD, Pirrallo RG, et al. A consensus-based criterion standard for trauma center need. J Trauma Acute Care Surg 2014;76:1157–63.
11. Lerner EB, Drendel AL, Falcone RA Jr, et al. A consensus-based criterion standard definition for pediatric patients who needed the highest-level trauma team activation. J Trauma Acute Care Surg 2015;78:634–8.
12. Lerner EB, McKee CH, Cady CE, et al. A consensus-based gold standard for the evaluation of mass casualty triage systems. Prehosp Emerg Care 2015;19:267–71.
13. Willenbring BD, Lerner EB, Brasel K, et al. Evaluation of a consensus-based criterion standard definition of trauma center need for use in field triage research. Prehosp Emerg Care 2016;20:1–5.
14. Heffernan RW, Lerner EB, McKee CH, et al. Comparing the accuracy of mass casualty triage systems in a pediatric population. Prehosp Emerg Care 2017;21:99.
15. Lerner EB, Cushman JT, Badawy M, et al. Do age appropriate vital sign cut points improve the predictive ability of the physiologic criteria of the field triage decision scheme for identifying children who need the resources of a trauma center? Prehosp Emerg Care 2018;22:103.
16. Lerner EB, Badawy M, Cushman JT, et al. Does mechanism of injury predict trauma center need for children. Prehosp Emerg Care 2018;22:108.

A Research Agenda to Advance Pediatric Emergency Care Through Enhanced Collaboration Across Emergency Departments

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ABSTRACT

In 2018, the Society for Academic Emergency Medicine and the journal *Academic Emergency Medicine* (*AEM*) convened a consensus conference entitled, "*Academic Emergency Medicine* Consensus Conference: Aligning the Pediatric Emergency Medicine Research Agenda to Reduce Health Outcome Gaps." This article is the product of the breakout session, "Emergency Department Collaboration-Pediatric Emergency Medicine in Non-Children's Hospital").

This subcommittee consisting of emergency medicine, pediatric emergency medicine, and quality improvement (QI) experts, as well as a patient advocate, identified main outcome gaps in the care of children in the emergency departments (EDs) in the following areas: variations in pediatric care and outcomes, pediatric readiness, and gaps in knowledge translation. The goal for this session was to create a research agenda that facilitates collaboration and partnering of diverse stakeholders to develop a system of care across all ED settings with the aim of improving quality and increasing safe medical care for children. The following recommended research strategies emerged: explore the use of technology as well as collaborative networks for education, research, and advocacy to develop and implement patient care guidelines, pediatric knowledge generation and dissemination, and pediatric QI and prepare all EDs to care for the acutely ill and injured pediatric patients. In conclusion, collaboration between general EDs and academic pediatric centers on research, dissemination, and implementation of evidence into clinical practice is a solution to improving the quality of pediatric care across the continuum.

According to a 2014 Centers for Disease Control and Prevention report, there are approximately 141 million emergency department (ED) visits per year in the United States. Of those, an estimated 27

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million visits were for children under 15 years of age (20% of all ED visits).[1] The approximately 5,000 EDs in the United States vary in their pediatric patient volume, and the overwhelming majority of EDs are general EDs, which provide care to both adults and children, in contrast to pediatric EDs, which provide care primarily to children. Overall, 85% of pediatric visits to EDs are to general EDs with varying pediatric volumes.[2]

General EDs face many challenges in caring for pediatric patients (e.g., conflicting demands on time and limited resources), which may lead to variations in pediatric care and patient outcomes between general and pediatric-specific EDs. For example, with respect to practice variation, the use of plain radiographs for respiratory diseases (asthma, bronchiolitis, and croup) is significantly lower in pediatric-specific EDs than in general EDs.[3,4] Similarly, a recent study evaluating imaging radiation exposure in patients with non–trauma-related abdominal complaints revealed lower computed tomography (CT) use in pediatric-specific EDs than in general EDs (odds ratio [OR] = 0.34, 95% confidence interval [CI] = 0.17–0.69) and higher ultrasound use in pediatric-specific EDs (OR = 2.14, 95% CI = 1.29–3.55).[5] In terms of patient outcomes, mortality is the ultimate outcome that differs by type of ED. Children with atraumatic out-of-hospital cardiac arrest have higher survival in pediatric EDs than general EDs (33.8% vs. 18.9%, $p < 0.001$) with an adjusted OR of survival in pediatric ED compared to general EDs of 2.2 (95% CI = 1.7–2.8).[6] Other studies have shown similar findings, with halved mortality rates in very high pediatric volume EDs (≥50,000 annual pediatric visits per year) compared with low-pediatric-volume EDs.[7]

Limited resources in EDs negatively impact pediatric readiness. The Emergency Medical Services for Children (EMSC) program has developed an ongoing quality improvement (QI) project to improve ED pediatric readiness in the United States, starting with the development of a survey that assigns an ED a pediatric readiness score out of 100. A national survey in 2013 showed that 86.3% of EDs see fewer than 28 children per day (<10,000 per year) and that pediatric readiness correlates with pediatric visit ED volume. For EDs with low-pediatric-visit volume (fewer than 1,800 pediatric visits per year or fewer than five children per day), the median pediatric readiness score was 68.9; in contrast, EDs with high-pediatric-visit volume (>10,000 visits per year) had a score of 89.8.[2]

In addition to conflicting demands and limited resources multiple other factors may contribute to the variability in pediatric care across practice settings. The lag in translation of scientific evidence to clinical practice for instance, a well-recognized problem in health care, may be more pronounced in general EDs than in pediatric-specific EDs when it comes to advances in the care of pediatric emergency patients. Many general EDs commit resources to meeting publicly reported indicators that address adult measures and may have limited resources to address pediatric quality measures. In addition, the availability of specific pediatric skills and resources in general EDs may limit the application of new knowledge for treatment of pediatric patients. Similarly, pediatric medical events such as cardiac and/or respiratory arrests occur infrequently in lower-pediatric-volume EDs, creating challenges in preparation for such rare events. Finally, the majority of pediatric emergency medicine (PEM) research and knowledge generation occurs in EDs associated with academic centers or children's hospitals.

The studies outlined above illustrate the gaps in the care of children in the ED. The lack of collaboration has negatively impacted resources, pediatric readiness, and knowledge dissemination to achieve the optimal care of children in the ED. This consensus conference offered a unique opportunity to create a research agenda that facilitates partnering of diverse stakeholders to develop a system of care across all ED settings with higher quality and increasingly safe care for children.

METHODS

General Approach and Methods Used for Consensus Generation

Over a 2-year period, the ED collaboration subcommittee, composed of a patient advocate, experts in emergency medicine practicing in EDs with different pediatric volumes, PEM, and simulation and practitioners with expertise in PEM quality, worked to identify for the *Academic Emergency Medicine* (*AEM*) consensus conference key areas of potential research in advancing collaboration in PEM. These areas of research address the goal of "understanding the complex interactions and the need for collaboration among the different types of emergency departments and providers caring for acutely sick and injured pediatric patients."

Following an extensive review of the literature to identify the current state of pediatric emergency care in general EDs, the subcommittee developed topics for future research, identifying clinically relevant research topics with the greatest potential impact. This resulted in the development of a list of four themes with associated questions (described under "Challenges to Creating a Research Agenda on Improving Pediatric Care in General EDs") for discussion at the consensus conference. These themes and questions were further refined by soliciting the input of stakeholders outside of the subcommittee prior to the conference using a Qualtrics survey. These stakeholders included conference registrants and members of the American Academy of Pediatrics (AAP) Section on Emergency Medicine, EMSC, American College of Emergency Physicians (ACEP) Pediatric Emergency Medicine Committee, and Pediatric Emergency Care Applied Research Network (PECARN). There were a total of 178 responses.

At the *AEM* consensus conference, committee members and approximately 115 participants assembled for the final phase of the consensus process. The breakout session took place over a period of 105 minutes with approximately 55 participants. The group was divided into four smaller subgroups, each one moderated in a similar format, involving brainstorming and prioritization of solutions using the KJ Method.[8] This process resulted in consensus recommendations and suggested strategies for future investigators.

STATEMENT OF OUTCOME GAPS

The main outcome gaps identified include variations in pediatric care and outcomes across EDs, gaps in knowledge translation, and limitations in pediatric readiness. For example, over the past few decades general EDs have made improvements in having pediatric-specific supplies and equipment; however, they may still have limited pediatric-centered staff and equipment and lack policies, procedures, and training specific to pediatrics.[2,9] Higher total pediatric volume and the presence of a physician and/or nurse pediatric emergency care coordinator (PECC) are associated with an ED's readiness to care for children.[2] The lack of collaboration negatively impacts the readiness of all EDs to care for children.

Similarly, although there has been a trend toward regionalization in pediatric care, with pediatric patients often being transferred from general EDs to pediatric centers, the question remains of the actual need to transfer noncritical pediatric patients. In one study of children who were transferred to a pediatric center from a general ED, 25% of non–critically ill children were discharged directly from the receiving ED, and 17% were admitted for less than 24 hours after transfer.[10] This study illustrates how the lack of collaboration between the transferring general EDs and the accepting institution negatively impacts the care of children. Additional thought must be provided to engaging general EDs in contributing to and translating pediatric-specific evidence generated primarily in academic pediatric centers to the bedside to improve pediatric outcomes across EDs.

CONCEPTUAL FRAMEWORK AND CREATION OF THE RESEARCH AGENDA

The conceptual framework for the research agenda should distinguish between three distinct but interrelated types of outcomes: implementation, quality, and patient outcomes. It is essential that all stakeholders recognize the importance of general EDs in providing pediatric emergency care and the need for collaboration as a solution to improve care across all EDs.

Implementation

It is important to not only collect information regarding the care of pediatric patients in general EDs but also to provide feedback on outcomes and benchmarking to strive for best practices. A multitude of ongoing initiatives (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13642/full) is making progress through the development of resources, measurement tools, standards, and requirements. In addition, collaboration has been evident in some pediatric-specific hospitals creating programs over the past decade involving innovative models in the ED (e.g., partnership in staffing general EDs and sharing policies/procedures, health system–based networks of pediatric emergency care), educational outreach, telemedicine, and use of simulation.[11–17]

For example, a Canadian network, TRanslating Emergency Knowledge for Kids (TREKK), has completed a series of projects to improve emergency care across all EDs by developing pediatric resources available to all settings. The group has identified

the preferred topics and methods of delivery for content by general ED providers and have created online resources in collaboration with these frontline providers.[12]

Another specific example of a collaborative QI project designed to promote the optimal care of children in EDs in the United States and all U.S. territories is the National Pediatric Readiness Project (NPRP) "Peds Ready."[18–21] The implementation of Peds Ready in low- to medium-volume EDs has been challenging. The most common barriers identified to implementing national guidelines are cost of training and lack of educational resources.[2] Therefore, the research agenda should focus on how collaboration between general EDs and their associated pediatric centers may support the training and engagement of PECCs, help overcome barriers to the adoption of Peds Ready, engage all EDs in process improvement and establish a benchmark that measures ED improvement over time. Currently, the EMSC Innovation and Improvement Center (EIIC) has started the Pediatric Readiness Quality Collaborative involving more than 140 hospitals EDs that could answer some of these research questions.

There are a variety of ongoing initiatives as well through AAP, ACEP, Emergency Nurse Association, American Academy of Family Physicians, the American Academy of Physician Assistants, the National Organization of Nurse Practitioner Faculties, EMSC, EIIC, NPRP, PECARN, and grass roots organization such as CALS (Comprehensive Advanced Life Support) to create pediatric resources. These groups must work with frontline stakeholders to develop and test systems of care that allow for optimization of quality across the continuum.

Additionally, investigators must always consider the generalizability of work that is conducted in larger academic centers to the broader community of practice in general EDs that care for most children. The PECARN head injury rule is an excellent example of effective knowledge translation/dissemination using decision support in the electronic medical record (EMR), apps as cognitive aids, and social media campaigns including the "Think-A-Head" movement from the Image Gently Alliance.[22,23]

Quality Measures

Pediatric-specific measures and implementation processes must be developed to ensure continuous QI to reduce errors, improve safety, and reduce variations in care, with the ultimate purpose of improving systems' ability to optimize patient outcomes. It is important to integrate these initiatives within the broader scope of emergency medicine care. The PECARN has developed and validated instruments to evaluate the quality of care delivery in pediatric care by using implicit review methods that can be used for diverse groups of patients.[24,25] A recent study used this implicit review methods tool to look at patient-level factors and the quality of care in 12 PECARN EDs and found that some chief complaint categories were associated with significantly lower than average quality of care, including fever (–0.65 points in quality, 95% CI = –1.24 to –0.06) and upper respiratory symptoms (–0.68 points in quality, 95% CI = –1.30 to –0.07).[26] The concern with current measures related to pediatric emergency care is the lack of a systematic and comprehensive approach. The quality agenda cannot be separated from implementation of these quality measures and should address the following outcomes suggested by Peds Ready: acceptability, adoption, appropriateness, feasibility, fidelity, cost, penetration, and sustainability.[27]

Patient Outcomes

The ultimate goal of the research agenda is to improve patient outcomes and provide high-quality care across all ED settings, which in turn is dependent on provider training, collaboration among the different stakeholders, developing and disseminating evidence-based knowledge to care for children that is sustainable in any ED setting,[28] development of QI initiatives, and the measurement of quality of the care provided.

RESEARCH PRIORITY/AGENDA ITEMS

Goals

The goals were to include all EDs in creating a research agenda to advance the quality and safety of pediatric emergency care across all EDs, understand the challenges, and enhance collaboration among EDs to achieve optimal health outcomes.

Objectives

- Create best practices for developing a system of care for general EDs and those in pediatric EDs to collaborate and focus on solutions to close the gap on safety, quality, and evidence-based practice in a patient/family-centered setting. This system should

meet the needs of both groups to provide the best clinical care for pediatric patients.
- Develop pediatric-specific outcome measures and implementation processes to ensure continuous QI.
- Evaluate ED preparedness and readiness to provide emergency care for children and its effect on patient outcomes.

These objectives lead to four themes with questions associated with each theme. The questions were prioritized prior to the consensus conference via a Qualtrics survey and are listed under each theme in Table 1 from highest to lowest priority.

Themes

I. Identify solutions to the challenges and barriers in developing a system of care in general EDs to provide safe and quality care for children.
II. Enhance collaboration between general EDs and pediatric-specific EDs when developing national guidelines and standardizing care.
III. Study the quality of care provided to children in EDs in the United States.
IV. Evaluate national pediatric readiness and its effects on patient outcomes.

During the breakout session, the subgroups for each theme addressed the first two to three questions that the premeeting survey had identified as top priorities. Using the KJ method, the group collaboratively brainstormed, categorized, and prioritized ideas for future investigations into those topics.[8] This process resulted in consensus recommendations and suggested strategies for future investigators, which are listed in detail in Table 2.

CHALLENGES TO CREATING A RESEARCH AGENDA ON IMPROVING PEDIATRIC CARE IN GENERAL EDS

To create a research agenda to improve care in general EDs, it is essential to appreciate the challenges and barriers to establishing and implementing such an agenda. These challenges are significant, and to proceed with the formation of a research agenda without addressing the difficulties in moving forward puts successful implementation of this agenda at risk.

The PEM community is at the core of establishing this research agenda, articulating both the content and the methodology for implementation. It is clear that the vast majority of U.S. children are seen in general EDs, which have a wide variation in pediatric visit volumes. Because pediatric visits comprise only 20% of a general ED's patient volume, more resources may be directed toward the care of adults.

At its core, understanding how to help smaller-pediatric-volume EDs improve pediatric care will require the PEM community to create a research agenda that establishes potential value for all EDs and will clearly involve partnering with the leadership of general EDs. Equally important is the need to share data across regions and provide benchmarking to improve care in all EDs as well as to then establish research priorities and interventions that improve pediatric outcomes.

A necessary starting point may be research aimed at understanding more about these challenges. Some preliminary questions might be:
- How do EDs with a low volume of pediatric patients view pediatric care? Is there interest in focusing on such care? If not, why not?
- What are their perceived barriers to focusing on pediatric care?
- What are their perceived incentives to focusing on pediatric care?
- What kinds of resources/training would they find of most benefit?

In summary, a traditional "top-down" approach, in which a research agenda is created by the pediatric academic community to improve care at general EDs, is unlikely to succeed. A more successful starting point would be an emphasis on understanding some of the basic challenges of pediatric emergency care in general EDs, where adult patients command the majority of leadership's attention, and understanding the need for active collaboration and partnership among the different stakeholders.

CONCLUSION

In conclusion, since the majority of acutely ill and injured pediatric visits in the United States are to general EDs, but most research is conducted in pediatric hospitals, providers in both settings must collaborate in their research efforts to improve care of children nationwide. Four key themes emerged from the 2018 Society for Academic Emergency Medicine Clinical Consensus Conference breakout session: Enhancing collaboration in pediatric emergency care

Table 1
Main Themes Identified and Associated Questions

Theme	I. Identify solutions to the challenges and barriers to developing a system of care in general EDs to provide safe and quality care for children.	II. Enhance collaboration between general EDs and pediatric-specific EDs when developing national guidelines and standardizing care.	III. Study the quality of care provided to children in EDs in the United States.	IV. Evaluate national pediatric readiness and its effects on patient outcomes.
Associated questions	1. How can we leverage technology, e.g., telehealth and "virtual EDs," to disseminate ideas, improve communication, and facilitate teamwork to provide patient centered care? 2. How can we establish collaborative networks to advance education, research, and advocacy for pediatric patients taken care of in all EDs? 3. Should we create financial incentives for general EDs to prioritize resources on pediatric care? How do we link outcomes and payment to care received by pediatric patients in general EDs (incentives to not transfer)? How do we change the transfer culture to view as partnership between hospitals? 4. How can pediatric subspecialty consultation be improved in general EDs? 5. How can the challenges that prevent PEM physicians in larger health care systems to decentralize their efforts between the children's hospitals and general EDs be evaluated? 6. What is the feasibility of a national poison control model for PEM consults? How would these be organized and funded?	1. How can guidelines developed in pediatric hospitals be translated to EDs without pediatric inpatient units/pediatric intensive care units? 2. How can providers in general EDs be engaged in developing clinical guidelines so that they are more relevant and applicable to the care of children in any ED? 3. What is the feasibility of creating an online database for management algorithms (short, intervention-based and universally applicable)? 4. Use of simulation for low-volume/high-acuity conditions and teamwork: How would simulation be implemented, and how would the impact of just-in-time training of low-frequency procedures in low-pediatric-visit-volume EDs be studied? 5. What type of pediatric emergency care research needs to be conducted in general EDs? 6. Additional suggestion by survey participants: Use of integrated EMR to implement standard of care guidelines for common pediatric emergency presentations.	1. How can pediatric-specific quality measures be implemented in all EDs? 2. How can the creation and maintenance of a QI program in low-volume EDs with limited resources be facilitated? 3. How can a process for data collection be established on quality indicators across the spectrum of ED settings that provide care for children? 4. How can general EDs get involved in the process of developing pediatric specific measures and contribute to work being done by ACEP through the Clinical Emergency Department Registry and the AAP Section on Emergency Medicine Quality Transformation? 5. Additional suggestion by survey participants: How can QI collaboratives be used to support identification of quality measures, data collection, and impact on outcomes across a wide variety of EDs?	1. What is the best way to prepare general EDs to care for pediatric patients? 2. What is the role of a PECC for EDs and what is the effect of PECC on patient care, quality markers, and patient outcomes? 3. Does identifying providers to serve as "pediatric champions" introduce best pediatric practices into the general EDs? 4. How can information on "pediatric readiness" be disseminated and key stakeholders educated about its implementation?

AAP = American Academy of Pediatrics;
ACEP = American College of Emergency Physicians; EMR = electronic medical record; PECC = pediatric emergency care coordinator; PEM = pediatric emergency medicine; QI = quality improvement.

Table 2
Consensus Recommendations and Suggested Strategies for Future Investigators

Theme	Questions Addressed	Consensus Recommendations	Strategies for Future Investigators
I	1. How can we leverage technology, for example, telehealth and virtual EDs, to spread ideas, improve communication, and facilitate teamwork to provide patient centered care, where "the right care is provided to the right patient at the right time and at the right place?"	• "Virtual EDs" and telemedicine could facilitate collaboration between PEM content experts and general EDs using "just-in-time" capability for challenging diagnoses and management of acutely ill and injured children.	• Perform needs assessment of target stakeholders. • Transition to system that provides mentorship and partnership in knowledge exchange, potentially utilizing technology (virtual ED" telemedicine, EMR-based clinical decision tools). ◦ Evaluate best model for operational implementation. ◦ Explore concerns related to reimbursement and liability. ◦ Address outcomes whenever possible (e.g., inappropriate transfers to pediatric-specific facilities, patient/family experience, provider satisfaction).
	2. How should we establish collaborative networks to advance education, research, and advocacy for pediatric patients in all EDs?	• Leverage existing networks such as PECARN, EMSC, and professional organizations (e.g., ACEP, AAP, AAFP, etc.) at both state-chapter and national levels. • Work with regional health systems to advance implementation and translation of knowledge to facilities providing pediatric emergency or urgent care services. • Form state-based PECC networks.	• Define key stakeholders and perform a needs assessment of general EDs. • Explore collaboration with existing networks to advance research in implementation of evidence-based care guidelines. • Evaluate state-based PECC networks' effect on adherence to existing quality measures and role in development of novel evidence-based quality measures. • Expand the concept of EDs approved for pediatrics to all EDs, *requiring* all EDs to meet minimum requirements for pediatric readiness, rather than being given the option to opt out. ◦ Record and evaluate outcomes. ◦ Develop a system similar to CMS measures for adults to link achievement of certain pediatric care targets, quality measures, and outcomes to reimbursement. ◦ Establish a national database of pediatric outcomes to assess readiness and quality of care, considering funding through a federal–state–industry partnership, similar to the Kids' Inpatient Database, a set of pediatric hospital inpatient databases included in the Healthcare Cost and Utilization Project family.
II	1. How do we translate guidelines typically developed in pediatric hospitals to hospitals without pediatric inpatient units or PICUs?	• PEM content experts should collaborate with local pediatric champions in general EDs in their region to reach consensus on best practices to implement specific diagnostic and management strategies for children.	• Perform a needs assessment to determine which components of treatment and diagnosis in general EDs are amenable to guidelines (such as over- or undertreatment and diagnostic error). • Examine barriers to implementation of guidelines in general EDs and pursue strategies to inspire interest in PEM and collaboration with PEM experts. • Explore strategies to facilitate development or adaptation of guidelines within general EDs that will lead to eventual adoption and sustained utilization, studying: ◦ Whether it is higher yield for the PEM expert and local champion to create, implement, and evaluate guidelines together or rather to involve the local champion in tailoring, implementing, and evaluating previously existing guidelines. ◦ How to get buy in from leadership and how a top-down strategy for eliciting support compares with one from the ground up. ◦ Whether or not receiving feedback from receiving pediatric EDs leads to a change in clinical practice. ◦ What the effect of implementing guidelines within an EMR has on ease of guideline use and overall job satisfaction.

(Continued)

Table 2 (continued)

Theme	Questions Addressed	Consensus Recommendations	Strategies for Future Investigators
	2. What is the optimal path for PEM knowledge generation and dissemination in general EDs?	• PEM research related to knowledge generation and dissemination should involve general EDs in addition to pediatric EDs.	• Perform a needs assessment to determine general EDs' interest in, and capacity for, participation in research, asking: ○ What is the optimal research role for general EDs (e.g., study design and implementation, sharing data, analyzing data)? ○ How can existing PEM research infrastructure best support general EDs? ○ What are feasible methods for performing research in a general ED setting? • Explore whether research involving general EDs should focus on knowledge generation, dissemination, or both. • Investigate how engagement in existing local and national quality initiatives can be leveraged as research. • Examine how bidirectional research partnerships between general EDs and existing drivers of PEM research (e.g., university researchers, legislators, insurance companies) can best be established and sustained.
III	1. What is the best way to understand the resources and capabilities of community EDs compared to their patient needs?	• PEM QI networks should further study general EDs, including the resources and capabilities available to support pediatric QI efforts and patient needs within these communities.	• Leverage NPRP data to identify PECC presence and investigate existing linkages to local and regional quality networks. • Explore barriers to data acquisition and evaluation, as well as implementation, including: ○ Lack of pediatric champions or PECCs. ○ Varying degrees of hospital support for pediatric QI. ○ Misaligned financial incentives and support for developing pediatric QI programs.
	2. How can pediatric QI measurement be implemented in all EDs?	• Reporting of quality metrics in EDs should be automated through the EMR and other data collection mechanisms to decrease the burden of manual chart review. • Quality metrics should be developed only if broadly applicable and achievable across the spectrum of emergency care. • Metric development should include general ED stakeholders, recognizing barriers to implementation.	• Identify simple achievable patient measures with broad consensus. • Form linkages for general EDs with more pediatric resource rich institutions. • Provide bidirectional feedback for success and larger cohort effectiveness of the program. • Explore regulatory mandates and support for developing pediatric QI initiatives specific to EDs.
	3. What is the best way to facilitate creation and maintenance of QI programs in low volume EDs with limited resources?	• Creating universal metrics applicable to all EDs and aligning financial incentives will support institutions in developing PEM QI programs.	• Create infrastructure to support measurement and data collection, including investigation into: ○ How to create patient level outcomes reporting. ○ How to create collaborative QI networks. ○ How to best use EMRs and clinical decision support to assist data collection and reporting. • Utilize information exchanges to increase learning. • Report outcomes and opportunities with EDs within these networks in a collaborative manner.

(Continued)

Table 2 (continued)

Theme	Questions Addressed	Consensus Recommendations	Strategies for Future Investigators
IV	1. What is the best way to prepare general EDs to be pediatric ready?	• Increase knowledge related to pediatric care. • Improve communication among all EDs caring for children. • Establish standard work and procedures to improve pediatric care. • Consider financial incentives to increase pediatric readiness of EDs. • Consider the use of technology in pediatric preparedness, which could impact knowledge, skill acquisition, cost, communication among different EDs, and patient-centered care delivery.	• Conduct needs assessment of different types of general EDs, varying in geographic area and pediatric volume. • Education: ◦ Identify a PECC. ◦ Develop easily accessible reference materials and educational tools specific to PEM. ◦ Create standardized management guidelines for common illnesses, sharing practice pathways and toolkits. ◦ Utilize technology to enhance education. ◦ Strengthen technical skills through simulation-based workshops. • Communication: ◦ Create collaborative network between general EDs and pediatric specific EDs either through PECC or through pediatric champions. ◦ Use telemedicine to enhance real-time communication. ◦ Provide a feedback system between general and pediatric EDs. • Standardizing work and procedures: ◦ Develop an established list of equipment, procedures, and guidelines, including: ■ Pediatric medication dosing; ■ Standard vital signs by age; ■ Measuring weight in kilograms; ■ Availability of procedural supplies; ■ Perform regular systematic review of quality of care; ■ Establish principles for pediatric centered care. • Financial considerations: ◦ Employing a child life specialist. ◦ Regularly replacing rarely used pediatric equipment. ◦ Providing financial incentives for general EDs to provide high-quality pediatric care by linking reimbursement with improved patient care outcomes. • Leverage technology to improve clinical care, education, and enhanced collaboration and communication and use EMRs to collect data and use in decision support.

(Continued)

Table 2 (continued)

Theme	Questions Addressed	Consensus Recommendations	Strategies for Future Investigators
	2. What is the role of the PECC?	PECCs should play a major role in ED preparedness for pediatric patients in four domains: • Quality of care ○ Provide QI oversight. ○ Establish benchmarking. ○ Establish process measures. ○ Conduct peer review. ○ Use markers such as: ■ Return visits; ■ Patient complaints; ■ Medical/medication errors; ○ Establish inter-facilities transfer policies. • Clinical care oversight ○ Manage pediatric care issues. ○ Ensure staff adherence to recognizing abnormal vital signs. ○ Ensure the availability and access to pediatric specific equipment in a cost-effective manner. ○ Establish a central area for guidelines, pathways and pediatric policies. ○ Develop protocols for common and life-threatening pediatric diseases. • Education ○ Provide access to evidence-based medicine pathways for all health care professionals caring for children in the ED. ○ Increase availability of continuing education. • Communication ○ Conduct regular meetings with other general EDs and pediatric EDs to streamline processes and enhance communication/knowledge sharing to improve patient outcomes.	Evaluate the effect of PECC on pediatric readiness in the four domains: • Quality of care ○ Percent of PALS-certified nurses. ○ Percentage of pediatric patients with pain assessment within 1 hour of ED presentation. ○ Frequency of return visits (within 24 hours and 30 days). ○ Transfers—e.g., ■ Fewer or more efficient transfers for certain illnesses; ■ Times to transfer to definitive care facility. ○ Standard quality indicators before and after PECC. ○ Improvement of disease-specific measures where greatest gaps in care have been identified. • Clinical care—examples of common diseases to use for evaluation of the effect of PECC included: ○ Asthma exacerbation: e.g., steroids given in a timely fashion. ○ Ultrasound versus CT scan of abdomen for appendicitis. ○ Medication dosing errors. ○ Head and C-spine CT use in trauma patients. ○ Chest radiography use in bronchiolitis. • Education ○ Implementation of evidence-based guidelines. ○ Opportunities provided for skills acquisition and maintenance, particularly for low frequency/lifesaving procedures. • Communication ○ Patient experience (e.g., Press Ganey scores). ○ Collaboration and timely feedback among various EDs to provide high-quality, patient-centered care. ○ Frequency of medical errors.

AAFP = American Academy of Family Physicians; AAP = American Academy of Pediatrics; ACEP = American College of Emergency Physicians; AHRQ = Agency for Healthcare Research & Quality; CMS = Centers for Medicare & Medicaid Services; EMR = electronic medical record; EMSC = Emergency Medical Services for Children; EIIC = Emergency Medical Services for Children Innovation and Improvement Center; NPRP = National Pediatric Readiness Project; PALS = Pediatric Advanced Life Support; PECARN = Pediatric Emergency Care Research Network; PECC = Pediatric Emergency Care Coordinator; PEM = pediatric emergency medicine; PICU = pediatric intensive care unit; QI = quality improvement.

(pediatric emergency medicine practice in non–children's hospitals):

I. Identify solutions to the challenges and barriers in developing a system of care in general EDs to provide safe and quality care for children.
   - Future research should explore use of technology to enhance real-time clinical care between EDs, as well as collaborative networks for education, research, and advocacy.

II. Enhance collaboration between general EDs and pediatric-specific EDs when developing national guidelines and standardizing care.
   - Future research should explore development and implementation of patient care guidelines in general EDs as well as examine pediatric knowledge generation and dissemination in general EDs.

III. Study the quality of care provided to children in EDs in the United States.
   - Future research should study resources and capabilities of general EDs with regard to pediatric patients as well as the feasibility of extending pediatric QI to all EDs.

IV. Evaluate national pediatric readiness and its effects on patient outcomes.
   - Future research should evaluate the best way to prepare general EDs for the care of the acutely ill and injured pediatric patients, including the role of a PECC in advancing the quality of emergent care for children.

The results of the work in preparation for the consensus conference breakout session and the discussions during the session unmistakably iterated collaboration between general EDs and academic pediatric centers on research, dissemination, and implementation of evidence into clinical practice as a solution to improving the quality of pediatric care across the continuum.

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References

1. Rui P, Kang K. National Hospital Ambulatory Medical Care Survey: 2015 Emergency Department Summary Tables. Available at: https://www.cdc.gov/nchs/data/nhamcs/web_tables/2015_ed_web_tables.pdf. Accessed May 12, 2018
2. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
3. Knapp JF, Simon SD, Sharma V. Variation and trends in ED use of radiographs for asthma, bronchiolitis, and croup in children. Pediatrics 2013;132:245–52.
4. Li J, Monuteaux MC, Bachur RG. Variation in pediatric care between academic and nonacademic US emergency departments, 1995-2010. Pediatr Emerg Care 2017 Jan 24 [Epub ahead of print].
5. Niles LM, Goyal MK, Badolato GM, Chamberlain JM, Cohen JS. US emergency department trends in imaging for pediatric nontraumatic abdominal pain. Pediatrics 2017;140. pii: e20170615.
6. Michelson KA, Hudgins JD, Monuteaux MC, Bachur RG, Finkelstein JA. Cardiac arrest survival in pediatric and general emergency departments. Pediatrics 2018;141. pii: e20172741.
7. Whitfill T, Auerbach M, Scherzer D, Shi J, Xiang H, Stanley R. Emergency care for children in the United States: epidemiology and trends over time. J Emerg Med 2018;55:423–34.
8. Kawakita J. The KJ Method–A Scientific Approach to Problem Solving. Technical report. Tokyo: Kawakita Research Institute, 1975.
9. Auerbach M, Whitfill T, Gawel M, et al. Differences in the quality of pediatric resuscitative care across a spectrum of emergency departments. JAMA Pediatr 2016;170:987–94.
10. Joyce Li, Monuteaux MC, Bachur RG. Interfacility transfers of noncritically ill children to academic pediatric emergency departments. Pediatrics 2012;130:83–92.
11. Sacchetti A, Benjamin L, Soriano AR, Ponce MG, Baren J. Should pediatric emergency physicians be decentralized in the medical community? Pediatr Emerg Care 2014;30:521–4.
12. Scott SD, Albrecht L, Given LM, et al. Pediatric information seeking behaviour, information needs, and information preferences of health care professionals in general emergency departments: results from the Translating Emergency Knowledge for Kids (TREKK) needs assessment. CJEM 2018;20:89–99.
13. CALS (Comprehensive Advanced Life Support). Available at: https://calsprogram.org/. Accessed May 12, 2018.
14. Barata IA, Stadnyck JM, Akerman M, et al. Novel approach to emergency departments' pediatric readiness across a health system. Pediatr Emerg Care 2018 Feb 5 [Epub ahead of print].

15. Abulebda K, Lutfi R, Whitfill T, et al. A collaborative in situ simulation-based pediatric readiness improvement program for community emergency departments. Acad Emerg Med 2018;25:177–85.
16. Whitfill T, Gawel M, Auerbach MA. Simulation-based quality improvement initiative improves pediatric readiness in community hospitals. Pediatr Emerg Care 2018;34:431–5.
17. Gangadharan S, Tiyyagura G, Gawel M, et al. INSPIRE ImPACTS investigators. A grounded theory qualitative analysis of interprofessional providers' perceptions on caring for critically ill infants and children in pediatric and general emergency departments. Pediatr Emerg Care 2018;34:578–83.
18. American Academy of Pediatrics, Committee on Pediatric Emergency Medicine; American College of Emergency Physicians, Pediatric Committee; Emergency Nurses Association, Pediatric Committee. Joint policy statement: guidelines for care of children in the emergency department. J Emerg Nurs 2013;39:116–31.
19. American Academy of Pediatrics; Committee on Pediatric Emergency Medicine; American College of Emergency Physicians; Pediatric Committee; Emergency Nurses Association Pediatric Committee. Joint policy statement–guidelines for care of children in the emergency department. Pediatrics 2009;124:1233–43.
20. American Academy of Pediatrics Committee on Pediatric Emergency Medicine; American College of Emergency Physicians Pediatric Committee; Emergency Nurses Association Pediatric Committee. Joint policy statement: guidelines for care of children in the emergency department. Ann Emerg Med 2009;54:543–52.
21. National Pediatric Readiness Project. Emergency Medical Services for Children. Available at: http://www.pediatricreadiness.org. Accessed May 12, 2008.
22. Kuppermann N, Holmes JF, Muizelaar JP, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. Lancet 2009;374:1160–70.
23. Think A-Head and Image Gently. Available at: https://www.imagegently.org/Procedures/Minor-CT-in-Head-Injuries. Accessed May 12, 2018.
24. Dharmar M, Marcin JP, Kuppermann N, et al. A new implicit review instrument for measuring quality of care delivered to pediatric patients in the emergency department. BMC Emerg Med 2007;7:13.
25. Marcin JP, Romano PS, Dharmar M, et al. Implicit review instrument to evaluate quality of care delivered by physicians to children in emergency departments. Health Serv Res 2018;53:1316–34.
26. Marcin JP, Romano PS, Dayal P, et al. Patient-level factors and the quality of care delivered in pediatric emergency departments. Acad Emerg Med 2018;25:301–9.
27. Proctor E, Silmere H, Raghavan R, et al. Outcomes for implementation research: conceptual distinctions, measurements challenges, and research agenda. Adm Policy Ment Health 2011;38:65–76.
28. Cloutier RL, Mistry RD, Cico S, et al. Keeping up with the kids: diffusion of innovation in pediatric emergency medicine among emergency physicians. Acad Emerg Med 2017;24:769–75.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13642/full

Data Supplement S1. Additional resources.

Pediatric Telemedicine Use in United States Emergency Departments

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ABSTRACT

Introduction: The receipt of remote clinical care for children via telecommunications (pediatric telemedicine) appears to improve access to and quality of care in U.S. emergency departments (EDs), but the actual prevalence and characteristics of pediatric telemedicine receipt remain unclear. We determined the prevalence and current applications of pediatric telemedicine in U.S. EDs, focusing on EDs that received telemedicine from clinicians at other facilities.

Methods: We surveyed all 5,375 U.S. EDs to characterize emergency care in 2016. We then randomly surveyed 130 (39%) of the 337 EDs who reported receiving pediatric telemedicine. The second survey was administered by phone to ED directors primarily. It confirmed that the ED received pediatric telemedicine services in 2017 and asked about ED staffing and the nature, purpose, and concerns with pediatric telemedicine implementation.

Results: The first survey (4,507/5,375, 84% response) showed that 337 (8%) EDs reported receiving pediatric telemedicine. Among the randomly sampled EDs completing the second survey (107/130, 82% response), 96 (90%) confirmed 2016 use and 89 (83%) confirmed 2017 use. Reasons for discontinuation included technical and scheduling concerns. Almost all who confirmed their pediatric telemedicine use in 2017 also reported 24/7 availability (98%). The most widely reported use was for patient placement and transfer coordination (80%). Many EDs (39%) reported no challenges with implementing pediatric telemedicine and described its utility. However, the most frequently reported challenges were process concerns (30%), such as concerns about slowing or interrupting providers' work flow and technological concerns (14%).

Conclusion: Few EDs receive telemedicine for the delivery of pediatric emergency care nationally. Among EDs that do use telemedicine for pediatric care, many report process concerns. Addressing these barriers through focused education or interventions may support EDs in further developing and optimizing this technological adjunct to pediatric emergency care.

Telemedicine is the remote provision of clinical care via audio or visual communications and can be administered to a facility by other hospitals or private companies.[1] Typically, clinicians in one facility provide telemedicine to patients in a different facility that receive these services. In emergency departments (EDs), receipt of telemedicine has led to higher patient satisfaction and better patient outcomes, especially when EDs lack in-

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person specialist care (e.g., pediatric emergency medicine [PEM]).[2] Telemedicine use in referring EDs is associated with improved stabilization of children admitted to a pediatric intensive care unit (PICU).[3] Furthermore, pediatric critical care telemedicine consultations in rural EDs have demonstrated higher physician-rated quality of care and lower risk of physician-related ED medication errors compared with either telephone or no consultation, underscoring the value of telemedicine in this population[4,5] Nevertheless, the prevalence, characteristics, and applications of receipt of pediatric telemedicine remain unclear. To address these knowledge gaps, we investigated the use of telemedicine for pediatric emergency care among U.S. EDs who reported receiving telemedicine services for pediatrics.

METHODS

Study Design

We administered two national surveys, both available in Data Supplement S1 (available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13629/full). The institutional review board determined that this study was exempt.

Study Protocol

From January through October 2017, we conducted a nine-question national survey of all U.S. EDs to characterize emergency care in 2016. Potential respondents were identified using the National Emergency Department Inventory (NEDI)-USA database,[6] which comprises all 5,375 nonfederal, nonspecialty EDs open 24 hours/day, 7 days/week. Each ED director was mailed a one-page survey up to three times. For nonresponding EDs, we contacted ED staff by telephone to complete the survey by interview. The survey took approximately 2 minutes to complete.

A random sample of 130 (39%) of the 337 respondents who reported receiving pediatric telemedicine on the 2016 NEDI-USA survey were further surveyed to characterize their pediatric telemedicine use during 2017. This random sample was selected via a random number macro (Excel, Microsoft). The sample size of 130 was determined by calculating the 95% confidence intervals of expected proportions (e.g., 50%) in different samples sizes; 130 EDs yielded sufficiently precise estimates for 426 EDs.

A nine-question survey was administered to these EDs by telephone from February through May 2018. Respondents were also given the option of completing the survey online. The director of each ED was surveyed whenever possible, and the survey took approximately 5 minutes to complete. These survey questions were developed based on feedback from several telemedicine and national survey research experts and were first piloted over the phone in a random sample of 20 EDs that reported that they receive pediatric telemedicine.

Measurements

For the 2016 NEDI-USA survey, data collection included ED location, visit volumes, and basic pediatric and telemedicine characteristics. Receipt of telemedicine was assessed with the question, "Does your ED receive telemedicine services for patient evaluation?" The follow-up question to this was, "If your ED receives telemedicine services, does your ED utilize telemedicine for: (check all that apply)," with "pediatrics" listed as a check-box option. For the follow-up survey, data collection included availability of pediatric telemedicine, staffing of ED, purposes (applications) for pediatric telemedicine use, and challenges with implementation.

Data Analysis

All analyses were performed using Stata 14.2 (StataCorp). Descriptive statistics are presented as proportions and medians with interquartile ranges (IQRs). We examined national use of pediatric telemedicine by ED characteristics using chi-square or Wilcoxon rank sum test, as appropriate. All p-values were two-tailed, with $p < 0.05$ considered statistically significant.

RESULTS

Overall, 84% of 5,375 EDs responded to the 2016 NEDI-USA survey. Among EDs that responded to the survey item pertaining to pediatric telemedicine use (n = 4,410), 337 (8%) reported receiving pediatric telemedicine. EDs receiving pediatric telemedicine had a lower median annual ED visit volume than EDs that did not: 9,490 vs. 21,845 ($p < 0.001$). EDs that received pediatric telemedicine had a similar annual pediatric visit volume as EDs that did not (19% [IQR = 12%–25%] vs. 18% [IQR = 11%–25%]). As shown in Table 1, EDs receiving pediatric telemedicine were less likely to be urban (located in a core-based statistical area) than EDs that did not receive pediatric telemedicine ($p < 0.001$) and EDs

Table 1
Characteristics of U.S. EDs by Receipt of Pediatric Telemedicine (n = 4,410)

ED Characteristics	All EDs, n = 4,410	EDs That Do Not Receive Pediatric Telemedicine, n = 4,073	EDs That Receive Pediatric Telemedicine, n = 337	p-value
Annual total ED visits				<0.001
<10,000	1,380 (31)	1,209 (30)	171 (51)	
10,000–19,999	746 (17)	696 (17)	50 (15)	
20,000–39,999	1.051 (24)	992 (24)	59 (18)	
≥40,000	1,233 (28)	1,176 (29)	57 (17)	
Percentage of annual ED visits by children				0.10
<15%	1,368 (31)	1,272 (31)	96 (28)	
15%–24.9%	1,546 (35)	1,411 (35)	135 (40)	
25%–49.9%	831 (19)	763 (19)	68 (20)	
≥50%	121 (3)	112 (3)	9 (3)	
Unknown	544 (12)	515 (13)	29 (9)	
Any PECC	844 (19)	790 (19)	54 (16)	0.13
Physician PECC	527 (12)	492 (12)	35 (10)	0.36
Nurse PECC	623 (14)	585 (14)	38 (11)	0.12
Other PECC	64 (1)	60 (1)	4 (1)	0.68
Regional location				<0.001
Northeast	549 (12)	508 (12)	41 (12)	
Midwest	1,205 (27)	1,082 (27)	123 (37)	
South	1,826 (41)	1,740 (43)	86 (26)	
West	830 (19)	743 (18)	87 (26)	
In core base statistical area				<0.001
No	959 (22)	803 (20)	156 (46)	
Yes	3,451 (78)	3,270 (80)	181 (54)	
Council of teaching hospital	213 (5)	206 (5)	7 (2)	0.01
Academic ED	163 (4)	160 (4)	3 (1)	0.004
Critical access hospital	1,168 (26)	987 (24)	181 (54)	<0.001

Data are reported as n (%).
IQR = interquartile range; PECC = pediatric emergency care coordinator.

overall. Approximately half (54%) of EDs receiving pediatric telemedicine were critical access hospitals, compared to 24% of EDs that did not receive pediatric telemedicine.

In the follow-up survey, 107 (82%) of the 130 randomly selected EDs responded; 99 completed the survey via telephone, and eight completed the survey online. Of these, 96 (90%) confirmed pediatric telemedicine use in 2016, and 89 (83%) further confirmed use in 2017 (Data Supplement S1, Table S1). Given the confirmation rate, we estimate that 7% of EDs used telemedicine for pediatrics in 2017. Of the 18 respondents who did not confirm use in 2017, seven reported that pediatric telemedicine either had previously been used and then discontinued or was being set up. They cited technical and scheduling difficulties as reasons for discontinuation. Of the other 11 EDs, seven received telemedicine for nonpediatric applications, and four did not receive telemedicine at all, indicating that 10% of ED respondents in the follow-up survey were misclassified.

Frequency

Of the 89 respondents who confirmed ED capacity to receive pediatric telemedicine, 76 (85%) reported using the service at least once in 2017. Almost half the respondents (48%) reported use for evaluation of at least one infant aged < 1 year, and most (81%) reported evaluation of at least one child aged between 1 and 17.9 years.

Staffing and Applications

Almost all EDs receiving pediatric telemedicine reported never having a board-certified or board-eligible PEM physician (90%) or pediatrician (93%)

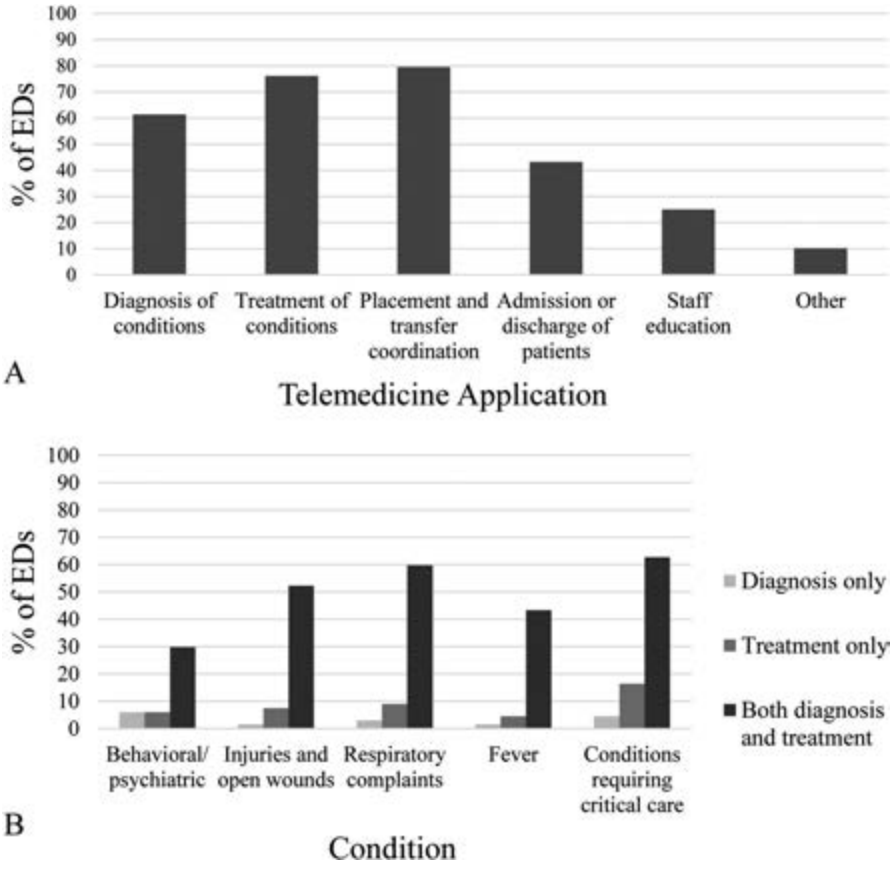

Figure 1. Pediatric telemedicine use in U.S. EDs. (**A**) Applications of pediatric telemedicine use in U.S. EDs (n = 88). ED respondents selected all applicable applications. Write-in responses of "other" applications included neonatal resuscitation, pharmacy assistance, and orthopedics. (**B**) Conditions diagnosed and treated with pediatric telemedicine in U.S. EDs (n = 67). Figure excludes those that did not report using pediatric telemedicine to diagnose or treat any conditions (n = 21). ED respondents selected all applicable conditions. *Bars* within each condition are mutually exclusive, representing the percentage of responding EDs that used pediatric telemedicine to 1) only diagnose that condition, 2) only treat that condition, or 3) both diagnose and treat that condition.

working clinically in their ED. Among the none EDs with a PEM physician, four (44%) reported that they were on duty for ≥8 hours on a typical day. Among the six EDs with a pediatrician, one (17%) reported that they were on duty for ≥8 hours on a typical day. EDs also reported specific applications for pediatric telemedicine, and the conditions it was used to diagnose or treat (Figure 1); EDs most frequently reported using telemedicine for patient placement and transfer coordination (80%).

Perceived Challenges

Many respondents (39%) reported no significant challenges with implementation of pediatric telemedicine in their ED. Others most frequently cited process (30%) and technology (14%) concerns (Table 1). Interestingly, 6% of total respondents reported an inadequate pediatric visit volume to observe challenges. Some respondents described difficulties getting staff members to remember pediatric telemedicine was available.

DISCUSSION

Telemedicine is defined as the remote provision of clinical care via audio or visual communications, and this study aimed to determine the prevalence, characteristics, and applications of telemedicine in EDs that receive pediatric telemedicine. Of the 4,410 U.S. EDs that responded to the NEDI-USA survey, 337 (8%) reported receiving pediatric telemedicine in 2016. This national survey allowed us to randomly sample a subset of EDs that receive pediatric telemedicine for a second, more focused survey on pediatric telemedicine. Briefly, most EDs receiving pediatric telemedicine had 24/7 access to this resource and were not staffed by a board-certified or board-eligible PEM physician or pediatrician, suggesting that telemedicine was filling a likely gap in pediatric specialist access. Placement and transfer coordination was the most commonly reported application, followed by treatment and diagnosis of conditions. Critical care conditions were most commonly treated or diagnosed with pediatric

telemedicine. Although many EDs reported no concerns with implementing pediatric telemedicine, process and technology concerns were often cited, including difficulties incorporating into workflow and recalling resource availability. These are similar to the anticipated barriers (e.g., infrequent need to use) reported from a study that conducted qualitative interviews with ED providers.[7] Of EDs that discontinued telemedicine between 2016 and 2017, scheduling and technical difficulties were frequently cited.

Many children in the United States lack timely access to EDs with high pediatric readiness, which underscores the potential benefit of pediatric telemedicine adoption in EDs in enabling access to pediatric-ready care where it otherwise would not be available.[8] Further, pediatric telemedicine can improve equity and access to acute care in an urban setting, critical care quality in rural EDs,[4,9] and stabilization of critical care transfers.[3] Specifically, when compared with no consultations, pediatric telemedicine in rural EDs demonstrated higher physician-rated quality of care and lower risk of physician-related medication errors.[5,9] Despite this evidence, we found only 8% of U.S. EDs currently receive pediatric telemedicine. Previously, clinicians identified factors affecting adoption of pediatric emergency telemedicine, including perceived usefulness and ease of use as well as contextual factors including geographical setting, culture, and personal experience.[10] These factors are predictors that could increase the prevalence of this service nationwide. A survey of a different stakeholder group, caregivers whose children were transferred to pediatric EDs, showed that although most had never heard of telemedicine, they were receptive to its use.[11]

Approximately 15% of sampled EDs equipped with this technology did not use pediatric telemedicine at all in 2017. This infrequent use may be partially due to the challenges and concerns described above, particularly in EDs with low pediatric visit volumes. Moreover, while our surveys show that a subset of EDs across the U.S. do successfully implement this technology, factors such as perceived usefulness and ease of use will influence nationwide adoption, and education about telemedicine use among providers may help providers use this service more often in their EDs. This increased access to care may help improve patient outcomes both in underresourced rural settings with low pediatric volumes and in crowded urban EDs, narrowing gaps in access to pediatric emergency care.

LIMITATIONS

This study has several potential limitations. First, the NEDI-USA survey queried telemedicine use in 2016 while the follow-up survey queried 2017 use; however, this actually enabled us to identify EDs that discontinued use and to begin to understand reasons for discontinuation. Second, as a cross-sectional study, causal inferences are not possible. Third, because data were self-reported, there may be information bias, which we tried to mitigate by surveying ED leadership. Fourth, these two surveys do not address the actual process or clinical outcomes of receipt of pediatric telemedicine. Finally, while the national survey had 4,507 ED respondents, the follow-up survey only had 107 and only 89 confirmed receipt or capability to receive telemedicine for the evaluation of children in 2017. While response rates were strong (>80%), this limited our ability to examine independent relationships in multivariable regression models. As the 130 EDs in the follow-up survey comprise over one-third of the 337 EDs receiving pediatric telemedicine, we believe that this was a reasonable sample size to provide the first benchmark data on this topic.

CONCLUSIONS

Overall, 8% (337) of all EDs surveyed nationally reported receiving pediatric telemedicine in 2016. Of the 107 EDs further surveyed, 83% (89) confirmed use in 2017, from which we estimate that 7% of EDs used pediatric telemedicine. Most EDs using pediatric telemedicine were not staffed by board-certified or board-eligible pediatric emergency medicine physicians or pediatricians. Over one-third of respondents reported no challenges implementing pediatric telemedicine in their EDs, but this resource is used infrequently. We encourage further study of the reported challenges, particularly process and technological concerns and identification of the optimal approach to educating providers and staff on the role of pediatric telemedicine in EDs.

References

1. Tuckson RV, Edmunds M, Hodgkins ML. Telehealth. N Engl J Med 2017;377:1585–92.
2. Ward MM, Jaana M, Natafgi N. Systematic review of telemedicine applications in emergency rooms. Int J Med Inform 2015;84:601–16.
3. Dayal P, Hojman NM, Kissee JL, Litman RL, Nesbitt TS, Marcin JP. Impact of telemedicine on severity of illness and outcomes among children transferred from referring

emergency departments to a children's hospital PICU. Pediatr Crit Care Med 2016;17:516–21.
4. Ronis SD, Mcconnochie KM, Wang H, Wood NE. Urban telemedicine enables equity in access to acute illness care. Telemed J E Health 2017;23:105–12.
5. Dharmar M, Kuppermann N, Romano PS, et al. Telemedicine consultations and medication errors in rural emergency departments. Pediatrics 2013;132:1090–7.
6. Sullivan AF, Richman IB, Ahn CJ, et al. A profile of US emergency departments in 2001. Ann Emerg Med 2006;48:694–701.
7. Kim JW, Tiyyagura G, Langhan M. A qualitative analysis on general emergency medicine providers' perceptions on pediatric emergency telemedicine. Pediatr Emerg Care 2017 [Epub ahead of print].
8. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. J Pediatr 2018;194:225–32.
9. Dharmar M, Romano PS, Kuppermann N, et al. Impact of critical care telemedicine consultations on children in rural emergency departments. Crit Care Med 2013;41:2388–95.
10. Ray KN, Felmet KA, Hamilton MF, et al. Clinician attitudes toward adoption of pediatric emergency telemedicine in rural hospitals. Pediatr Emerg Care 2017;33:250–7.
11. Mollen CJ, Henien M, Jacobs LM, Myers S. Parent perceptions on transfers to pediatric emergency departments and the role of telemedicine. Pediatr Emerg Care 2016 [Epub ahead of print].

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13629/full

Data Supplement S1. Supplemental material.

Factors Associated With Pediatric Nontransport in a Large Emergency Medical Services System

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ABSTRACT

Background: Pediatric patients attended to by emergency medical services (EMS) but not transported to the hospital are an at-risk population. We aimed to evaluate risk factors associated with nontransport by EMS in pediatric patients.

Methods: We reviewed medical records of 24 agencies in a regional EMS system in Southwestern Pennsylvania between January 1, 2014, and December 31, 2017. We abstracted demographics (age, sex, medical complaint, median household income by zip code, race, ethnicity), clinical characteristics (abnormal vital signs by age, procedures done), and transport characteristics. We excluded patients ≥ 18 years, interfacility transfers, scene assists, cardiac arrest, and those without a patient encounter. We used unadjusted and adjusted logistic regression to identify factors associated with nontransport, reporting adjusted odds ratios (aOR) with 95% confidence intervals (CIs).

Results: We included 30,663 pediatric patients (52.9% male, mean ± SD age = 8.5 ± 6.2 years), of whom 5,002 (16.3%) were nontransports. In adjusted analysis (aOR, 95% CI), nontransports were associated with medical categories of trauma (4.32, 3.57–5.23), respiratory (4.03, 3.09–5.26), toxicologic (2.53, 1.66–3.86), and syncope (5.97, 3.78–9.41). Nontransports were less likely for psychiatric (0.52, 0.34–0.79) complaints; for black patients compared to white (0.31, 0.26–0.37); and in patients 6 to <12 years (0.76, 0.65–0.90), 2 to <6 years (0.77, 0.65–0.91), 1 to <2 years (0.53, 0.42–0.66), and 1 month to 1 year (0.52, 0.40–0.66) compared to patients ≥ 12 years of age. Nontransport was associated with longer scene time (1.03, 1.02–1.04) and with fall compared to winter (1.29, 1.08–1.54) and was less likely in those with abnormal mental status (0.45, 0.33–0.62), medication administration (0.16, 0.08–0.31), or monitor application (0.10, 0.06–0.15).

Conclusion: Pediatric nontransports are associated with traumatic, respiratory, and toxicologic complaints and older age. These findings can facilitate development of refusal protocols and research on outcomes of these at-risk patients.

Out-of-hospital scene responses without transport to the hospital represent a medical, administrative, and legal challenge for emergency medical services (EMS). In studies of adult populations, rates of nontransports have been reported from 5% to as high as 48% of EMS responses.[1–3] Previous investigators have found that between 2 and 16% of patients refusing transport require subsequent hospitalization,[1,4–6] potentially representing a missed opportunity in patient care. Additionally, nontransports account for

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one of the most commonly reported reasons for malpractice claims against EMS agencies and personnel.[7,8]

In this setting, pediatric nontransports represent an additional medicolegal challenge. While there are some data on adult nontransports, data on pediatric nontransports are more limited. Children constitute approximately 7% of EMS responses in the United States.[9] Rates of pediatric nontransport have been reported in between 19% and 28% of EMS responses.[10–12] Up to 10% of pediatric patients not transported by EMS may require subsequent hospitalization, a figure similar to the above-mentioned adult studies.[13] Children are an inherently at-risk population; caregivers must advocate for them due to limits in communication and minority legal status. Due to this reliance on caregivers, combined with a limited ability to engage in decision making directly with the patient and complex legal implications, pediatric refusals are especially challenging for EMS personnel. To date, previous evaluations of pediatric nontransport have been limited by small sample size[10,11] or have been unable to control for potential confounders.[12] For example, while patients with trauma are associated with a higher rate of nontransport,[12] it is unknown if this association persists after accounting for patient age or sex, factors that are also closely associated with trauma. A larger and more detailed analysis of nontransports may be able to better identify factors associated with this outcome. Better data on risk factors for pediatric nontransport are needed to inform the medical decision making surrounding refusal protocols and ensure that these protocols adequately identify those who should be transported. Additionally, identification of high-risk subgroups may identify areas that can better inform medical decision making as part of refusal protocols addressing these patients.

We aimed to evaluate potential risk factors associated with pediatric nontransport by EMS with the goal of identifying if specific patient characteristics, timing of EMS contact, scene factors, and geographic factors were associated with higher rates of transport refusal. We hypothesized that certain subgroups may be at higher risk of nontransport compared to transported pediatric patients.

METHODS

Study Design and Setting

We performed a retrospective review of ground EMS scene responses by 24 urban, suburban, and rural EMS agencies in a regional EMS system of Western Pennsylvania between January 1, 2014, and December 31, 2017. These EMS agencies receive centralized medical oversight and have research data use agreements with the University of Pittsburgh Medical Center. This study was approved by the University of Pittsburgh Institutional Review Board with a waiver of informed consent.

Emergency medical services medical care and the management of nontransports is outlined in statewide EMS protocols. By protocol, refusals of transport are initiated by the patient (if ≥ 18 years of age) or guardian. The agencies and protocols within our EMS system do not support provider-initiated refusals. Therefore, refusals are principally because upon assessment, the patient or parent/guardian declines transport to the hospital. All refusals involving minor patients require discussion with online medical direction. Upon discussion with a physician, if the patient or guardian understands the clinical situation and is able to understand the risks of nontransport, then the patient may not be transported to the hospital (Figure 1). The Pennsylvania refusal protocol is similar to recommendations in the National Model EMS Clinical Guidelines.[14] During the study period, there was no change in the statewide refusal protocol.[15–17]

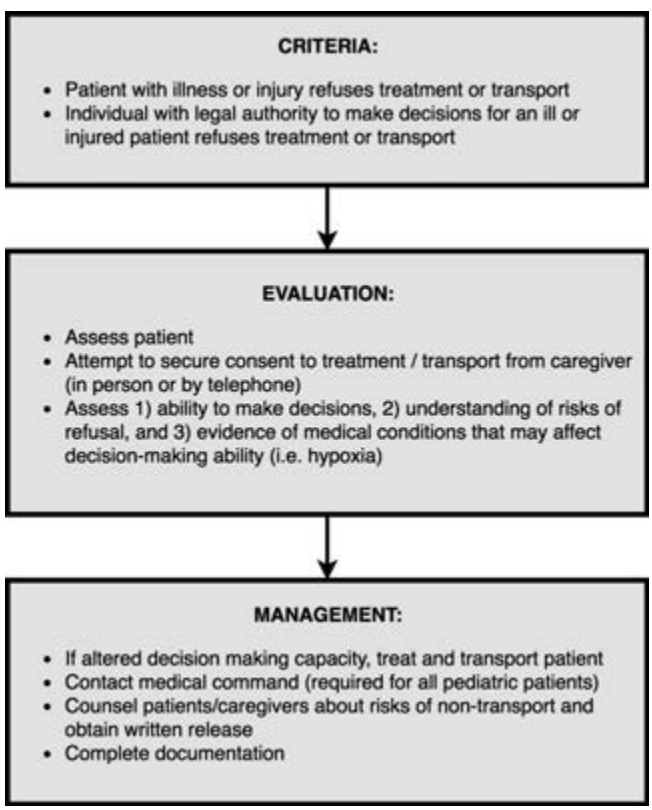

Figure 1. Summary of Pennsylvania refusal protocol as applicable to unemancipated minors.

Data Source and Selection of Participants

We obtained data from a National EMS Information System–compliant electronical prehospital patient care record system (emsCharts, Warrendale, PA) used by all participating EMS agencies. Data were obtained from emsCharts in XML format and compiled into a research data set using Matlab (MathWorks) for extraction and Stata (StataCorp) for synthesis into a prehospital registry data set. We considered patients to be pediatric if they were < 18 years of age. We screened all patient reports from the participating EMS agencies over the study period and excluded cases if there was documentation of cardiac arrest or age, if the transport was between medical facilities, or if the EMS call was a scene assist (an additional EMS crew called to the scene to provide additional assistance but not providing primary care of the patient). Cardiac arrest was defined as any of the following: 1) documented provider impression of cardiac arrest, death, traumatic arrest, or dead on arrival; 2) documented outcome listed as funeral home, pronounced, dead, or coroner transport; 3) documented rhythm of asystole, PEA, pulseless, agonal, ventricular fibrillation, or ventricular tachycardia; 4) documented procedure of defibrillation or CPR; or 5) documented use of epinephrine as dosed for cardiac arrest.

Patient Demographics and Assessments

Patient demographics included age, sex, race, ethnicity, and medical complaint. Age was classified as neonates (≤30 days), infants (1 month to <1 year), toddlers (1 to <2 years), early childhood (2 to <6 years), middle childhood (6 to <12 years), and adolescent (12 to <18 years). Race was divided into categories of white, black, other, and unknown. Ethnicity was categorized as Hispanic and not Hispanic. Documented medical categories based on chief complaints were reclassified into 12 categories: general medical, trauma, respiratory, allergic, gastrointestinal, cardiovascular, neurologic, psychiatric, toxicologic, dizziness/syncope, other, and unknown. From each patient zip code, we abstracted median household income derived from the 2012 to 2016 American Community Survey 5-year estimates.[18] Income data were divided into four categories based on quartile.

EMS Assessments

Vital signs of maximum heart rate, respiratory rate, and lowest systolic blood pressure per age group were determined on the basis of age-related normal ranges as defined by Pediatric Advanced Life Support (ALS) guidelines.[19] We categorically abstracted if any vital sign (heart rate, respiratory rate, or blood pressure) was assessed on each patient. After converting all Fahrenheit measurements to Celsius, we defined fever as a measurement of ≥38.0°C. We defined oxygen desaturation as a recorded pulse oximetry < 95%. Additionally, we noted EMS impressions of history of loss of consciousness or altered mental status. We defined altered mental status as an EMS impression other than "alert" or a Glasgow Coma Scale < 15.

Transport Characteristics

Transport characteristics included year, season, day of week, and time of day of transport (classified into four time groups as 00:00–05:59, 06:00–11:59, 12:00–17:59, 18:00–23:59), response time (between dispatch and arrival to scene), time at scene (between arrival to scene and departure to hospital), transport time (between departure from scene to arrival at hospital), provider certification for the highest level of provider (basic life support vs. ALS), contact with online medical direction, administration of any medications, placement of a peripheral intravenous (IV) line, and use of a cardiac monitor or supplemental oxygen. Season was defined using meteorologic definitions (winter, January 1 to March 31; spring, April 1 to June 30; summer, July 1 to September 30; and fall, October 1 to December 31). Day of week was classified into weekend (Saturday and Sunday) and weekday (all others).

Data Analysis

We performed unadjusted analysis using univariate regression, followed by adjusted analysis using multivariable logistic regression to test associations of demographics, assessments, and EMS characteristics with outcome. Our outcome of interest was nontransport. Ethnicity and vital signs parameters were removed from the model due to a due to a >20% rate of missing data. We included variables in adjusted models if they had an unadjusted association with outcome significant at a threshold of $p < 0.10$. Results were presented as adjusted odds ratios (aOR) with 95% confidence intervals (CIs), taking p-values of <0.05 as significant. Statistical analysis was performed using R version 3.5.1 (R Foundation for Statistical Computing). Only cases with complete data were used in the final model. As a sensitivity analysis to incorporate cases with missing data, we conducted random forest imputation using the *missForest* package (version 1.4) for missing data and reperformed the logistic regression.

RESULTS

A total of 799,894 EMS responses were reviewed. Of the 686,825 with a recorded patient age, 44,290 (6.4%) were pediatric. After additional exclusions, we identified 5,002 of 30,663 (16.3%) pediatric nontransports and 25,661 of 30,663 (83.7%) transports (Figure 2). Mean (±SD) patient age was 8.6 (±6.2) years. Of those with a listed sex, 16,034 of 30,304 were male (52.9%). Characteristics of study subjects by transport outcome are provided in Table 1.

Results of univariate and multivariable logistic regression are provided in Table 2. Multivariable logistic regression revealed an increased odds of nontransports with the following characteristics: medical categories of trauma, respiratory, allergic, neurologic, toxicologic, or dizziness/syncope compared to the general medical category; presentation in years 2015, 2016, and 2017 compared to 2014; during all day periods compared to the times 00:00 to 05:59; and during the fall compared to winter. Contact with online medical direction and longer scene times were associated with a higher odds of nontransport.

Demographic factors associated with lower rate of nontransports included black race compared to white race and age groups 6 to <12 years, 2 to 6 years, 1 to <2 years, and 1 month to 1 year. A lower aOR of nontransport was found in patients with psychiatric complaints. Lower aOR of nontransports was seen in patients with any vital sign assessed, abnormal mental status, an ALS assessment, shorter response time, given medications, or oxygen; who had an IV line placed, or for whom a monitor was applied.

Results of a sensitivity analysis using data imputation for missing values had similar results. There was a higher aOR of nontransports in the zip code regions with the third highest income quartile compared to the highest income quartile (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13652/full).

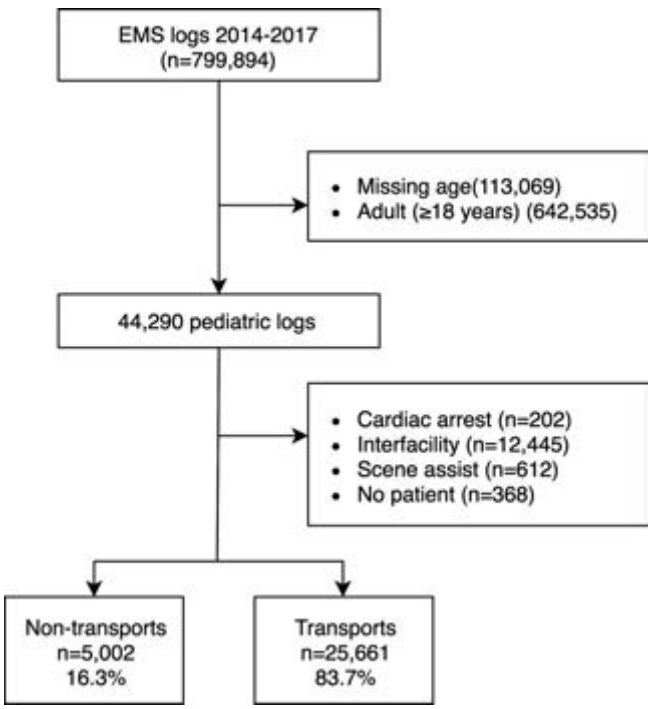

Figure 2. STROBE diagram illustrating patient inclusion. EMS = emergency medical services.

DISCUSSION

Using a multivariable regression model from a large regional data set, we found that nontransports were associated with traumatic and respiratory complaints. Nontransports were less likely in younger children and in patients with psychiatric complaints. Notably, the proportion of nontransports has increased over time without any changes made to statewide refusal protocols over the study period. These findings may be useful in identifying populations at greatest risk of nontransport and can facilitate the development of refusal protocols and prehospital triaging guidelines.

We found a rate of pediatric nontransports of 16.3%, similar to a rate of 19.8% identified by Gerlacher et al.,[12] in a pediatric study evaluating children < 12 years of age in a single urban EMS system. However, higher pediatric nontransport rates have been previously reported as well: a rate of 28% was reported in a Canadian system[10] and rate of 27.2% was identified in a Detroit-based EMS network.[11] Our relatively lower rate may be attributed to a larger sample size and our evaluation of multiple EMS agencies, covering a broader range of urban and rural communities.

The higher odds of nontransport in patients with traumatic complaints has been previously described.[11,12] Similar findings have been described in adult nontransports.[3] Unlike previous investigators, we found that other categories associated with nontransport were those with toxicologic, cardiovascular, and dizziness/syncopal complaints. As some of these patients may have significant association with disease, including the potential for a delayed development of symptoms, these medical complaints may be important

Table 1
Patient Demographics Among Included Patients Who Were Transported and Not Transported in Study

	Total	Transported	Not Transported
Number	30,663	25,661 (83.7)	5,002 (16.3)
Age			
Adolescent	11,378 (37.1)	9,519 (37.1)	1,859 (37.2)
Middle childhood	6,234 (20.3)	5,098 (19.9)	1,136 (22.7)
Early childhood	6,095 (19.9)	5,082 (19.8)	1,013 (20.3)
Toddler	3,062 (10.0)	2,641 (10.3)	421 (8.4)
Infant	3,324 (10.8)	2,848 (11.1)	476 (9.5)
Neonate	570 (1.9)	473 (1.8)	97 (1.9)
Male sex*	16,034/30,304 (52.9)	13,424/25,469 (52.7)	2,610/4,835 (54.0)
Race			
White	8,871 (28.9)	6,960 (27.1)	1,911 (38.2)
Black	8,156 (26.6)	7,028 (27.4)	1,128 (22.6)
Other	344 (1.1)	308 (1.2)	36 (0.7)
Unknown	13,292 (43.3)	11,365 (44.3)	1,927 (38.5)
Ethnicity			
Non-Hispanic	16,750/17,071 (98.1)	13,762/14,023 (98.1)	2,988/3,048 (98.0)
Hispanic	321/17,071 (1.9)	261/14,023 (1.9)	60/3,048 (2.0)
Medical category			
General medical	8,070 (26.3)	7,354 (28.7)	716 (14.3)
Trauma	9,085 (29.6)	6,705 (26.1)	2,380 (47.6)
Respiratory/airway	3,650 (11.9)	3,103 (12.1)	547 (10.9)
Allergic	686 (2.2)	583 (2.3)	103 (2.1)
Gastrointestinal	1,282 (4.2)	1,204 (4.7)	78 (1.6)
Cardiovascular	315 (1.0)	287 (1.1)	28 (0.6)
Neurologic	2,653 (8.7)	2,468 (9.6)	185 (3.7)
Psychiatric/behavioral	1,278 (4.2)	1,180 (4.6)	98 (2.0)
Toxicologic	821 (2.7)	692 (2.7)	129 (2.6)
Dizziness/syncope	911 (3.0)	769 (3.0)	142 (2.8)
Other	1,590 (5.2)	1,144 (4.5)	446 (8.9)
Unknown	322 (1.1)	172 (0.7)	150 (3.0)
Year			
2014	7,825 (25.5)	6,741 (26.3)	1,084 (21.7)
2015	7,918 (25.8)	6,733 (26.2)	1,185 (23.7)
2016	7,593 (24.8)	6,258 (24.4)	1,335 (26.7)
2017	7,327 (23.9)	5,929 (23.1)	1,398 (27.9)
Day period			
00:00–05:59	3,265 (10.6)	2,876 (11.2)	389 (7.8)
06:00–11:59	6,607 (19.8)	5,172 (20.2)	895 (17.9)
12:00–17:59	10,780 (35.2)	8,811 (34.3)	1,969 (39.4)
18:00–23:59	10,551 (34.4)	8,802 (34.3)	1,749 (35.0)
Day of week			
Weekday	22,025 (71.8)	18,534 (72.2)	3,491 (69.8)
Weekend	8,638 (28.2)	7,127 (27.8)	1,511 (30.2)
Time of year			
Winter	7,482 (24.4)	6,353 (24.8)	1,129 (22.6)
Spring	7,615 (24.8)	6,357 (24.8)	1,258 (25.1)
Summer	7,881 (25.7)	6,507 (25.4)	1,374 (27.5)
Fall	7,685 (25.1)	6,444 (25.1)	1,241 (24.8)

(Continued)

Table 1 (Continued)

	Total	Transported	Not Transported
Income by zip code*			
Fourth quartile	7,075/29,953 (23.6)	5,854/25,050 (23.4)	1,221/4,903 (24.9)
Third quartile	7,890/29,953 (26.3)	6,511/25,050 (26.0)	1,379/4,903 (28.1)
Second quartile	6,793/29,953 (22.7)	5,714/25,050 (22.8)	1,079/4,903 (22.0)
First quartile	8,195/29,953 (27.4)	6,971/25,050 (27.8)	1,224/4,903 (25.0)
Vital signs*			
At least one vital assessed	24,584 (80.2)	21,661 (84.4)	2,923 (58.4)
Tachycardia for age	5,825/24,335 (23.9)	5,356/21,505 (24.9)	469/2,830 (16.6)
Hypotension for age	478/20,954 (2.3)	449/18,707 (2.4)	29/2,247 (1.3)
Tachypneic for age	7,073/23,976 (29.5)	6,319/21,157 (29.9)	754/2,819 (26.7)
Febrile	357/746 (47.9)	340/703 (48.4)	17/43 (39.5)
Pulse oximetry < 95%	498/21,622 (2.3)	491/19,406 (2.5)	7/2,216 (0.3)
Neurologic characteristics			
Abnormal mental status*	3,509/30,412 (11.5)	3,349/25,526 (13.1)	160/4,886 (3.3)
Loss of consciousness*	936/29,985 (3.1)	876/25,123 (3.5)	60/4,862 (1.2)
Response characteristics			
Medical consult called	2,910 (9.5)	1,828 (7.1)	1,082 (21.6)
ALS transport	29,241 (95.4)	24,570 (95.7)	4,671 (93.4)
Response time	8.9 ± 5.3	9.1 ± 5.3	8.2 ± 5.3
Scene time	12.7 ± 13.5	12.2 ± 12.7	19.9 ± 21.4
Transport time	18.1 ± 11.5	18.1 ± 11.5	Not applicable
Peripheral IV obtained	4,160 (13.6)	4,154 (16.2)	6 (0.1)
Given any medication	3,124 (10.2)	3,049 (11.9)	75 (1.5)
Monitor use	6,414 (20.9)	6,283 (24.5)	131 (2.6)
Given oxygen	1,994 (6.5)	1,731 (6.7)	263 (5.3)

Data are reported as n (%) or mean ± SD.
ALS = Advanced Life Support provider; IV = intravenous line.
*Denominator represents cases with documentation of the variable.

targets for EMS protocols and provider education addressing patient groups that are more commonly not transported.

Similar to work by previous investigators, we found a lower rate of nontransport in younger children,[11,12] which may reflect EMS inexperience with young children or increased parental apprehension at this age. We identified that black patients were at a lower risk of nontransports as compared to white patients. While rates of nontransports in Hispanic patients were noted to be lower by Gerlacher et al.,[12] racial and ethnic attitudes toward nontransport have not previously been explored.

A variety of reasons have been hypothesized for nontransports. Our EMS system does not support provider-initiated nontransport. EMS is required to transport a minor to the hospital based on parental request, and refusal for transport requires agreement with both the provider and the guardian. In a survey-based study of parents who refused transport for their children, reasons provided for refusal of transport included parental desire to transport their child by private vehicle, apprehension about EMS transport costs, and a paramedic implication that transport was unnecessary.[13]

Nontransports represent a significant burden to EMS systems. Our study suggested that nontransports were associated with a longer scene time compared to those patients who are transported, a finding that has been previously reported.[11] Given the high rate of medically unnecessary transports described in the literature, it is likely that many patients not transported to the hospital have low acuity of illness and are at low risk of adverse events.[2,20,21] However, a subset of patients not transported to the hospital may be at higher risk. Previous evaluations of triaging tools to identify low-risk patients in the prehospital setting have demonstrated an overall poor sensitivity.[22,23] Patients refusing transports have also been found to have a poor understanding of the risks of refusing care.[5] While our own EMS system has a structured statewide protocol for patient refusals, many EMS systems lack adequate protocols or policies related to patient refusals.[24] Given the liability associated with

Table 2
Unadjusted and Adjusted Logistic Regression of Factors Associated With Pediatric Nontransport

	Univariate Analysis		Multivariable Analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age				
12 to < 18 years	Ref	—	Ref	—
6 to < 12 years	1.14 (1.05–1.24)*	0.001*	0.76 (0.65–0.90)*	0.001*
2 to < 6 years	1.02 (0.94–1.11)	0.632	0.77 (0.65–0.91)*	0.002*
1 to < 2 years	0.82 (0.73–0.92)*	<0.001*	0.53 (0.42–0.69)*	<0.001*
1 month to < 1 year	0.86 (0.77–0.95)*	0.005*	0.52 (0.40–0.66)*	<0.001*
≤30 days	1.05 (0.84–1.31)	0.669	0.93 (0.59–1.49)	0.775
Male sex	1.05 (0.99–1.12)	0.104	n/a	
Race				
White	Ref	—	Ref	—
Black	0.58 (0.54–0.63)*	<0.001*	0.31 (0.26–0.37)*	<0.001*
Other	0.43 (0.30–0.60)*	<0.001*	0.41 (0.20–0.83)*	0.013*
Unknown	0.62 (0.58–0.66)*	<0.001*	0.28 (0.25–0.33)*	<0.001*
Medical category				
General medical	Ref	—	Ref	—
Trauma	3.65 (3.33–3.99)*	<0.001*	4.32 (3.57–5.23)*	<0.001*
Respiratory/airway	1.81 (1.61–2.04)*	<0.001*	4.03 (3.09–5.26)*	<0.001*
Allergic	1.81 (1.45–2.27)*	<0.001*	2.17 (1.32–3.57)*	0.002*
Gastrointestinal	0.67 (0.52–0.85)*	0.001*	0.65 (0.38–1.11)	0.116
Cardiovascular	1.00 (0.67–1.49)	0.992	2.11 (0.86–5.16)	0.102
Neurologic	0.77 (0.65–0.91)*	0.002*	1.54 (1.08–2.20)*	0.018*
Psychiatric/behavioral	0.85 (0.68–1.06)	0.156	0.52 (0.34–0.79)*	0.003*
Toxicologic	1.91 (1.56–2.35)*	<0.001*	2.53 (1.66–3.86)*	<0.001*
Dizziness/syncope	1.90 (1.56–2.30)*	<0.001*	5.97 (3.78–9.41)*	<0.001*
Other	4.00 (3.50–4.58)*	<0.001*	3.02 (2.22–4.09)*	<0.001*
Unknown	8.96 (7.10–11.30)*	<0.001*	5.10 (2.96–8.77)*	<0.001*
Year				
2014	Ref	—	Ref	—
2015	1.09 (1.00–1.20)*	0.047*	1.90 (1.55–2.32)*	<0.001*
2016	1.33 (1.22–1.45)*	<0.001*	2.82 (2.33–3.43)*	<0.001*
2017	1.47 (1.34–1.60)*	<0.001*	3.12 (2.56–3.79)*	<0.001*
Day period				
00:00–05:59	Ref	—	Ref	—
06:00–11:59	1.28 (1.13–1.45)*	<0.001*	1.77 (1.34–2.34)*	<0.001*
12:00–17:59	1.65 (1.47–1.86)*	<0.001*	1.79 (1.38–2.33)*	<0.001*
18:00–23:59	1.47 (1.31–1.65)*	<0.001*	1.49 (1.14–1.94)*	0.004*
Day of week				
Weekday	Ref	—	Ref	—
Weekend	1.13 (1.05–1.20)*	<0.001*	1.13 (0.99–1.29)	0.069
Time of year				
Winter	Ref	—	Ref	—
Spring	1.11 (1.02–1.22)*	0.016*	1.00 (0.83–1.2)	0.997
Summer	1.19 (1.09–1.29)*	<0.001*	1.16 (0.97–1.38)	0.099
Fall	1.08 (0.99–1.18)	0.073	1.29 (1.08–1.54)*	0.005*
Income by zip code				
Fourth quartile	Ref	—	Ref	—
Third quartile	1.02 (0.93–1.11)	0.723	1.16 (0.97–1.38)	0.099
Second quartile	0.91 (0.83–0.99)*	0.030*	0.97 (0.81–1.17)	0.769

(Continued)

Table 2 (Continued)

	Univariate Analysis		Multivariable Analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
First quartile	0.84 (0.77–0.92)*	<0.001*	0.93 (0.77–1.11)	0.402
Vital signs				
At least one vital done	0.26 (0.24–0.28)*	<0.001*	0.14 (0.13–0.16)*	<0.001*
Neurologic characteristics				
Abnormal mental status	0.22 (0.19–0.26)*	<0.001*	0.45 (0.33–0.62)*	<0.001*
Loss of consciousness	0.35 (0.27–0.45)*	<0.001*	1.05 (0.55–2.01)	0.880
Response characteristics				
Medical consult called	3.60 (3.31–3.91)*	<0.001*	11.71 (9.43–14.55)*	<0.001*
ALS transport	0.63 (0.55–0.71)*	<0.001*	0.74 (0.58–0.94)*	0.012*
Response time	0.97 (0.96–0.97)*	<0.001*	0.97 (0.95–0.98)*	<0.001*
Scene time	1.04 (1.04–1.05)*	<0.001*	1.03 (1.02–1.04)*	<0.001*
Peripheral IV obtained	0.01 (0.00–0.01)*	<0.001*	0.03 (0.01–0.10)*	<0.001*
Given any medication	0.11 (0.09–0.14)*	<0.001*	0.16 (0.08–0.31)*	<0.001*
Monitor use	0.08 (0.07–0.10)*	<0.001*	0.10 (0.06–0.15)*	<0.001*
Given oxygen	0.77 (0.67–0.88)*	<0.001*	0.35 (0.22–0.56)*	<0.001*

ALS = Advanced Life Support provider; IV, intravenous line.
*P value significant in unadjusted ($p < 0.10$) or adjusted ($p < 0.05$) analysis.

nontransports and the significant burden caused by these events to EMS, further study is needed to identify the motivations behind nontransports, better risk stratify these patients, and determine the rate at which they receive appropriate follow-up.

The findings from this study have multiple implications. The low rates of vital sign assessments and online medical direction contact in nontransport cases should prompt quality initiatives to improve these rates, as these are critical steps toward assessing the safety of patient nontransport. A low rate of pediatric vital sign documentation remains a crucial problem in prehospital pediatric care even among transported patients.[25,26] While nontransported patients may generally be of lower acuity than transported patients, reporting of vital signs is an important component of patient assessments. These results can be used to inform EMS education aimed to identify at-risk patients to prevent adverse events. Furthermore, results of this study provide important baseline data to inform investigation into factors associated with poor outcomes following nontransport of pediatric patients, which can inform protocol revisions.

LIMITATIONS

This was a retrospective study that relied on previously collected data from a single EMS region in the United States. This study was unable to provide data on outcomes of patients who were not transported, including repeat calls to 911, later transport to the hospital, or whether they received appropriate follow-up with primary care physicians. While we performed statistical corrections, several variables had missing data. Despite these limitations, the evaluation of nontransports in a large granular EMS database provides additional data regarding disease and socioeconomic factors associated with risk of nontransport, which can inform future investigations and modeling to identify patients at highest risk from nontransport.

CONCLUSION

We found that 16.3% of pediatric patients evaluated by emergency medical services are not transported to the hospital, and the rate of nontransports appears to be increasing over time after accounting for potential confounders. Younger children, black race, and those with unstable vital signs or requiring interventions are more likely to be transported, whereas children with trauma, dizziness, and cardiovascular complaints are at a higher risk of nontransport. A better understanding of reasons for nontransport for these patients and the development of sensitive prehospital guidelines may serve to more safely stratify patients refusing hospital transport.

References

1. Knight S, Olson LM, Cook LJ, Mann NC, Corneli HM, Dean JM. Against all advice: an analysis of out-of-hospital refusals of care. Ann Emerg Med 2003;42:689–96.
2. Pringle RP, Carden DL, Xiao F, Graham DD. Outcomes of patients not transported after calling 911. J Emerg Med 2005;28:449–54.
3. Selden BS, Schnitzer PG, Nolan FX, Veronesi JF. The "no-patient" run: 2,698 patients evaluated but not transported by paramedics. Prehosp Disaster Med 1991;6:135–42.
4. Zachariah BS, Bryan D, Pepe PE, Griffin M. Follow-up and outcome of patients who decline or are denied transport by EMS. Prehosp Disaster Med 1992;7:359–64.
5. Schmidt TA, Mann NC, Federiuk CS, Atcheson RR, Fuller D, Christie MJ. Do patients refusing transport remember descriptions of risks after initial advanced life support assessment? Acad Emerg Med 1998;5:796–801.
6. Cone DC, Kim DT, Davidson SJ. Patient-initiated refusals of prehospital care: ambulance call report documentation, patient outcome, and on-line medical command. Prehosp Disaster Med 1995;10:3–9.
7. Goldberg RJ, Zautcke JL, Koenigsberg MD, et al. A review of prehospital care litigation in a large metropolitan EMS system. Ann Emerg Med 1990;19:557–61.
8. Soler JM, Montes MF, Egol AB, Nateman HR, Donaldson EA, Greene HH. The ten-year malpractice experience of a large urban EMS system. Ann Emerg Med 1985;14:982–5.
9. Diggs LA, Sheth-Chandra M, De Leo G. Epidemiology of pediatric prehospital basic life support care in the United States. Prehospital Emerg Care 2016;20:230–8.
10. Richard J, Osmond MH, Nesbitt L, Stiell IG. Management and outcomes of pediatric patients transported by emergency medical services in a Canadian prehospital system. CJEM 2006;8:6–12.
11. Kannikeswaran N, Mahajan PV, Dunne RB, Compton S, Knazik SR. Epidemiology of pediatric transports and non-transports in an urban emergency medical services system. Prehospital Emerg Care 2007;11:403–7.
12. Gerlacher GR, Sirbaugh PE, Macias CG. Prehospital evaluation of non-transported pediatric patients by a large emergency medical services system. Pediatr Emerg Care 2001;17:421–4.
13. Seltzer AG, Vilke GM, Chan TC, Fisher R, Dunford JV. Outcome study of minors after parental refusal of paramedic transport. Prehospital Emerg Care 2001;5:278–83.
14. NASEMSO Medical Directors Council. National Model EMS Guidelines. 2018. Available at: https://nasemso.org/nasemso-document/national-model-ems-clinical-guidelines-2017-version2-1-29june2018/. Accessed October 4, 2018.
15. Pennsylvania Statewide Basic Life Support Protocols. Harrisburg, PA: Pennsylvania Department of Health Bureau of Emergency Medical Services, 2013.
16. Pennsylvania Statewide Basic Life Support Protocols. Harrisburg, PA: Pennsylvania Department of Health Bureau of Emergency Medical Services, 2015.
17. Pennsylvania Statewide Basic Life Support Protocols. 2017. Available at: www.health.state.pa.us. Accessed August 6, 2018.
18. United States Census Bureau. American Community Survey (ACS). Available from: https://www.census.gov/programs-surveys/acs/. Accessed June 25, 2018.
19. American Academy of Pediatrics, American Heart Association. Pediatric Advanced Life Support: Provider Manual. Dallas, TX: American Heart Association, 2016.
20. Patterson PD, Baxley EG, Probst JC, Hussey JR, Moore CG. Medically unnecessary emergency medical services (EMS) transports among children ages 0 to 17 Years. Matern Child Health J 2006;10:527–36.
21. Weaver MD, Moore CG, Patterson PD, Yealy DM. Medical necessity in emergency medical services transports. Am J Med Qual 2012;27:250–5.
22. Newgard CD, Fu R, Zive D, et al. Prospective validation of the national field triage guidelines for identifying seriously injured persons. J Am Coll Surg 2016;222:146–58.e2.
23. Newgard CD, Hui SH, Griffin A, Wuerstle M, Pratt F, Lewis RJ. Prospective validation of an out-of-hospital decision rule to identify seriously injured children involved in motor vehicle crashes. Acad Emerg Med 2005;12:679–87.
24. Weaver J, Brinsfield KH, Dalphond D. Prehospital refusal-of-transport policies: adequate legal protection? Prehosp Emerg Care 2000;4:53–6.
25. Hewes H, Hunsaker S, Christensen M, Whitney J, Dalrymple T, Taillac P. Documentation of pediatric vital signs by EMS providers over time. J Pediatr Surg 2016;51:329–32.
26. Ramgopal S, Elmer J, Escajeda J, Martin-Gill C. Differences in prehospital patient assessments for pediatric versus adult patients. J Pediatr 2018;199:200–5.e6.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13652/full

Data Supplement S1. Unadjusted and adjusted logistic regression of factors associated with pediatric non-transport using imputed data.

Grassroots Intervention to Increase Appointment of Pediatric Emergency Care Coordinators in Massachusetts Emergency Departments

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ABSTRACT

Objectives: Appointment of a pediatric emergency care coordinator (PECC) is considered the single best intervention to improve pediatric emergency care and has been recommended for all U.S. general emergency departments (EDs) for more than a decade. Unfortunately, many EDs do not adhere with this recommendation. In 2017, we performed a grassroots intervention to establish a PECC in every Massachusetts ED.

Methods: We conducted annual surveys of all 73 Massachusetts EDs from 2014 to 2018. Data collection included ED visit volumes, presence of a pediatric area, and PECC status. The intervention in 2017–2018 included e-mails and telephone calls to every ED director to not only assess PECC status but also encourage him/her to appoint one as needed.

Results: Survey response rates were > 85% in all years and 100% during 2016 to 2018. While Massachusetts EDs did not materially change over time (in terms of visit volumes or presence of a pediatric area), the 2017 intervention increased the percentage of EDs with an appointed PECC. Specifically, PECCs were present in approximately 30% of EDs during 2014 to 2016, climbed to 85% in 2017, and reached 100% in 2018. Most of the newly appointed PECCs were physicians.

Conclusions: Through a relatively simple grassroots intervention, we increased the appointment of PECCs in Massachusetts EDs from 30% to 100%. In addition to providing PECCs with online educational materials, ongoing work is focused on building community, identifying best practices, and implementing interventions at the local level.

Children and adolescents account for approximately 20% of visits to U.S. emergency departments (EDs).[1] Since 99% of these facilities are "general EDs" (i.e., EDs not based in children's hospitals), it is critical that ED staff are well versed in pediatric emergency care. In 2007, the U.S. Institute of Medicine (IOM) addressed this issue in their landmark report entitled "Emergency Care for Children:

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Growing Pains."[2] The IOM report documented numerous problems and offered recommendations to improve pediatric emergency care. The recommendations were endorsed by the American College of Emergency Physicians, the Emergency Nursing Association, and the American Academy of Pediatrics.

Appointment of a pediatric emergency care coordinator (PECC or "pediatric champion") was a key recommendation from the IOM,[2] as well as from the American Academy of Pediatrics.[3] While implementation of all recommendations would be ideal, appointing a PECC is generally considered the single most important process change to improve pediatric emergency care.[4] The National Pediatric Readiness Project (NPRP) was established in 2012 and has vigorously promoted this goal.[5] Although robust data are lacking, the appointment of an individual who assumes responsibility for pediatric care in the ED, and who educates staff on this topic, has common-sense appeal. Moreover, there is cross-sectional evidence that EDs with an appointed PECC are more likely to have better overall pediatric readiness.[4] Nevertheless, many EDs do not adhere with this recommendation.[4,6] The most recent data suggest that only 16% of U.S. general EDs have an appointed PECC.[7]

In spring 2017, with the endorsement of the Massachusetts College of Emergency Physicians, we embarked on a grassroots intervention to establish at least one PECC in all Massachusetts EDs. If successful, we hoped that our experience might serve as a model to help other states to increase appointment of PECCs in their own EDs.

METHODS

Study Design

The current study was composed of two parts: 1) annual ED surveys from 2014 to 2018 and 2) the grassroots intervention in 2017 to 2018. The study was approved by the Partners Human Research Committee.

Study Protocol, Measurements, and Intervention

The annual ED survey data for 2014 to 2017 came from two projects: the 2014 National ED Inventory (NEDI)-New England survey[8] and the 2015 to 2017 NEDI-USA surveys.[7] These data were supplemented in 2017 to 2018 with a more focused survey of each Massachusetts ED director as part of the intervention. All surveys included similar questions about ED visit volumes, presence of a pediatric area, and PECC status. The 2017 NEDI-USA survey is available in Data Supplement S1 (available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13630/full).

Massachusetts EDs were identified using the National Emergency Department Inventory-USA database,[9] a comprehensive list of all 5,403 nonfederal, nonspecialty EDs open 24 hours/day, 7 days/week. Briefly, the 2014 to 2017 data collection involved mailing each ED director the survey up to three times. We then contacted nonresponding EDs by telephone for completion of the survey by interview. As noted earlier, this regional/national data collection was supplemented in 2017 to 2018 with a more focused survey in Massachusetts only, both during and after the intervention. The intervention involved one or two short e-mails that were typically followed by a telephone discussion with the ED director; overall, approximately 85% of ED directors were contacted by telephone. The discussion focused on the 2007 IOM report[2] and its endorsement by several professional societies; the NPRP efforts as the "criterion standard"[5] but with an understanding that most general EDs would not have the funds to pay for a PECC, even part-time and a direct appeal for the ED director to identify at least one staff member who would be willing to volunteer at least "2–4 hours per month" to improve pediatric emergency care in their ED.

Data Analysis

All analyses were performed using Stata 14.2 (StataCorp). Descriptive statistics are presented as medians with interquartile ranges or proportions with 95% confidence intervals (CIs). When annual visit volume data were missing (e.g., for 2018), these values were estimated based on the visit volumes from prior years.

RESULTS

Across all years, from 2014 to 2018, Massachusetts has had 73 EDs (Table 1). Response rates to the annual survey were > 85% in all years and 100% during 2016 to 2018. The basic characteristics of these EDs did not change substantially over this time, with a median annual ED visit volume of approximately 42,000 across all years. The median number of ED visits by children remained in the 4,000 to 6,000 range in all years. Likewise, the presence of a separate

Table 1
Characteristics of Massachusetts EDs (n = 73) During 2014 to 2018

	Result				
Characteristics	2014	2015	2016	2017	2018
Response rate (%)	86	99	100	100	100
Annual ED visits, overall*	42,000 (26,700–59,300)	43,800 (23,700–56,800)	41,000 (24,100–59,500)	42,100 (27,400–58,100)	42,100 (27,400–58,100)
Annual children ED visits*	4,000 (2,400–9,400)	5,500 (2,400–9,600)	4,700 (2,300–9,500)	4,800 (2,600–9,900)	4,800 (2,600–9,900)
Separate pediatric area†					
Yes	21 (10–31)	24 (14–34)	22	25	25
No	78 (67–88)	75 (65–85)	77	74	74
Not applicable (children's hospital)	2 (0–5)	1 (0–4)	1	1	1
Any PECC†					
Yes	29 (17–40)	26 (16–37)	34	85	100
No	70 (58–81)	74 (63–84)	66	15	0
Unknown	2 (0–5)	—	—	—	—
Type of PECC†					
Physician	22 (12–33)	26 (16–37)	25	73	84
Nurse	6 (0–13)	—	7	11	15
Other	—	—	1	1	1
None	70 (58–81)	74 (63–84)	66	15	0
Unknown	2 (0–5)	—	1	—	—

Percentage totals may not equal 100% because of rounding. Visit volumes are rounded to nearest 100.
PECC = pediatric emergency care coordinator.
*Data are reported as median (IQR).
†Data are reported as % (95% CI when < 100% response).

pediatric area did not materially change over time, with approximately 21% to 25% of EDs reporting this feature.

By contrast, the percentage of EDs with an appointed PECC increased over the study period. Levels were stable during 2014 to 2016, with PECCs present in approximately 30% of all EDs. The percentage climbed to 85% in 2017 and reached 100% in early 2018. Figure 1 shows the geographic impact of the changes between 2016 and 2018. We are not aware of any other PECC-related interventions during the study period. The observed increase was driven by substantial increases in physician PECCs, who accounted for 84% of the PECCs in 2018; nurses accounted for 15%, and one ED reported a physician assistant PECC.

DISCUSSION

In response to low adoption of PECCs in U.S. general EDs, we developed an intervention to have ED directors appoint a PECC in every Massachusetts ED. We achieved our objective and, to our knowledge, Massachusetts is the first state to achieve 100% PECC status. We attribute the success of this initiative to its grassroots approach and believe that motivated individuals in other states could use this approach to appoint PECCs in their EDs.

Grassroots movements use collective action at the local level to create change at not only the local level, but also the regional, national, or even international levels.[10] They are associated with ground-up, rather than top-down, decision making. By encouraging self-organization and local change, they encourage community members to take responsibility and action for their community. We applied these principles in developing our intervention, which acknowledged the challenges of following the IOM recommendations,[2] introduced the NPRP[5] to many ED directors, and encouraged appointment of a volunteer PECC for at least "2–4 hours per month." This requirement differs from the criterion standard PECC (as described by NPRP[5]), which has proven difficult to implement in most U.S. EDs.[7] While the Massachusetts PECCs will not undertake every task on the NPRP agenda,[5] we believe that these "grassroots" PECCs are adding value since many basic improvements can be made without substantial resources or time (e.g., promoting the weighing of all children in kilograms rather than pounds).

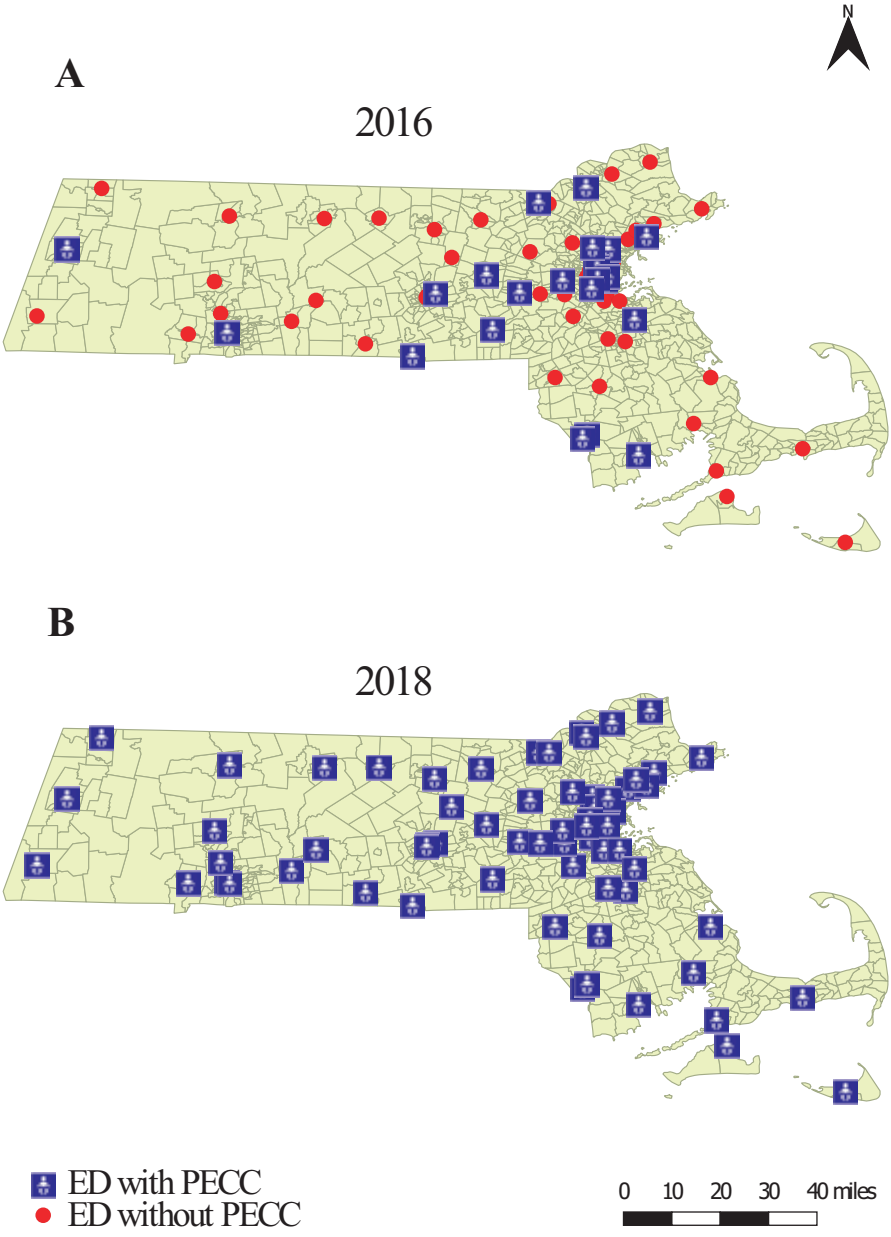

Figure 1. Changes in the prevalence of PECCs in Massachusetts EDs. (**A**) 2016, before intervention. (**B**) 2018, after intervention. More detailed geographic data—for all U.S. states—are available on the Emergency Medicine Network's smartphone application entitled "findERnow." PECC = pediatric emergency care coordinator.

To provide value to the newly appointed PECCs, we created a website (http://MassPediatricToolkit.com/) with focused educational offerings, along with links to more detailed information on the NPRP website. The Massachusetts website includes a password-protected section with all PECCs names and contact info. In early 2018, we initiated short, monthly e-mails to highlight educational offerings and to encourage each PECC to undertake a simple quality improvement project in their ED. We believe that future improvements in pediatric emergency care require both the grassroots and NPRP approaches. While most of the newly appointed PECCs will not undertake every task on the NPRP agenda,[5] we believe that these grassroots PECCs are adding value since many basic improvements can be made without substantial resources or time. Our hope is that motivated individuals from within the Massachusetts PECC network will gradually adopt more of the NPRP standards and thereby further improve pediatric emergency care.

LIMITATIONS

This study has potential limitations. First, Massachusetts EDs tend to have larger annual visit volumes than EDs in most other states,[9] but it does

include more than a dozen EDs with less than 20,000 visits/year. Second, Massachusetts has substantially fewer EDs ($n = 73$) than larger states (e.g., Texas with > 700 EDs), where implementation of our approach probably would require dividing the state into more manageable geographic units. Third, because all data were self-reported, there may be information bias. However, the Table 1 shows relative consistency across years leading us to believe that the information is accurate. Moreover, the 2017 to 2018 PECC data were confirmed by ED directors, who would presumably know if their ED had an appointed PECC, and we have the names and contact information of every appointed PECC. Finally, while there is consensus that having a PECC improves pediatric emergency care,[2–5] there has been little quantitative research on actual patient outcomes or the cost-effectiveness of different levels of PECC engagement (e.g., 40 hours/week vs. 2–4 hours/month). As volunteers, however, we anticipate that the cost-effectiveness of the newly appointed PECCs will be favorable. These efficacy issues merit further investigation.

CONCLUSIONS

In summary, we implemented a grassroots intervention to increase appointment of PECCs in Massachusetts EDs and, within 1 year, had appointed PECCs in every ED. In addition to providing PECCs with online resources, ongoing work is focused on building community, identifying best practices, and implementing simple interventions at the local level. Emergency medicine can learn from other grassroots movements, and our efforts (and success) appear generalizable to other states. Working together, ED staff can make meaningful progress toward the 2007 IOM recommendations[2] and thereby improve health outcomes in children and reduce disparities in pediatric emergency care.

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References

1. Goto T, Hasegawa K, Faridi MK, Sullivan AF, Camargo CA Jr. Emergency department utilization by children in the US, 2010-2011. West J Emerg Med 2017;18:1042–6.
2. Institute of Medicine. Emergency Care for Children: Growing Pains. Washington, DC: The National Academies Press, 2007.
3. Krug S, Gausche-Hill M. American Academy of Pediatrics Policy Statement: guidelines for care of children in emergency departments. Pediatrics 2009;124:1233–43.
4. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
5. Emergency Medical Services for Children. National Pediatric Readiness Project. Available at: https://emscimprovement.center/projects/pediatricreadiness/. Accessed August 13, 2018.
6. Sullivan AF, Rudders SA, Gonsalves AL, Steptoe AP, Espinola JA, Camargo CA Jr. National survey of pediatric services available in U.S. emergency departments. Int J Emerg Med 2013;6:13.
7. Camargo A, Boggs KM, Auerbach M, et al. National study of self-reported pediatric areas in U.S. general emergency departments. *Acad Emerg Med* 2018. doi: 10.1111/acem.13633. [Epub ahead of print].
8. Raja AS, Venkatesh A, Mick N, et al. Choosing Wisely imaging recommendations: initial implementation in New England emergency departments. West J Emerg Med 2017;18:454–8.
9. Sullivan AF, Richman IB, Ahn CJ, et al. A profile of U.S. emergency departments in 2001. Ann Emerg Med 2006;48:694–701.
10. Brown TM, Fee E. Social movements in health. Annu Rev Public Health 2014;35:385–8.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13630/full

Data Supplement S1. National emergency department inventory.

Long-term Mortality in Pediatric Firearm Assault Survivors: A Multicenter, Retrospective, Comparative Cohort Study

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ABSTRACT

Objectives: The objective was to determine whether children surviving to hospital discharge after firearm assault (FA) and nonfirearm assault (NFA) are at increased risk of mortality relative to survivors of unintentional trauma (UT). Secondarily, the objective was to elucidate the factors associated with long-term mortality after pediatric trauma.

Methods: This was a multicenter, retrospective cohort study of pediatric patients aged 0 to 16 years who presented to the three trauma centers in San Francisco and Alameda counties, California, between January 2000 and December 2009 after 1) FA, 2) NFA, and 3) UT. The Social Security Death Master File and the California Department of Public Health Vital Statistics (2000–2014) were queried through December 31, 2014, to identify those who died after surviving their initial hospitalization and to delineate cause of death. Multivariate Cox proportional hazards regression was performed to determine associations between exposure to assault and long-term mortality.

Results: We analyzed 413 FA, 405 NFA, and 7,062 UT patients who survived their index hospital visit. A total of 75 deaths occurred, including 3.9, 3.2, and 0.7% of each cohort, respectively. Two-thirds of all long-term deaths were due to homicide. After multivariate adjustment, adolescent age, male sex, black race/ethnicity, and public insurance were independent risk factors for long-term mortality. FA (adjusted hazard ratio [AHR] = 1.8, 95% confidence interval [CI] = 0.82–4.0) and NFA (AHR = 1.9, 95% CI = 0.93–3.9) did not convey a statistically significant difference in risk of long-term mortality compared to UT. Being assaulted by any means (with or without a firearm), however, was an independent risk factor for long-term mortality in the full study population (AHR = 1.9, 95% CI = 1.01–3.4) and among adolescents (AHR = 1.9, 95% CI = 1.01–3.6).

Conclusion: Children and adolescents who survive assault, including by firearm, have increased long-term mortality compared to those who survive unintentional, nonviolent trauma.

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In the first decade of the 21st century, more than 20,000 children died from firearm injuries in the United States.[1] American children account for more than 90% of all children killed by firearms in high-income countries.[2] Pediatric and youth survivors of firearm injury and other forms of assault are at particularly high risk of trauma recidivism.[3–6] Recent evidence suggests that both firearm injury and nonfirearm assault (NFA) patients presenting to an urban emergency department (ED) have higher risk of 5-year mortality in comparison to those who present after motor vehicle collision, and those victimized by firearms have a particularly high risk of death in the first year after their index injury, largely due to homicide by firearm.[7] Research on long-term outcomes among pediatric FA survivors is sparse.

Prior research on pediatric firearm-related injuries has focused on the clinical features and demographics of children cared for in the clinical setting, highlighting that these children tend to be adolescent males[6,8–15] and socioeconomically disadvantaged[6,8,10,13,15] and from racial and ethnic minority groups.[6,8–11,13–15] These factors have also been associated with risk of subsequent firearm injury among pediatric survivors of both assault[4] and firearm injury.[5] In one urban pediatric cohort, the trauma recidivism rate among penetrating trauma patients was about twice that of blunt trauma patients.[3] While the body of literature underscores the disparate health impacts of violence in America, such studies are limited by follow-up periods that were brief[4,6] or did not extend beyond adolescence.[3,5] No studies have examined long-term mortality among pediatric survivors of firearm violence nor compared these outcomes to those who survive other forms of assault and trauma. Understanding the largely unstudied, long-term outcomes for children impacted by gun violence could play an essential role in identifying missed opportunities for prevention and in spurring further research[16] to guide evidence-based policy change and resource allocation.

To this end, we conducted a multicenter, retrospective cohort study examining incidence of posthospital mortality in pediatric FA, NFA, and unintentional trauma (UT) survivors. We aimed 1) to determine whether children who survive to hospital discharge following FA and NFA are at increased risk of all-cause, long-term mortality relative to those who survive UT and 2) to identify factors associated with long-term mortality among pediatric trauma patients. We hypothesized that exposure to assault would be associated with increased risk of long-term mortality among pediatric trauma survivors, in a dose-dependent fashion by assault-exposed cohort.

METHODS

Study Design

This is a multicenter, retrospective, comparative cohort study of pediatric trauma patients. The study was approved by the institutional review boards of the University of California, San Francisco (UCSF), UCSF Benioff Children's Hospital Oakland, Alameda Health System, and the California Health and Human Services Agency, which granted exemption from obtaining informed consent due the minimal risk posed by and the retrospective nature of the research.

Study Setting and Population

We included patients ages 0 to 16 years who presented to the three trauma centers in San Francisco and Alameda counties, California, between January 1, 2000, and December 31, 2009. Subjects were sampled consecutively from the trauma registries of UCSF Benioff Children's Hospital Oakland, Highland Hospital, and Zuckerberg San Francisco General and Trauma Center using International Classification of Diseases, Ninth Revision, external cause of injury codes (ICD-9 E-codes), to create three cohorts of patients: 1) assaulted by firearm (firearm assault [FA]), 2) assaulted by means other than firearm (nonfirearm assault [NFA]), and (3) a comparison cohort who experienced UT. If a patient appeared more than once between 2000 and 2009 in the trauma registries, either due to transfer from one hospital to another in the context of one trauma episode or due to repeat trauma, we included them only in the cohort corresponding to their initial hospital visit. We excluded patients evaluated for suicide and child abuse due to the unique, albeit overlapping, risk factors and causal pathways that they face in relation to subsequent mortality. We also excluded two patients with incomplete identifying information.

We conceptualized the two exposed cohorts as representing exposure to differential severities of community-level violence, with FA being the more violent (and most deadly[17]) and NFA (both blunt and penetrating) being the less violent. The UT cohort represents a non–assault-based, nonviolent form of trauma and serves as an intentionally broad comparison,

isolating the impact of violence and minimizing selection bias. To allow for the determination of additional risk and protective factors with respect to long-term mortality, matching was not performed in the selection of the comparison cohort.

Exposure and Covariate Measurement

The first, or primary, ICD-9 E-code was used to allocate subjects to their primary injury mechanism cohort. Firearm injuries are classified by ICD-9 E-codes as assault (E965.0–4; E970–legal intervention), undetermined intent (E986.0–4), self-inflicted (E950–958), and accidental (E922). To ensure capture of children "caught in the crossfire" in their communities as experiencing violence, and given that most accidental firearm injuries occur in the home,[18,19] an a priori decision was made to reclassify the firearm injuries occurring with "undetermined intent" as assault if the injury occurred outside of the home (secondary ICD-9 location of injury code E849.1–9) and as accidental if the injury occurred inside the home (secondary ICD-9 location of injury code E849.0). Aside from firearm injuries, other injuries of undetermined intent were not included in the cohorts. The codes used for sampling and classification are shown in Data Supplement S1 (available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13631/full). To determine whether our survival analysis would be affected by this injury classification approach, we performed two sensitivity analyses, alternatively classifying all of the undetermined intent subjects as either assault or accidental.

Clinical and demographic covariates at the time of index visit were obtained from the trauma registry and medical record. The clinical variables included injury severity score, severe injury severity score (>15), location (s) of injury, mechanism of NFA, mechanism of UT, medical comorbidities, mode of arrival, disposition from the ED, date of injury, hospital disposition, length of stay (LOS), intensive care unit LOS, and whether or not the patient died during the index visit. Patients who appeared on the trauma registries for two hospitals due to transfer during a single trauma episode were considered to have one hospitalization for the purposes of determining whether they died prior to hospital discharge. Two patients who were transferred outside of the three study hospitals after one-night stay in the intensive care unit were deemed to have died on index visit by unanimous consensus of the lead authors (AS, IHY, HJA, JF) after careful review of their case details. We performed a sensitivity analysis to determine whether this decision altered the study findings.

The potential demographic covariates included age, sex, race/ethnicity, insurance status, year of index visit, hospital of index visit, and violent crime index (VCI; number of violent crimes per 100,000 population) by city of residence. City of residence was based on the address available from the trauma registry or medical record at or nearest to the time of index visit. To standardize for changes in crime rate over the study period, the mean of the VCIs from the years 2000, 2005, and 2010 was calculated for each city[20] and this mean VCI was utilized in the multivariate analysis. Additional identifying variables collected for the purpose of matching subjects with the outcome databases included name, date of birth, social security number (SSN), and mother or father's name, as available.

Ascertainment of Outcomes

The primary outcome was hazard of all-cause mortality in person-years from the date of injury through December 31, 2014. Death was ascertained through two outcome databases, the Death Master File (DMF) of the USA Social Security Administration and the California Department of Public Health Vital Statistics death records from 2000 through 2014. We first queried both databases by SSN and subsequently queried the California Vital Statistics records by first name, last name, sex, and date of birth for all subjects without a SSN (n = 4,058). Death was confirmed with an exact match of SSN or an exact match of first and last name, sex, and date of birth. Cause and date of death were recorded for those who died. Three additional probabilistic matches were also considered in which first name, last name, or date of birth varied by one or two characters. All deaths were reviewed by an investigator (AS) to ensure true matches, and two matches were deemed to be false-positives (e.g., a 4-month-old who "died" at 2 months of age and has had multiple recent hospital visits in the medical record). We did not match with the DMF based on name, as the large number of records in the data set would result in a high potential for false positives. To minimize false-negative determination of death, subjects without a SSN were excluded from the outcome analyses if they were not known to have an address in California at the time of their index injury.

Planned secondary outcomes included death by homicide, recorded from the mortality databases;

subsequent FA and subsequent trauma, ascertained in subjects with multiple different trauma registry appearances over time; and number of ED visits and hospital admissions during 5-year follow-up, obtained through queries of medical billing records. Additional reported outcomes included follow-up duration, years to death, age at enrollment among those who died following index visit, and age at death.

Data Analysis

Outcome data among subjects who survived their index visit were summarized by primary injury cohort using counts and proportions for categorical variables and medians with interquartile ranges (IQRs) for continuous variables. Bivariate comparisons of outcome variables were made among the three cohorts using chi-square and analysis of variance tests, as appropriate.

We performed a Cox proportional hazards regression to determine associations between exposure to violence and long-term mortality using predetermined, purposeful selection of covariates, including potential confounders as well as suspected risk factors for mortality based on biologic plausibility and prior literature. In addition to the primary injury exposure, the covariates included in the model were age by strata (0–5, 6–11, and 12–16 years),[21] sex, race/ethnicity, presence of any medical comorbidities, insurance status, severe injury severity score > 15, VCI by city of residency, year of index visit, hospital of visit, injury location involving the head, and whether or not there were multiple injury locations. We report unadjusted as well as multivariate, adjusted hazard ratios (AHRs) with their 95% confidence intervals (CIs) for the primary exposure and each covariate. Kaplan-Meier survival curves were created for the three cohorts, in which the risk period began on the date of index visit and ended on the date of death or December 31, 2014.

We conducted planned, stratified analyses by age strata to evaluate age as an effect modifier, including the Cox proportional hazards regression and the Kaplan-Meier survival analysis. Finally, we performed a post hoc analysis combining the two assault cohorts into a single assault cohort and determining unadjusted and AHRs in comparison with the UT cohort utilizing an otherwise equivalent Cox proportional hazards model.

Missing data were coded as missing and no values were imputed. A significance level of 0.05 was used and all hypothesis tests were two-sided. All statistical analyses were performed using SAS software (Version 9.4, SAS Institute Inc.).

RESULTS

Baseline Characteristics of Cohorts

Sampling from the trauma registries yielded 8,415 unique and identifiable subjects meeting inclusion criteria. After excluding patients evaluated for suicide ($n = 15$) and child abuse ($n = 149$), the cohorts included 461 FA patients, 417 NFA patients, and 7,373 UT patients. Of eligible subjects, 7,880 (97.3%) had adequate identifying information for long-term follow-up, after exclusion of 150 individuals who were deemed to have died during their index visit. The final cohorts involved in the outcome and survival analyses included 413 FA, 405 NFA, and 7062 UT patients, respectively (Figure 1). Demographic and clinical features of the cohorts, including death during index visit, are displayed in Table 1.

The cohorts were significantly different by age, sex, race/ethnicity, insurance status, VCI by city of residence, injury location, injury severity score, hospital LOS, and death during index visit. The assault cohorts tended to be older (median age = 15.4 years vs. 8.6 years), had higher percentages of male patients, and lived in cities with higher violent crime indices. The majority of children in the FA cohort were black/non-Hispanic (65.5%). The racial/ethnic distribution was more uniform in the other cohorts with black/non-Hispanic (38.6%) and white/non-Hispanic (28.3%) representing the highest proportion of the NFA and UT cohorts, respectively. Most NFA (56.1%) and UT (51.6%) patients had injuries involving the head whereas FA patients were more commonly injured in their extremities (41.6%), chest/trunk and/or abdomen/pelvis (37.5%), and neck/back/spine (10.2%). Nearly 30% of all three cohorts had multiple injury locations. In comparison with the other cohorts, patients who experienced FA had higher average injury severity scores, had longer hospital LOS, and had higher likelihood of dying during their index visit.

Mechanism of injury among the 417 NFA patients was predominantly blunt trauma, including 164 children (39.3%) who were punched or kicked and 68 (16.3%) who were struck by an object. Remarkably, nearly two of five (39.2%) in this cohort experienced assault by penetrating trauma, including stabbing by knife and assault by air rifle. Among the UT cohort,

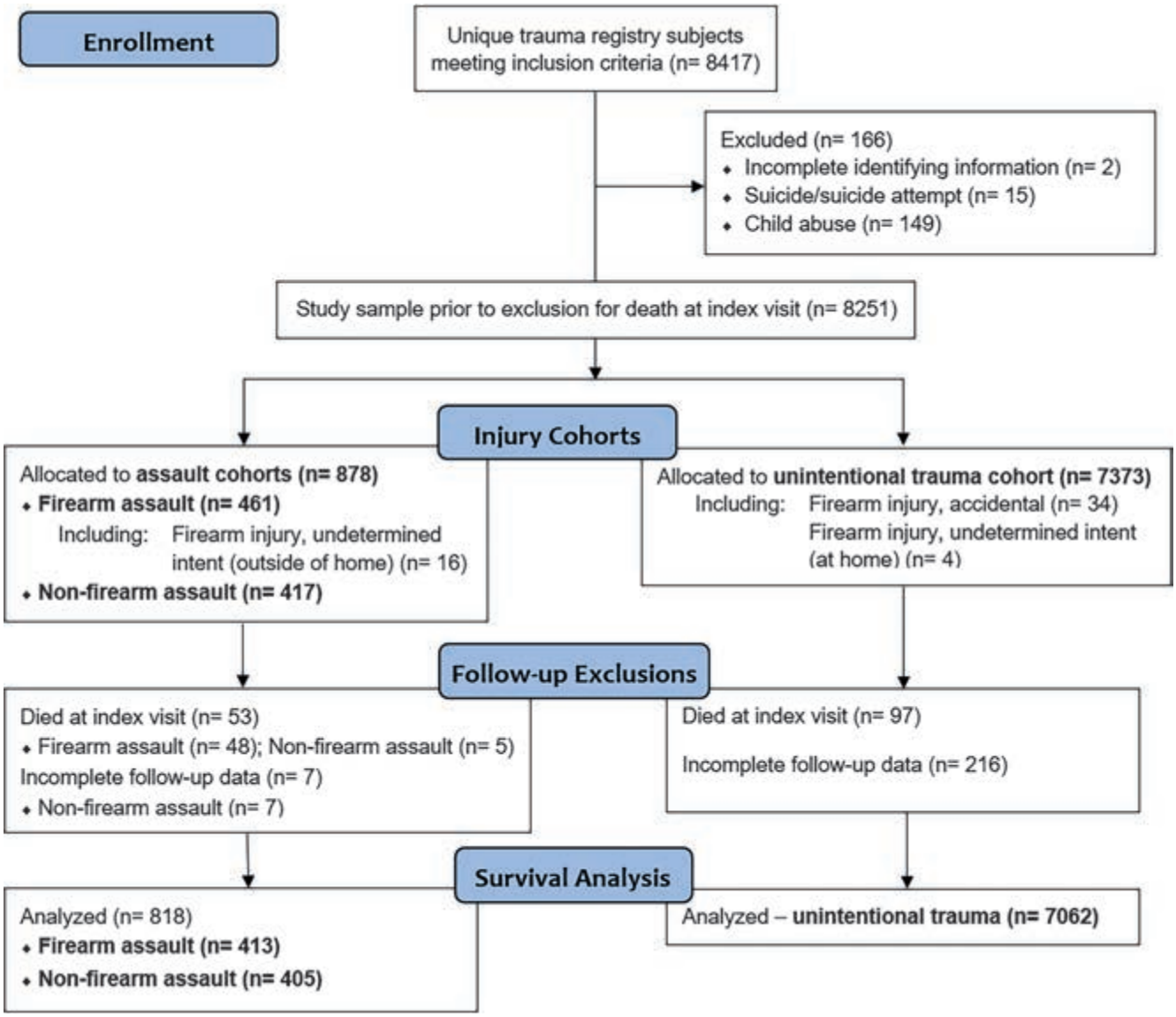

Figure 1. Enrollment flow diagram.

mechanism of injury was mostly distributed among fall (27.6%), automobile striking pedestrian or bicyclist (27.1%), and motor vehicle collisions (26.4%).

Long-term Outcomes and Survival Analysis

Cohorts had median durations of follow-up from 8.2 to 9.3 years. Among those who survived to hospital discharge, 16 (3.9%) of the firearm patients, 13 (3.2%) of the NFA patients, and 46 (0.7%) of the UT patients died during the follow-up period. Deaths occurred a median of 4.6, 5.3, and 5.9 years following index injuries, in each respective cohort. Two-thirds of all long-term deaths after surviving index injury were due to homicide, which was by far the most common cause of long-term mortality in all three cohorts. Long-term outcomes by cohort are displayed in Table 2.

Firearm assault patients had high rates of subsequent ED utilization, with 158 (38.3%) patients having at least one ED visit following their index injury. This cohort also had significantly higher rates of subsequent hospital admission, with 59 (14.3%) of these patients having at least one inpatient admission following their index hospitalization. Both of the assault cohorts had higher rates of trauma recidivism within the three study hospitals compared to the UT cohort. Fifteen (3.6%) FA victims and 14 (3.5%) NFA victims reappeared in a study trauma registry for trauma of any type before their 17th birthday. Eleven (73%) and six (43%) of these later traumas, respectively, were due to assault by firearm.

Results of the long-term mortality analysis reporting univariate and multivariate hazard ratios with 95%

Table 1
Baseline Characteristics of Cohorts

Variable	Cohort			
	FA (*n* = 461)	NFA (*n* = 417)	UT (*n* = 7,373)	p-value
Age (years)	15.5 (14.4–16.2)	15.1 (13.9–16.1)	8.6 (3.8–12.8)	<0.0001
Male	381 (82.6)	342 (82.0)	4,721 (64.0)	<0.0001
Race/ethnicity				<0.0001
White, non-Hispanic	21 (4.6)	46 (11.0)	2,083 (28.3)	
Black, non-Hispanic	302 (65.5)	161 (38.6)	1,703 (23.1)	
Hispanic	105 (22.8)	141 (33.8)	1,812 (24.6)	
Asian/Pacific Islander	17 (3.7)	37 (8.9)	897 (12.2)	
Other	16 (2.6)	20 (4.8)	588 (8.0)	
Insurance status				<0.0001
Private	95 (20.6)	118 (28.3)	3,069 (41.6)	
Medicaid/MediCal/Medicare	212 (46.0)	152 (36.4)	2,370 (32.1)	
Uninsured	88 (19.1)	64 (15.3)	882 (12.0)	
VCI, by city of residence (violent crimes/100,000 population)	1,003 (±416)	877 (±471)	650 (±491)	<0.0001
Medical comorbidity	10 (14.3)	34 (22.4)	537 (11.1)	<0.0001
Hospital of index visit				<0.0001
UBCHO (formerly CHRCO)	65 (14.1)	146 (35.0)	4,823 (65.4)	
Highland (formerly ACMC)	203 (44.0)	119 (28.5)	377 (5.1)	
ZSFG (formerly SFGH)	193 (41.9)	152 (36.4)	2,173 (29.5)	
Mode of arrival				<0.0001
Ambulance	281 (61.0)	283 (67.9)	3,967 (53.8)	
Walk-in/ambulatory	72 (15.6)	50 (12.0)	494 (6.7)	
Helicopter	10 (2.2)	8 (1.9)	846 (11.5)	
Transfer/other facility	7 (1.5)	15 (3.6)	845 (11.5)	
Injury Severity Score	13.8 (±15.1)	6.7 (±7.9)	7.0 (±7.9)	<0.0001
Injury location				
Head	72 (15.6)	234 (56.1)	3,805 (51.6)	<0.0001
Neck/back/spine	47 (10.2)	17 (4.1)	177 (2.4)	<0.0001
Chest/trunk	88 (19.1)	72 (17.3)	782 (10.6)	<0.0001
Abdomen/pelvis	85 (18.4)	24 (5.8)	466 (6.3)	<0.0001
Extremity	218 (47.3)	90 (21.6)	177 (2.4)	<0.0001
Other	34 (7.4)	74 (17.7)	1,378 (18.7)	<0.0001
Multiple locations	138 (29.9)	124 (29.7)	2,114 (28.7)	0.77
Disposition from ED				<0.0001
Admit, ward/step-down	99 (21.5)	94 (22.5)	1,668 (22.6)	
Admit, ICU/OR	149 (32.3)	80 (19.2)	1,867 (25.3)	
Posthospital (includes home)	187 (40.6)	230 (55.2)	3,313 (44.9)	
Morgue	25 (5.4)	2 (0.5)	26 (0.4)	
Hospital LOS (days)	5.0 (±11.6)	2.6 (±5.3)	2.6 (±4.2)	<0.0001
ICU LOS (days)	1.5 (±6.0)	0.5 (±1.9)	1.5 (±30.8)	0.62
Died during index visit	48 (10.3)	5 (1.2)	97 (1.3)	<0.0001

Data are reported as median (IQR), *n* (%), or mean (±SD).
ACMC = Alameda County Medical Center; CHRCO = Children's Hospital and Research Center Oakland; FA = firearm assault; Highland = Highland Hospital; ICU = intensive care unit; IQR = interquartile range; LOS = length of stay; NFA = nonfirearm assault; OR = operating room; SFGH = San Francisco General Hospital; UBCHO = UCSF Benioff Children's Hospital Oakland; UT = unintentional trauma; VCI = violent crime index; ZSFG = Zuckerberg San Francisco General and Trauma Center.

CIs can be seen in Table 3. Hospital and year of index visit are not included in the table but were adjusted for in the model. After multivariate adjustment with the Cox proportional hazards model, adolescent age (AHR = 2.9, 95% CI = 1.3–6.6), male sex (AHR = 3.0, 95% CI = 1.3–7.1), black race/ethnicity (AHR = 3.3, 95% CI = 1.2–9.4), and public insurance (AHR = 2.5, 95% CI = 1.2–5.2) were

Table 2
Outcomes Among Subjects Surviving Index Visit

Variable	Cohort			
	FA (*n* = 413)*	NFA (*n* = 405)*	UT (*n* = 7,062)*	p-value
Follow-up period (years)	8.2 (6.6–9.9)	9.0 (7.1–11.6)	9.3 (7.1–11.8)	<0.0001
Subjects with subsequent ED visits	158 (38.3)	38 (9.4)	849 (12.0)	<0.0001
Subjects with subsequent hospital admissions	59 (14.3)	20 (4.9)	424 (6.0)	<0.0001
Subjects with subsequent trauma	15 (3.6)	14 (3.5)	80 (1.1)	<0.0001
Years to subsequent trauma	0.6 (0.4–1.1)	0.8 (0.5–2.5)	1.9 (0.6–3.6)	0.006
Subjects with subsequent firearm injury	11 (2.7)	6 (1.5)	25 (0.4)	<0.0001
Years to subsequent firearm injury	0.5 (0.4–1.1)	0.8 (0.6–2.2)	2.3 (0.6–4.2)	0.02
Death after index visit	16 (3.9)	13 (3.2)	46 (0.7)	<0.0001
By homicide	12 (75.0)	11 (84.6)	27 (58.7)	<0.0001
By suicide	0 (0)	1 (7.7)	3 (6.5)	0.18
By accidental injury	2 (12.5)	0 (0)	4 (8.7)	0.008
By nontraumatic cause	2 (12.5)	1 (7.7)	12 (26.1)	<0.0001
Age at enrollment in those who died after index visit	15.4 (15.0–16.0)	15.1 (13.9–16.2)	13.4 (11.1–14.8)	0.006
Years to death	4.6 (3.6–6.8)	5.3 (4.5–7.6)	5.9 (4.4–8.7)	0.56
Age at death	20.0 (18.1–22.2)	19.8 (16.6–22.7)	19.2 (17.1–21.5)	0.0004

Data are reported as median (IQR) or *n* (%).
IQR = interquartile range; FA = firearm assault; NFA = nonfirearm assault; UT = unintentional trauma.
*Excluding subjects with inadequate identifying information for long-term follow-up.

independent risk factors for long-term mortality. In comparison with the UT cohort, neither FA patients (AHR = 1.8, 95% CI = 0.82–4.0) nor NFA patients (AHR = 1.9, 95% CI = 0.93–3.9) experienced a statistically significant difference in long-term mortality risk. However, in post hoc analysis, exposure to any type of assault (with or without a firearm) was an independent risk factor for mortality after survival to hospital discharge (AHR = 1.9, 95% CI = 1.01–3.4). The Kaplan-Meier survival curves by cohort can be seen in Figure 2. There is a significant difference in the curve trajectories ($p < 0.0001$).

Our sensitivity analyses, respectively, showed that our a priori classification approach for subjects who experienced firearm injury by undetermined intent had no impact on the conclusions of the survival analysis and that our determination of death on index visit for two patients transferred to outside facilities altered the study findings toward the null hypothesis.

Age-stratified Analysis: Adolescent Outcomes

All 29 of the assault survivors as well as 30 (65%) of the UT survivors who died on follow-up were young adolescents, aged 12 to 16, at the time of their index injury and enrollment into their respective study cohort. Among those who survived their index injury, 4.1% of adolescents assaulted by firearm, 3.6% of adolescents assaulted by means other than firearm, and 1.4% of adolescents who experienced UT died. Adolescents aged 12 to 16 years who survived FA and NFA had no statistically significant difference in long-term mortality compared to nonassaulted adolescents (AHR = 1.9, 95% CI = 0.83–4.3; and AHR = 1.9, 95% CI = 0.92–4.1, respectively), similar to the nonstratified cohort. As in the broader study population, however, adolescents who were assaulted by any means (with or without a firearm) carried a significantly higher risk of long-term mortality (AHR = 1.9, 95% CI = 1.01–3.6). Due to an overall low assault exposure and death incidence among younger children, the data were not robust enough to perform the Cox proportional hazards analysis in the younger age strata nor to fully evaluate age as an effect modifier of the relationship between exposure to violence and long-term mortality.

DISCUSSION

Among pediatric trauma patients aged 0 to 16 seen at three trauma centers in our study population, children and adolescents who present for and survive after assault with or without a firearm had an approximately 3% to 4% risk of mortality over a median of 8 to 9 years. Most long-term deaths among these patients, regardless of the intent behind the index injury, were

Table 3
Cox Proportional Hazards Regression Results With Unadjusted and AHRs for Death After Surviving Index Visit*

Variable	Unadjusted Hazard Ratio (95% CI)	Multivariate, AHR (95% CI)
Primary injury cohort		
UT	1 (reference)	1 (reference)
FA	6.9 (3.9–12.2)†	1.8 (0.82–4.0)
NFA	5.0 (2.7–9.2)†	1.9 (0.93–3.9)
Age strata (years)		
6–11	1 (reference)	1 (reference)
12–16	3.5 (2.0–6.3)†	2.9 (1.3–6.6)‡
0–5	0.13 (0.03–0.57)†	0.11 (0.01–0.9)‡
Sex		
Female	1 (reference)	1 (reference)
Male	4.4 (2.1–9.2)†	3.0 (1.3–7.1)‡
Race/ethnicity		
White, non-Hispanic	1 (reference)	1 (reference)
Black, non-Hispanic	8.1 (3.5–18.8)†	3.3 (1.2–9.4)‡
Hispanic	2.0 (0.73–5.4)	0.92 (0.28–3.1)
Asian/Pacific Islander	1.5 (0.42–5.3)	0.70 (0.13–3.7)
Other	2.0 (0.60–6.4)	1.5 (0.36–6.6)
Comorbidities		
No medical comorbidity	1 (reference)	1 (reference)
Medical comorbidity	1.4 (0.7–2.8)	0.81 (0.39–1.7)
Insurance status		
Private insurance	1 (reference)	1 (reference)
Medicaid/MediCal/Medicare	3.4 (1.8–6.2)†	2.5 (1.2–5.2)‡
Uninsured	1.3 (0.51–3.5)	0.63 (0.14–2.9)
Injury Severity Score		
≤15	1 (reference)	1 (reference)
>15	1.3 (0.64–2.8)	0.81 (0.35–1.9)
VCI		
VCI (per 1-point increase)	1.001 (1.000–1.001)†	1.000 (0.999–1.001)
Injury location		
No injury involving head	1 (reference)	1 (reference)
Injury involving head	0.66 (0.42–1.1)	0.87 (0.58–1.9)
Multiple vs. isolated injury		
Isolated injury location	1 (reference)	1 (reference)
Multiple injury locations	1.2 (0.72–1.9)	0.95 (0.52–1.7)

AHR = adjusted hazard ratio; VCI = violent crime index.
*Excluding subjects with inadequate identifying information for long-term follow-up.
†$p < 0.01$.
‡$p < 0.05$.

due to homicide (66.7%). Adolescent age, male sex, black race/ethnicity, and public insurance status were independent risk factors for mortality after surviving trauma. Importantly, these variables were also those that were associated with being a victim of assault in our sample, mirroring those described in prior studies.[5,6,8–15] On the other hand, our study did not detect additional independent risk posed separately by exposure to FA or NFA nor a dose-dependent association with mortality risk by assault-exposed cohort. However, being assaulted by any means (with or without a firearm) independently conveyed nearly twice the risk of long-term mortality compared to experiencing unintentional, nonviolent trauma (AHR = 1.9, 95% CI = 1.01–3.4).

Our findings are consistent with those of two recent cohort studies that reported increased all-cause[7] and firearm-related[22] mortality among both firearm injury[7,22] (AHR = 2.54 and 4.3, 95% CI = 1.41–4.59 and 1.3–14.1, respectively) and NFA survivors[7]

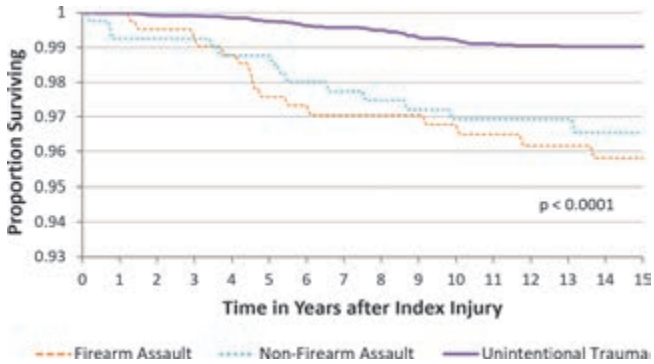

Figure 2. Kaplan-Meier survival curves by cohort after excluding those who died during index visit. Subjects with inadequate identifying information for long-term follow-up were also excluded.

(AHR = 1.64, 95% CI = 1.01–2.68) compared to accidentally injured[7] and noninjured[22] patients, further expanding this understanding of long-term risk to include the pediatric population. In the recent investigation by Fahimi et al.,[7] nonfatal firearm injury and NFA both carried a 5% risk of death at 5 years; our study further underscores that children and adolescents who are seen in urban trauma centers for either FA or NFA may both be at similarly high risk for mortality over time. However, while most deaths in the former study's surviving firearm injury cohort occurred in the first year after index injury, the median time to death among FA and NFA subjects in the present study was 4.6 and 5.3 years, respectively. This potential difference in the epidemiology of recidivism between young adolescents and young adults following FA is particularly salient when considering secondary prevention interventions and warrants further study.

Mediators of the increased risk of long-term mortality among the assault survivors in our study might include risky coping behaviors, such as drug use and gang membership, as well as insecurity precluding prosocial behavior such as health care seeking and school attendance. For instance, while poor academic performance[23] and lack of commitment to school[24] have been described as predictors of youth violence, teacher support[25,26] and perceived safety at school[26] are protective against the consequences of exposure to community violence. Repeat exposure to violent trauma in late adolescence and young adulthood seems to play a central role in conveying long-term mortality risk, and the recidivism rates among our assault (3.6 and 3.4%) and unintentional injury (1.1%) cohorts mirrored those described in prior studies.[3,6] However, retrospective determinations of violent injury recidivism likely underestimate risk. For example, in one prospective cohort of assault-exposed youth aged 14 to 24 years, 59% experienced subsequent exposure to gun violence (either aggression or victimization) within 2 years of their initial ED visit.[4] In contrast with their influence on short-term mortality,[7,27] clinical and injury-specific covariates were not significant predictors of long-term mortality in our sample and, therefore, medical complications of more severe injuries were unlikely to play an important role in conveying this increased risk. On the other hand, given that falling victim to firearm or NFA often reflects community-level violence, we hypothesize that community-level factors associated with firearm injury[5,6,15] and homicide[28,29] may play a more important role in long-term mortality risk than the individual-level factors examined in this study. Future research should address this gap in the literature.

While it may seem intuitive that pediatric victims of community violence, and particularly firearm violence, may be a high-risk population, our findings are notable. They contribute meaningfully to the body of literature by expanding our understanding of long-term outcomes among children and adolescents who survive assault. Reflecting patients from three major trauma centers, including a stand-alone children's hospital and two county hospitals, our findings are likely generalizable to hospitals in similar urban communities that face high rates of violence. By reinforcing the motivation for health care, public health, education, social service, and law enforcement communities to target the most at-risk children and adolescents, our hope is that the growing body of evidence will inform the ongoing development of primary and secondary prevention interventions, such as risk factor modification,[30] gun safety laws,[31,32] asset development and supportive services,[33,34] mentoring,[35] and/or motivational interviewing and harm reduction.[36,37]

LIMITATIONS

This study has a number of limitations. First, the relationship between violence and mortality risk is a complex one, and there is certainly unmeasured confounding for which we were unable to control. We do believe that we addressed the most important confounders as evidenced by the sizeable changes in effect sizes after multivariate adjustment. Furthermore, our purposeful, rather than stepwise, approach to covariate selection for the model decreased the likelihood of finding spurious associations. We hope to address

unmeasured confounding further with a future study incorporating neighborhood-level factors into the model among the same cohort of patients.

In addition, the overall low mortality rate as well as the relatively short follow-up period inhibited our ability to fully elucidate age as an effect modifier of the relationship of exposure to violent injury on later mortality. Given that most deaths occurred during or after adolescence, the short follow-up period likely had a disproportionate impact on the youngest subjects, who were less likely to reach adolescence by the end of the follow-up period. Therefore, although assault by any means was associated with higher risk of long-term mortality across the entire study population after adjusting for age as well as within the adolescent stratum, we were unable to determine whether or not younger children were separately at higher risk of long-term mortality after assault.

Finally, although we made every effort to ensure the reliability of our data and the accuracy of our outcome matching, we cannot be certain that every death was captured. To be captured in the outcome databases, subjects had to either have a SSN or be living in California at the time of their death. We addressed this limitation by excluding subjects without a SSN from the long-term analysis if they were not known to have an address in California at the time of their index injury. There was no significant difference between cohorts with regards to exclusion from the long-term analysis, so we do not anticipate that these biased our findings. Furthermore, because coding for cause of death is based on coroners' reports and death certificates, there is a possibility of inaccuracies, including in the determination of homicide.[38,39] We cannot be certain whether a death coded as homicide represents the immediate impact of an assault or the later sequelae of a prior assault that occurred months or years earlier.

CONCLUSIONS

In summary, among children and adolescents seen in urban trauma centers, those who survive after exposure to assault, including by firearm, have increased long-term mortality compared to those who survive unintentional, nonviolent trauma. Our findings again highlight the disparities that black adolescent males and the socioeconomically disadvantaged face with regard to community violence and premature mortality. In light of our findings, and particularly given that so many of these deaths are due to homicide, the need for prospective studies and the implementation of evidence-based programs and policies is urgent.

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References

1. Web-based Injury Statistics Query and Reporting Systems: Fatal Injury Data. Centers for Disease Control and Prevention, 2000–2009. Available at: https://www.cdc.gov/injury/wisqurs/fatal.html. Accessed January 8, 2017.
2. Grinshteyn E, Hemenway D. Violent death rates: the US compared with other high-income OECD countries, 2010. Am J Med 2016;129:266–73.
3. Davis JS, Pandya RK, Sola JE, Perez EA, Neville HL, Schulman CI. Pediatric trauma recidivism in an urban cohort. J Surg Res 2013;182:326–30.
4. Carter PM, Walton MA, Roehler DR, et al. Firearm violence among high-risk emergency department youth after an assault injury. Pediatrics 2015;135:805–15.
5. Gibson PD, Ippolito JA, Shaath MK, Campbell CL, Fox AD, Ahmed I. Pediatric gunshot wound recidivism: Identification of at-risk youth. J Trauma Acute Care Surg 2016;80:877–83.
6. Carter PM, Cook LJ, Macy ML, et al. Individual and neighborhood characteristics of children seeking emergency department care for firearm injuries within the PECARN Network. Acad Emerg Med 2017;24:803–13.
7. Fahimi J, Larimer E, Hamud-Ahmed W, et al. Long-term mortality of patients surviving firearm violence. Inj Prev 2016;22:129–34.
8. Schecter SC, Betts J, Schecter WP, Victorino GP. Pediatric penetrating trauma: the epidemic continues. J Trauma Acute Care Surg 2012;73:721–5.
9. Davis JS, Castilla DM, Schulman CI, Perez EA, Neville HL, Sola JE. Twenty years of pediatric gunshot wounds: an urban trauma center's experience. J Surg Res 2013;184:556–60.
10. Senger C, Keijzer R, Smith G, Muensterer OJ. Pediatric firearm injuries: a 10-year single-center experience of 194 patients. J Pediatr Surg 2011;46:927–32.
11. Leventhal JM, Gaither JR, Sege R. Hospitalizations due to firearm injuries in children and adolescents. Pediatrics 2014;133:219–25.
12. Newgard CD, Kuppermann N, Holmes JF, et al. Gunshot injuries in children served by emergency services. Pediatrics 2013;132:862–70.
13. Nance ML, Templeton JM Jr, O'Neill JA Jr. Socioeconomic impact of gunshot wounds in an urban pediatric population. J Pediatr Surg 1994;29:39–43.

14. Kalesan B, Dabic S, Vasan S, Stylianos S, Galea S. Racial/ethnic specific trends in pediatric firearm-related hospitalizations in the United States, 1998–2011. Matern Child Health J 2016;20:1082–90.
15. Monuteaux MC, Mannix R, Fleegler EW, Lee LK. Predictors and outcomes of pediatric firearm injuries treated in the emergency department: differences by mechanism of intent. Acad Emerg Med 2016;23:790–5.
16. Ranney ML, Fletcher J, Alter H, et al. A consensus-driven agenda for emergency medicine firearm injury prevention research. Ann Emerg Med 2017;69:227–40.
17. Lee LK, Fleegler EW, Forbes PW, Olson KL, Mooney DP. The modern paediatric injury pyramid: injuries in Massachusetts children and adolescents. Inj Prev 2010;16:123–6.
18. Fowler KA, Dahlberg LL, Haileyesus T, Gutierrez C, Bacon S. Childhood firearm injuries in the United States. Pediatrics 2017;140. pii: e20163486.
19. Choi PM, Hong C, Bansal S, Lumba-Brown A, Fitzpatrick CM, Keller MS. Firearm injuries in the pediatric population: a tale of one city. J Trauma Acute Care Surg 2016;80:64–9.
20. Uniform Crime Reporting. Federal Bureau of Investigation, 2000, 2005, 2010. Available at: https://ucr.fbi.gov. Accessed April 4, 2017.
21. Williams K, Thomson D, Seto I, et al. Standard 6: age groups for pediatric trials. Pediatrics 2012;129 Suppl 3: S153–60.
22. Rowhani-Rahbar A, Zatzick D, Wang J, et al. Firearm-related hospitalization and risk for subsequent violent injury, death, or crime perpetration: a cohort study. Ann Intern Med 2015;162:492–500.
23. Maguin E, Loeber R. Academic performance and delinquency. In: Tonry M, editor. Crime and Justice. Chicago: The University of Chicago Press, 1996:145–264.
24. Williams J, Ayers C, Abbott R, Hawkins J, Catalano R. Structural equivalence of involvement in problem behavior across racial groups using multiple group confirmatory factor analysis. Social Work Res 1996;20:168–79.
25. O'Donnell DA, Schwab-Stone ME, Muyeed AZ. Multidimensional resilience in urban children exposed to community violence. Child Dev 2002;73:1265–82.
26. Ozer EJ, Weinstein RS. Urban adolescents' exposure to community violence: the role of support, school safety, and social constraints in a school-based sample of boys and girls. J Clin Child Adolesc Psychol 2004;33:463–76.
27. Feldman KA, Tashiro J, Allen CJ, Perez EA, Neville HL, Schulman CI, et al. Predictors of mortality in pediatric urban firearm injuries. Pediatr Surg Int 2017;33:53–8.
28. Culyba AJ, Jacoby SF, Richmond TS, Fein JA, Hohl BC, Branas CC. Modifiable neighborhood features associated with adolescent homicide. JAMA Pediatr 2016;170:473–80.
29. Hohl BC, Wiley S, Wiebe DJ, Culyba AJ, Drake R, Branas CC. Association of drug and alcohol use with adolescent firearm homicide at individual, family, and neighborhood levels. JAMA Intern Med 2017;177:317–24.
30. Posner JC, Hawkins LA, Garcia-Espana F, Durbin DR. A randomized, clinical trial of a home safety intervention based in an emergency department setting. Pediatrics 2004;113:1603–8.
31. Lee J, Moriarty KP, Tashjian DB, Patterson LA. Guns and states: pediatric firearm injury. J Trauma Acute Care Surg 2013;75:50–3; discussion 53.
32. Safavi A, Rhee P, Pandit V, et al. Children are safer in states with strict firearm laws: a National Inpatient Sample study. J Trauma Acute Care Surg 2014;76:146–50; discussion 150–1.
33. Zun LS, Downey L, Rosen J. The effectiveness of an ED-based violence prevention program. Am J Emerg Med 2006;24:8–13.
34. Cheng TL, Wright JL, Markakis D, Copeland-Linder N, Menvielle E. Randomized trial of a case management program for assault-injured youth: impact on service utilization and risk for reinjury. Pediatr Emerg Care 2008;24:130–6.
35. Cheng TL, Haynie D, Brenner R, et al. Effectiveness of a mentor-implemented, violence prevention intervention for assault-injured youths presenting to the emergency department: results of a randomized trial. Pediatrics 2008;122:938–46.
36. Walton MA, Chermack ST, Shope JT, et al. Effects of a brief intervention for reducing violence and alcohol misuse among adolescents: a randomized controlled trial. JAMA 2010;304:527–35.
37. Johnston BD, Rivara FP, Droesch RM, Dunn C, Copass MK. Behavior change counseling in the emergency department to reduce injury risk: a randomized, controlled trial. Pediatrics 2002;110:267–74.
38. Nielsen GP, Bjornsson J, Jonasson JG. The accuracy of death certificates. Implications for health statistics. Virchows Arch A Pathol Anat Histopathol 1991;419:143–6.
39. Barber C, Hemenway D, Hochstadt J, Azrael D. Underestimates of unintentional firearm fatalities: comparing Supplementary Homicide Report data with the National Vital Statistics System. Inj Prev 2002;8:252–6.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13631/full

Data Supplement S1. ICD-9 E-code primary injury mechanism cohort allocation.

National Study of Self-reported Pediatric Areas in United States General Emergency Departments

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ABSTRACT

Objectives: While many U.S. emergency departments (ED) have a "pediatric ED," there are, to our knowledge, no accepted criteria for this type of ED. We investigated the prevalence, distribution, staffing, and characteristics of self-reported pediatric areas in U.S. general EDs.

Methods: We conducted a survey of all 5,273 U.S. EDs to characterize emergency care in 2015. We then surveyed 130 of the 426 general EDs who reported having a pediatric area. Data collection for the second survey included confirmation of a pediatric area and information on that area's structure and staffing.

Results: The national survey (85% response) showed 10% of general EDs reported a pediatric area. Only 16% of all U.S. EDs had a pediatric emergency care coordinator (PECC). EDs with larger visit volumes, or in the Northeast or South, were more likely to have a pediatric area. Nine states had no general EDs with pediatric areas. Among general EDs with a pediatric area, 75% had a PECC and 74% had a board-certified or board-eligible pediatric emergency medicine (PEM) physician on staff. Ninety-three percent had designated pediatric beds. Rarely (3%) was the pediatric area just a separate waiting area within a general ED, without any PECC or PEM physician present.

Conclusions: We found that 10% of U.S. general EDs had a pediatric area and that this prevalence varies nationwide. Moreover, only 16% of U.S. EDs had a PECC. Further studies on the impact of ED structure and staffing on pediatric care and patient outcomes are urgently needed. As a long-term objective, a standardized definition of a pediatric ED would not only help quality improvement efforts but also help families make more informed choices about where to bring their children to receive care.

Although children account for approximately 22% of U.S. emergency department (ED) visits,[1] there is, to our knowledge, no accepted definition of a pediatric ED or a pediatric area within the ED. Some acute care hospitals have an entirely separate facility for pediatric patients, while others see children within

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the general ED (i.e., an ED that cares for both children and adults). The prevalence of having a pediatric area in U.S. general EDs is unknown.

The relation of pediatric areas to ED staffing also is unknown. Although general EDs can provide outstanding pediatric care, prior studies and policy statements have described that for major illnesses and injuries, physicians with pediatric training may be more prepared to treat children;[2,3] pediatric emergency medicine (PEM) physicians in particular have extra training in this area and are therefore especially equipped to handle these patients. One proxy measure of improved pediatric readiness of an ED is the presence of a pediatric emergency care coordinator (PECC).[4,5]

To address these knowledge gaps, we investigated the prevalence and characteristics of self-reported pediatric areas in general EDs. Understanding the current description of pediatric areas will assist with the long-term objective of standardizing the definition to help guide quality improvement efforts in pediatric emergency care.

METHODS

Study Design

The current study was composed of two cross-sectional surveys. The study was approved by the Partners Human Subjects Committee.

Study Protocol

From January to November 2016, we conducted a national survey of U.S. EDs to characterize emergency care in 2015. We used the National Emergency Department Inventory-USA[4] database, a comprehensive list of all 5,273 nonfederal and nonspecialty EDs open 24 hours/day, 7 days/week. We mailed each ED director a one-page survey (Data Supplement S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13633/full) up to three times until a response was received. We then contacted nonresponding EDs by telephone for completion of the survey by interview.

To further explore the meaning of "pediatric ED," in 2017, we then randomly sampled a subset of 130 of the 426 EDs who answered "yes" to the pediatric area question. The sample size of 130 was determined by calculating the 95% confidence intervals (CIs) of expected proportions (e.g., 50%) in different samples sizes; 130 EDs yielded sufficiently precise estimates for 426 EDs. This sample of 130 EDs included EDs in 35 states and with annual child ED visit volumes that ranged from 28 to 60,000 visits. We contacted this second survey subset by telephone for completion of the structured interview (Data Supplement S1).

Measurements

For the national survey, the data collection included ED location, visit volumes, and basic pediatric characteristics. These survey questions have been used to assess the presence of a pediatric area and PECC in prior studies.[6]

For the second survey, data collection included confirmation that the general ED had a pediatric area in 2017 and then information on that area's structure and staffing, including the presence of a board-certified or board-eligible PEM physician. We assessed whether the pediatric area was in an entirely separate area from adults by asking whether the pediatric beds were adjacent to the adult beds and, if so, if these beds were separated by a physical barrier. The second survey questions were developed with feedback from experts in pediatric emergency medicine and national survey research. These questions were also piloted in a randomly selected sample of 20 EDs that reported a pediatric area before they were administered to the 130 EDs in the current study. Both the pilot and the full samples were selected using a random number macro (Excel, Microsoft Corp.).

Data Analysis

All analyses were performed using Stata 14.2 (StataCorp). Descriptive statistics are presented as proportions and medians with interquartile ranges (IQRs). To examine associations between U.S. ED characteristics and the presence of a pediatric area, we performed unadjusted analyses using chi-square, Fisher's exact test, and Wilcoxon rank-sum tests, as appropriate. All p-values were two-tailed, with $p < 0.05$ considered statistically significant.

RESULTS

Overall, 4,481 (85%) of 5,273 EDs, from all 50 states and the District of Columbia, responded to the national survey; the response rate was > 80% in all states. We later excluded four EDs that did not meet our inclusion criteria (i.e., were open less than 24/7), seven EDs that did not respond to the survey question

regarding presence of a pediatric area, and 63 EDs that responded "not applicable" to this same question (e.g., because ED was part of a children's hospital). Among this analytic sample of 4,407 EDs, 16% reported having a PECC and 426 (10%; 95%CI, 9–11%) reported having a pediatric area. EDs with larger visit volumes, in urban areas, or in the Northeast or South were more likely to have a pediatric area (Table 1, all $p < 0.001$). Nine states had no general EDs with pediatric areas. We also found that only 16% of general EDs had a PECC. However, 66% of EDs with a self-reported pediatric area also reported having a PECC whereas 11% of U.S. EDs without a pediatric area reported having a PECC ($p < 0.001$).

In the second survey, of the 130 randomly sampled general EDs, two closed before survey implementation. Of the remaining 128, 105 responded (82% response) of which 11 stated that they actually did not have a pediatric area; thus, 94 (90%; 95% CI = 82%–95%) confirmed their earlier report.

We found that 67% (58/87) of general EDs who reported a pediatric area had nonadjacent pediatric and general bends, indicating that children are treated in an entirely separate area from adults. Of the 29 EDs with adjacent pediatric and adult beds, 93% (26/28) reported a barrier between the two bed types.

In terms of staffing, 74% (65/88) of EDs reported having a PEM physician and 75% (70/93) reported having a PECC. Additionally, 86% (80/93) of pediatric areas were run by the overall ED, 15% (14/93) were run by the Department of Pediatrics, and 1% (1/93) was run by the "pediatric emergency department" (Table 2).

DISCUSSION

Recent studies have shown that while there are over 30 million pediatric ED visits annually, pediatric readiness varies dramatically between EDs.[5,7] By surveying all U.S. EDs, and then a randomly selected subset

Table 1
Characteristics of General U.S. EDs by Presence of a Pediatric Area (n = 4,407)

ED Characteristics	All General EDs, n = 4,407	General EDs Without Pediatric Area, n = 3,981	General EDs With Pediatric Area, n = 426	p-value*
Annual total ED visits	20,398 (7,300–41,308)	18,250 (7,000–36,500)	58,988 (34,024–87,373)	<0.001
Annual total ED visits				<0.001
<10,000	1,361 (31)	1,300 (33)	61 (14)	
10,000–19,999	799 (18)	782 (20)	17 (4)	
20,000–39,999	1,061 (24)	1,009 (25)	52 (12)	
≥40,000	1,186 (27)	890 (22)	296 (69)	
Percentage of annual ED visits by children	18% (11%–25%)	18% (11%–24%)	22% (16%–30%)	<0.001
Percentage of annual ED visits by children				<0.001
<15%	1,024 (23)	965 (24)	59 (14)	
15%–24.9%	1,1129 (26)	1,024 (26)	105 (25)	
25%–49.9%	649 (15)	547 (14)	102 (24)	
≥50%	56 (1)	46 (1)	10 (2)	
Unknown	1,549 (35)	1,399 (35)	150 (35)	
Any PECC	690 (16)	415 (11)	275 (66)	<0.001
Physician PECC	463 (11)	238 (6)	225 (54)	<0.001
Nurse PECC	480 (11)	296 (7)	184 (44)	<0.001
Other PECC	2 (0.1)	2 (0.1)	0 (0)	1.00
Urban location	3,421 (78)	3,005 (75)	416 (98)	<0.001
Regional location				<0.001
Northeast	551 (13)	441 (11)	110 (26)	
Midwest	1,233 (28)	1,170 (29)	63 (15)	
South	1,802 (41)	1,591 (40)	211 (50)	
West	821 (19)	779 (20)	42 (10)	

Data are reported as median (IQR) or n (%).
IQR = interquartile range; PECC = pediatric emergency care coordinator.
*Based on chi-square, Fisher's exact test, and Wilcoxon rank-sum test, as appropriate.

Table 2
Characteristics of Pediatric Areas Within General EDs (n = 94)

Characteristics of Pediatric Areas	n (%)
Primary entrance to the pediatric area is separate from the primary entrance to the adult/general ED	34 (36)
General structure	
Only has a designated pediatric waiting room	3 (3)
Only has designated pediatric beds	20 (22)
Has both designated pediatric beds and waiting rooms	67 (74)
ED includes designated pediatric waiting area	70 (74)
if yes . . .	
Designated area is adjacent to the adult/general waiting area	41 (59)
If yes . . .	
Physical barrier (e.g., a wall or curtain) separates designated pediatric waiting area from the adult/general waiting area	31 (76)
ED includes designated pediatric beds	87 (93)
If yes . . .	
Pediatric beds are adjacent to other adult/general beds	29 (33)
If yes . . .	
Physical barrier (e.g., a wall or curtain) separates pediatric beds from the adult/general waiting beds	26 (93)
Ever a board-certified or board-eligible pediatric emergency physician who works clinically in the ED	65 (74)
Percentage of a typical 24-hour day that there is at least one board-certified or board-eligible pediatric emergency physician on duty in the ED, median (IQR)	75% (50–100%)
Designated pediatric area(s) is run by	
ED	80 (86)
Someone other than the general ED director is responsible for running the designated pediatric area	50 (63)
Physician	35 (70)
Nurse	30 (60)
Administrator	3 (6)
Other	1 (2)
Department of pediatrics	14 (15)
Someone other than the director of pediatrics is responsible for running the designated pediatric area	8 (57)
Physician	5 (63)
Nurse	5 (63)
Administrator	0 (0)
Other	0 (0)

24/7/365 = 24 hours per day/7 days per week/365 days per year; IQR = interquartile range.

with a self-reported pediatric area, we found that 10% of 4,407 EDs had a pediatric area. Of the sample of EDs that originally reported a pediatric area, 10% reported no area on the second survey, and almost all of those that reported no area suggested that they never had one, supporting the ambiguousness of this concept and definition. We also observed important differences in ED structure and staffing, which was not surprising, given that a standardized definition of a pediatric area does not yet exist.

While studies have shown that specialized facilities are beneficial for pediatric emergency care,[8,9] the optimal structure of these pediatric areas is a largely neglected area of research. Since approximately one in 10 U.S. EDs has a self-reported pediatric area, standardizing the definition of a pediatric area would advance research in this field and permit more meaningful comparisons of how these ED characteristics relate to health outcomes.

The national survey suggests that there are many factors associated with presence of a pediatric area. For example, EDs with a higher visit volume were more likely to have a pediatric area, which is understandable as these EDs are likely to have the resources and a greater need to have this separate space. EDs with pediatric areas also were more likely to have higher percentage of ED visits by children and PECCs, showing that these EDs may be more focused on pediatric readiness as a whole than those without a pediatric area.

As for staffing, various studies emphasize the significance of ED staffing to improve pediatric emergency care.[2,10] In EDs with pediatric areas, we found that 74% have at least one PEM physician. Given the heterogeneity of U.S. EDs, especially in general and pediatric annual visit volumes,[4] we recognize that having a PEM physician or even a pediatric area is unrealistic for many EDs. Fortunately, several studies have found that readiness also is higher in EDs with a physician and/or nurse PECC.[5] Some studies even stress that having a PECC is more important than having a PEM physician.[5] More than a decade ago, the Institute of Medicine recommended that all U.S. EDs have two PECCs to increase pediatric readiness.[2,5] We found that while 16% of all U.S. EDs have a PECC, 66% of EDs with a self-reported pediatric area have a PECC whereas 11% of EDs without a pediatric area have one. This alone suggests that pediatric emergency care may indeed be better in general EDs with a pediatric area.

LIMITATIONS

This study has several potential limitations. First, while the national survey had 4,481 ED respondents, the

second survey only had 105. Both response rates were > 80%, but detailed analyses were not possible for the information collected in the second survey. As the 130 EDs in the second survey make up over 30% of the 426 EDs with pediatric areas nationwide, we determined that this was a reasonable sample size. Moreover, of the 105 respondents, only 94 confirmed that they actually had a pediatric area. However, this 10% misreporting provides valuable insight into the ambiguity surrounding this entire topic. Third, because this was a cross-sectional study, causal inferences are not possible. Fourth, because all data were self-reported, there may be information bias. However, we have noted very similar responses to these questions on prior regional surveys,[6] leading us to believe that the information is accurate. Additionally, since we did not provide hospitals with a definition of PECC, there may be some measurement bias on the assessment of the presence of PECCs in EDs. However, because we are able to answer ED directors' questions about the definition of PECC during telephone interviews, we believe that the overestimate is small. Finally, while there is general agreement on how pediatric training improves quality of pediatric emergency care, there has been little research on pediatric areas per se. This is a new field and established definitions are lacking—and merit further investigation.

CONCLUSIONS

In summary, this national survey confirms that the definition of a pediatric area in the ED is troublingly ambiguous and that the prevalence of these areas varies nationwide. Among the 99% of U.S. general EDs not based in children's hospitals, approximately 10% initially reported having a pediatric area, of which 90% affirmed this response on repeat questioning. Among general EDs with a pediatric area, 93% had designated pediatric beds; 67% of these had nonadjacent pediatric and adult beds, and 93% of EDs with adjacent pediatric and adult beds had these beds separated with a physical barrier. However, we found overall only 16% of EDs had a PECC and some pediatric areas had neither a PEM physician nor PECC present.

While we cannot rely on ED structures/staffing to draw firm conclusions about high-quality pediatric emergency care, standardizing the definition of a pediatric area would advance research in this field, as this would help to more uniformly compare EDs that definitely have an area rather than having one pediatric area vary from the next. By doing this, perhaps EDs would be encouraged to take steps to improve their pediatric emergency care and, ultimately, a more consistent definition of pediatric area could assist families to make more informed choices.

References

1. Goto T, Hasegawa K, Faridi MK, Sullivan AF, Camargo CA Jr. Emergency department utilization by children in the US, 2010–2011. West J Emerg Med 2017;18:1042–6.
2. Institute of Medicine. Emergency Care for Children: Growing Pains. Washington, DC: The National Academies Press, 2007.
3. Krug S, Gausche-Hill M. American Academy of Pediatrics Policy Statement: Guidelines for care of children in emergency departments. Pediatrics 2009;124:1233–1243.
4. Sullivan AF, Richman IB, Ahn CJ, et al. A profile of U.S. emergency departments in 2001. Ann Emerg Med 2006;48:694–701.
5. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. JAMA Pediatr 2015;169:527–34.
6. Raja AS, Venkatesh A, Mick N, et al. "Choosing Wisely" imaging recommendations: initial implementation in New England emergency departments. West J Emerg Med 2017;18:454–8.
7. Athey J, Dean JM, Ball J, Wiebe R, Melese-d'Hospital I. Ability of hospitals to care for pediatric emergency patients. Pediatr Emerg Care 2001;17:170–74.
8. Weinberg J, Barlow B, Foltin G, Hirschfeld J, Hodge D, Knapp J. American Academy of Pediatrics: guidelines for pediatric emergency care facilities. Pediatrics 1995;96:526–37.
9. Schappert SM, Bhuiya F. Availability of pediatric services and equipment in emergency departments: United States, 2006. Natl Health Stat Rep 2012;(47):1–21.
10. American Academy of Pediatrics Committee on Pediatric Emergency Medicine; American College of Emergency Physicians Pediatric Committee; Emergency Nurses Association Pediatric Committee. Joint policy statement–guidelines for care of children in the emergency department. Ann Emerg Med 2009;54:543–52.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13633/full

Data Supplement S1. Supplemental material.

A Machine Learning Approach to Predicting Need for Hospitalization for Pediatric Asthma Exacerbation at the Time of Emergency Department Triage

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ABSTRACT

Objectives: Pediatric asthma is a leading cause of emergency department (ED) utilization and hospitalization. Earlier identification of need for hospital-level care could triage patients more efficiently to high- or low-resource ED tracks. Existing tools to predict disposition for pediatric asthma use only clinical data, perform best several hours into the ED stay, and are static or score-based. Machine learning offers a population-specific, dynamic option that allows real-time integration of available nonclinical data at triage. Our objective was to compare the performance of four common machine learning approaches, incorporating clinical data available at the time of triage with information about weather, neighborhood characteristics, and community viral load for early prediction of the need for hospital-level care in pediatric asthma.

Methods: Retrospective analysis of patients ages 2 to 18 years seen at two urban pediatric EDs with asthma exacerbation over 4 years. Asthma exacerbation was defined as receiving both albuterol and systemic corticosteroids. We included patient features, measures of illness severity available in triage, weather features, and Centers for Disease Control and Prevention influenza patterns. We tested four models: decision trees, LASSO logistic regression, random forests, and gradient boosting machines. For each model, 80% of the data set was used for training and 20% was used to validate the models. The area under the receiver operating characteristic (AUC) curve was calculated for each model.

Results: There were 29,392 patients included in the analyses: mean (±SD) age of 7.0 (±4.2) years, 42% female, 77% non-Hispanic black, and 76% public insurance. The AUCs for each model were: decision tree 0.72 (95% confidence interval [CI] = 0.66–0.77), logistic regression 0.83 (95% CI = 0.82–0.83), random forests 0.82 (95% CI = 0.81–0.83), and gradient boosting machines 0.84 (95% CI = 0.83–0.85). In the lowest decile of risk, only 3% of patients required hospitalization; in the highest decile this rate was 100%. After patient vital signs and acuity, age and weight, followed by socioeconomic status (SES) and weather-related features, were the most important for predicting hospitalization.

Conclusions: Three of the four machine learning models performed well with decision trees preforming the worst. The gradient boosting machines model demonstrated a slight advantage over other approaches at predicting need for hospital-level care at the time of triage in pediatric patients presenting with asthma exacerbation. The addition of weight, SES, and weather data improved the performance of this model.

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Seven million children in the United States have asthma.[1] Pediatric asthma accounts for 2% of all emergency department (ED) visits or 700,000 visits each year.[1,2] Asthma is also the most common reason for hospitalization in children, accounting for 6% of all pediatric hospitalization.[2] Furthermore, hospitalization is the largest contributor to health care cost associated with pediatric asthma.[3] Earlier identification of need for hospital-level care could reduce cost by reducing ED boarding time,[4] triaging patients more efficiently to high- or low-resource ED tracks,[5] or potentially preventing hospitalization by ensuring early, intensive treatment for patients with high probability of admission.[6–8]

Several asthma severity scores have attempted to predict hospitalization at the time of triage.[9–14] However, most are better at predicting safe discharge from the hospital, rather than making an early determination of need for hospital-level care.[9–20] Traditional prediction models and asthma scores have relied solely on clinical data and response to treatment.[9–20] Asthma, however, is a heterogeneous disease with many phenotypes, each with a different set of environmental, genetic, and clinical factors.[21] Qiu et al.[22] documented an association of asthma-related hospitalization with regional temperature fluctuation. In addition to weather changes, other well-documented environmental triggers for asthma include dust, pollen, pollution, and cockroach dander.[23–25] Seasonal variation of pediatric asthma exacerbation, with peaks occurring in September related to the start of school and increased passage of viral infections, has also been shown.[26,27] Additionally, viral detection with fever[17] and seasonal influenza[28] are associated with need for hospitalization in pediatric asthma.

Machine learning easily enables the inclusion of large amounts of data beyond clinical information available in the electronic health record (EHR). Allowing a computer to learn a nonlinear predictive function, mapping many different types of inputs to the desired output, machine learning is ideally suited for complex, multidimensional data and may discover interactions that humans might not consider when developing models. Finally, machine learning models can improve over time by recalibrating each time more data are entered. Goto et al.[29] recently demonstrated the ability of four machine learning approaches to predict need for admission in an adult population with COPD and asthma, using data available at triage.

Our objective was to compare the performance of four common machine learning approaches to predict need for hospital-level care in pediatric asthma at the time of triage by combining available clinical data with information about weather, neighborhood characteristics, and community viral load.

METHODS

Study Design

We performed a retrospective analysis of all patients evaluated for asthma exacerbation in the pediatric ED. The hospital institutional review board approved this study.

Study Setting and Population

We included all patient visits age 2 to 18 years with asthma exacerbation evaluated at two urban pediatric EDs affiliated with a single children's hospital between January 1, 2012, and December 31, 2015. This children's hospital is a large, academic, tertiary care center and serves a predominantly African American population. The ED treats approximately 5,000 to 7,000 ED visits for asthma each year, with approximately 15% resulting in admission.[30]

Acute asthma exacerbation was defined as having received one or more doses of a beta-agonist and systemic corticosteroids. Patients who received diphenhydramine were excluded to avoid inclusion of patients being treated for severe allergic reaction or anaphylaxis.

Study Protocol and Measures

The outcome of interest was hospitalization. Admission criteria for asthma are standardized and include the need for at least Q2h treatments with beta-agonists, oxygen, advanced respiratory support (e.g., BiPAP), or the inability to tolerate oral fluids. Conceptually, need for hospital-level care is a measure of severity of illness.

Because our focus was early prediction of the need for hospitalization, exposure variables of interest were those potentially available at the time of triage. We abstracted the following from the EHR: demographic information (including patient sex, age, race, and ethnicity), patient acuity at triage (measured by the Emergency Severity Index [ESI]), and the first recorded measurement of (weight, oxygen saturation, heart rate, and respiratory rate). The ESI rates a patient's urgency

on a 5-point scale, with 1 being the most urgent.[31] Additionally, we created a standardized variable for weight by calculating a weight-for-age z-score.[32]

We also included data potentially available at the time of triage from other publicly available data sources. We accessed climate data made available by the weather station at the local airport.[33] For each patient, we computed the maximum, minimum, mean, and range of the dry bulb temperature, hourly visibility, relative humidity, wind speed, and station pressure over the 24, 48, 168, and 336 hours prior to their ED visit. We used community viral load data from the Centers for Disease Control and Prevention (CDC) to compute the mean percentage weighted influenza-like illness (ILI); percentage unweighted ILI; and ILI total over the 1-, 2-, and 4-week period prior to the ED visit.[34]

We also included information on home environment and socioeconomic status (SES) from the American Community Survey (ACS).[35] Using each patient's zip code, we extracted the percentage of people below the poverty line and the breakdown of types of housing units available in that zip code.

Data Analysis

To develop our models, we randomly split the data into an 80% training data set and a 20% test data set. Once the data set was split, each feature was normalized so that it would have a zero mean and unit standard deviation (SD) in the training data set. Normalization is required for logistic regressions with L1 (LASSO or least absolute shrinkage and selection operator) regularization so that all variables have the same magnitude range. The normalizing coefficients were then applied to the training data set.

The training data set was used to train each of the four models: classification trees, logistic regressions with L1 (LASSO) regularization, random forests, and gradient boosting machines. For each type of model, we optimized the hyperparameters using 100 iterations of randomized search, evaluating the results using a threefold cross-validation. Once the optimal parameters were selected, we trained each model on the complete training data set.

We chose four common machine learning classification algorithms to model hospital admission. Briefly, classification trees use recursive partitioning to classify subjects based on a binary outcome. Binary logistic regression models the probability of a binary outcome using odds ratios for each predictor. LASSO regularization prevents overfitting by penalizing complex models based on the parameter estimates. Random forests create multiple independently trained classification trees using random subsets of the data and features and combine their predictions to produce a single estimate. Gradient boosting machines are similar to random forests but each new model is specifically chosen to improve the aggregate prediction for all data points over the previous model rather than generated independently. All of these models were used for *supervised* learning, meaning that the outcome was provided in the training set. In contrast, unsupervised machine learning is used to determine associations of variables without a known outcome (e.g., word clouds).

Model performance was measured on the accuracy in predicting hospitalization in the test data set. For each model, we computed an area under the receiver operating characteristic curve (AUC). We then measured calibration by reporting observed admissions versus expected admissions for each decile of predicted risk.

RESULTS

There were 32,697 ED visits for patients with a diagnosis of asthma who were treated with beta-agonists and systemic corticosteroids. A total of 3,305 (10%) were excluded because they were missing initial weight, vital signs, insurance, disposition, weather, or SES data (Figure 1). Thus, there were 29,392 ED visits included in the analyses. Overall, the mean (±SD) age was 7 (±4.2) years, 42% (12,328) were female, 77% (22,630) were non-Hispanic black, and 76% (22,350) had public insurance. A total of 4,957 (16.9%) of patient visits resulted in hospitalization (Table 1).

The AUCs for each model were 1) decision tree, 0.72 (95% confidence interval [CI] = 0.66–0.77); 2) logistic regression, 0.83 (95% CI = 0.82–0.83); 3) random forests, 0.82 (95% CI = 0.81–0.83); and 4) gradient boosting machines, 0.84 (95% CI = 0.83–0.85) (Table 2). Figure 2 shows the AUC with sensitivity and specificity at five points for the gradient boosting machines model. Using the gradient boosting machines model, in the lowest decile of risk, only 3% of patients required hospitalization; in the highest decile this rate was 100% (Figure 3) After patient vital signs and acuity information, weight, age, SES, and weather-related features were the most important for predicting asthma admission (Figure 4).

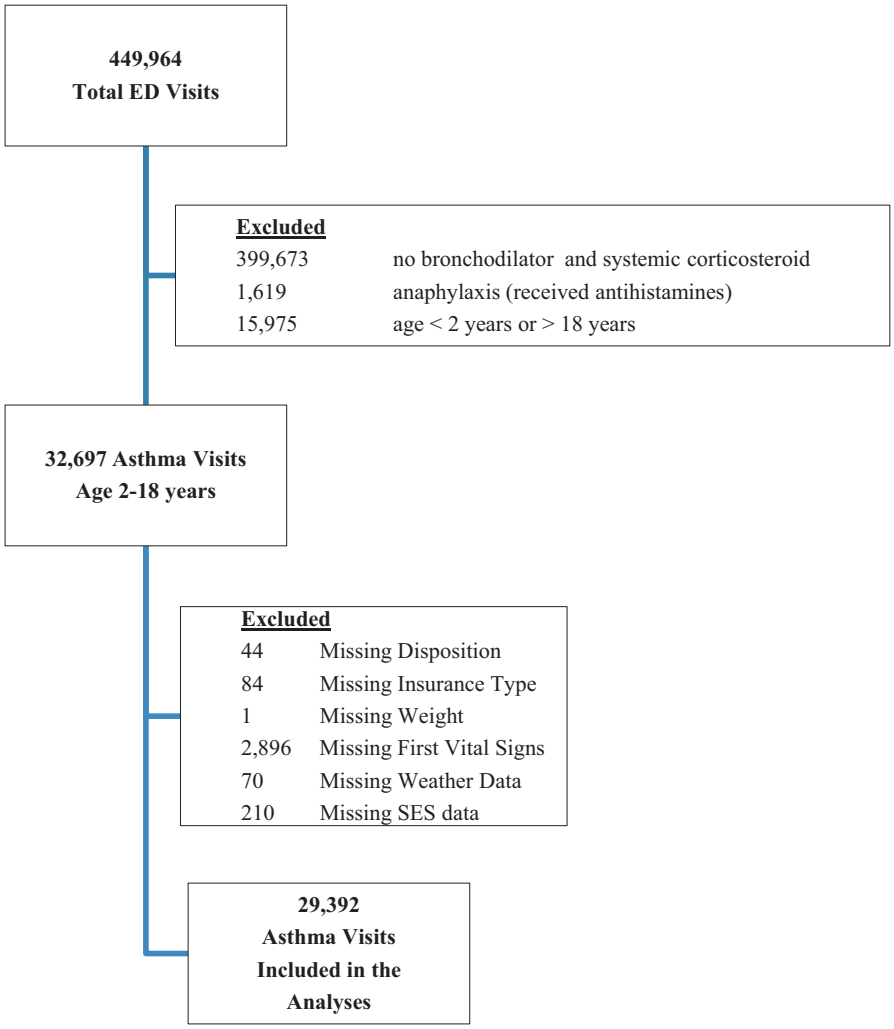

Figure 1. Flow diagram for visits included in analysis [Color figure can be viewed at wileyonlinelibrary.com]

Table 1
Characteristics of the Study Population by Disposition Outcome

	All (Column %)	Admitted (Row %)	Discharged (Row %)
ED visits for asthma	29,392	4,957 (17)	24,435 (83)
Variable			
Age (years), mean (±SD)	7.0 (±4.2)	7.1 (±4.3)	7.0 (±4.2)
Race/ethnicity			
Non-Hispanic black	22,630 (77)	3,479 (15)	19,151 (85)
Hispanic	4,881 (17)	911 (19)	3,970 (81)
White	880 (3)	338 (38)	542 (62)
Other	1,001 (3)	229 (23)	772 (77)
Sex			
Female	12,328 (42)	2,106 (17)	10,222 (83)
Male	17,064 (58)	2,851 (17)	14,213 (83)
Insurance status			
Public	22,350 (76)	3,456 (15)	18,894 (85)
Other	7,042 (24)	1,501 (21)	5,541 (79)

Data are reported as mean (±SD) or *n* (%).

Table 2
Comparison of Model Performance

Model	AUC	95% CI
Decision tree	0.72	0.66–0.77
Random forests	0.82	0.81–0.83
Logistic LASSO regression	0.83	0.82–0.83
Gradient boosting machines	0.84	0.83–0.85

DISCUSSION

Using data available at triage, we developed four machine learning approaches to model the risk of need for hospital-level care for an acute exacerbation of childhood asthma. All four models performed moderately well with three of the four models achieving AUCs greater than 0.80. We further explored the gradient boosting model. The optimum cutoff point for prediction of admission would have to be a consensus based decision at the institutional level with buy-in from all stakeholders. In our sample, we could safely

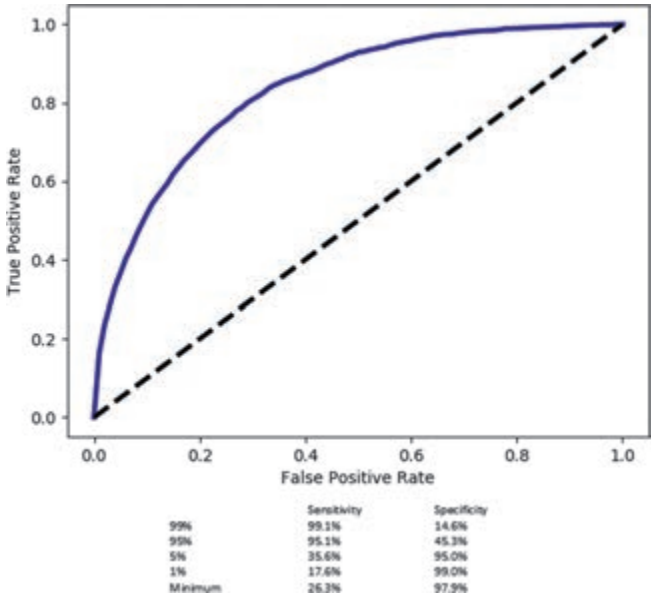

Figure 2. AUC for the gradient boosting machine model with sensitivity and specificity. [Color figure can be viewed at wileyonlinelibrary.com]

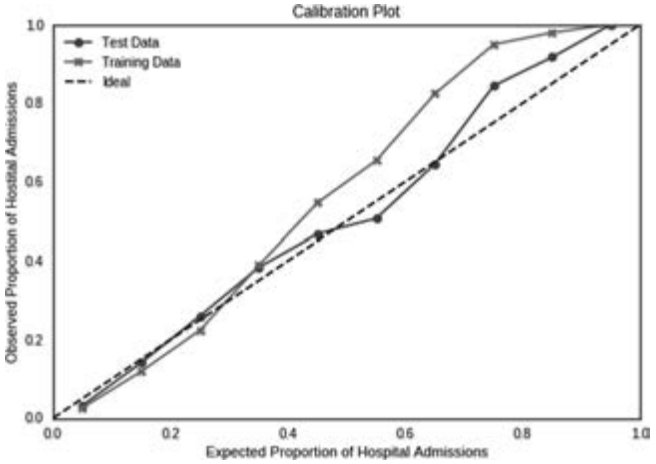

Figure 3. Calibration plot for observed admissions versus expected admissions by decile of predicted risk. The *dotted black line* depicts perfect calibration. [Color figure can be viewed at wileyonlinelibrary.com]

send 5% of the validation sample to a "high-resources-utilization track" with 95% specificity of requiring admission and conversely could send 5% of our sample to a "low-resource-utilization track" with 95% sensitivity of being safely discharged (Figure 2). Calibration showed good agreement between observed and predicted admissions (Figure 3).

In addition to being accurate, the model is clinically sensible, incorporating, in descending order of importance, oxygen saturation, respiratory rate, triage acuity, pulse rate, weight-for-age z-score, and age, followed by SES and weather variables. Consistent with prior studies, initial oxygen saturation was the most important predictor of hospitalization.[9,12,14,17] Weight as a risk factor for poor asthma control and severity in children is well studied; however, it has not been used to predict need for hospital-level care in the pediatric ED setting.[36,37] Similarly, SES is a strong risk factor for asthma and poor asthma control, but has not previously been studied as a risk factor in the ED setting. Housing and community level of influenza at the time of the ED visit did not have large effects in the final model. It is possible that these features did not have a

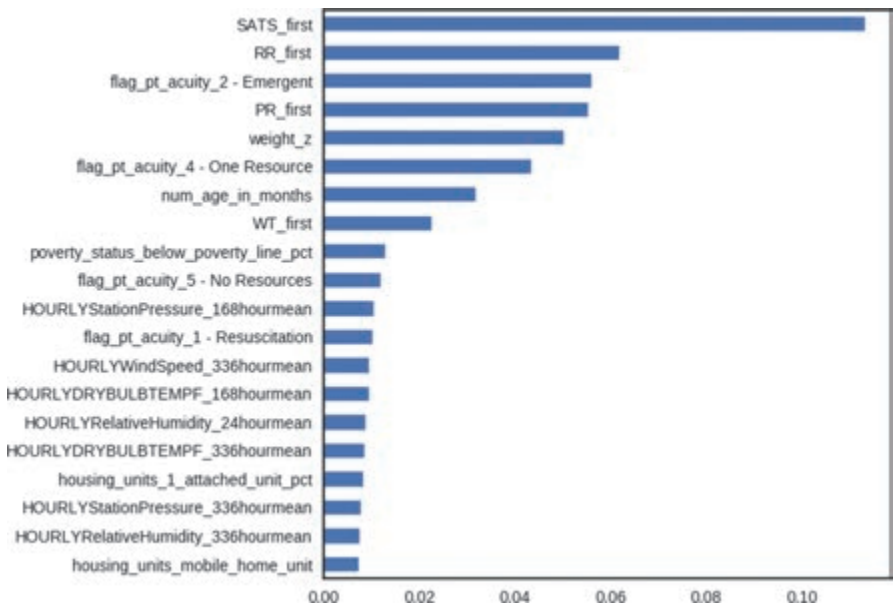

Figure 4. Feature weights and contributions to gradient boosting model (note: figure only includes top features contributing to the model).

high enough geographic resolution to measure poverty status or viral load in the patient's actual community.

Machine learning has several advantages over traditional multivariable modeling. First, machine learning can uncover meaningful interactions that may not occur to the human investigator. For example, we were surprised to discover that tachycardia is almost as important as acuity and tachypnea (Figure 4). We were also surprised that weight was an important factor in the disposition of acutely ill patients with asthma. These would not have been likely hypotheses in developing a traditional logistic regression model for acute asthma. Nevertheless, they are physiologically plausible. Tachycardia may represent an EMR-based proxy for high use of bronchodilators prior to emergency room presentation or simply a catecholamine-induced response to stress. Overweight/obesity is an important comorbidity in patients with asthma, but we are unaware of previous literature demonstrating its importance in the ED setting. Second, machine learning can easily perform iterative recalibration of models over time as new data are provided. We plan to provide future data to this machine learning algorithm to improve our model over time. Finally, machine learning can be incorporated into clinical workflow and can provide dynamic modeling of risk. Inclusion of posttreatment vital signs or information about retractions, for example, can provide additional information about risk assessment over time during an ED visit and refine prediction of ultimate disposition.

The performance of this model is promising especially given the efficiency with which it was developed. A previous model of risk of hospital admission, the Pediatric Risk of Admission (PRISA) score, took investigators approximately 2 years and hundreds of hours of data abstraction and modeling to achieve similar performance (AUC = 0.85). PRISA incorporated additional data beyond triage, including worst vital signs and laboratory results.[38] In contrast, the model presented in this paper took approximately 100 hours of data abstraction and modeling and achieved and AUC of 0.85 using only data available in triage. This bodes well for future model development using machine learning based on data from the EHR.

A mathematic model of admission risk with an AUC of 0.85 is not useful for making admission decisions for individual patients. However, such performance could be used to initially track patients to low-urgency versus high-urgency areas of the ED, for example. Theoretically such a machine model would enhance current clinical severity based triage by assigning relative importance of clinical variables and include other nonclinical variables not readily available or interpretable by a nurse at the time of presentation. In the lowest risk decile, the likelihood of hospitalization is 3%. Arguably, these patients could be treated differently than patients in the highest risk decile, who have a probability of admission of 100%. Such an approach could be used to improve the use of resources to optimize ED efficiency. A model with this level of performance could also be used to compare groups of patients to ensure similar severity for clinical trials or quality assessment, for example. Future steps include retrospective evaluation in a multicenter population, prospective validation, and understanding of real-life utility in triage-based decisions.

LIMITATIONS

This study has several limitations. First, this study was performed at a single institution. It is likely that an admission model would be different at other hospitals and in cities with different weather patterns. The principles of model development would be similar. The future of machine learning is likely to include individualized site-specific models to improve accuracy. Second, we defined our asthma population pragmatically, based on treatment with a bronchodilator and systemic corticosteroids.[39] It is possible that this includes children with viral-induced wheeze rather than true asthma. We limited our patient population to patients older than the second birthday to reduce this potential confounder. Regardless, this model is useful for this population of patients with acute wheezing receiving standard asthma therapies. Third, we did not validate the necessity of hospitalization. It is possible that some patients were hospitalized unnecessarily. Therefore, we are modeling physician behavior. Given the large data set including the practice of many providers over multiple years, the effect of individual bias on admitting practices and those due to nonclinical reasons on the model is likely minimal. Additionally, criteria for admission for asthma are well standardized at our institution. A machine learning approach could learn and account for site-specific factors and even provider-specific preferences for admission. Fourth, as a retrospective study based on EHR data, we were limited to the data available. Potentially important information on progression of illness or nonclinical reasons (social, cultural, other) for hospitalization was not considered.

We did not mine documents for specific text, for example. Furthermore, more sophisticated EHRs could allow better patient phenotyping by including treatment during previous encounters, for example, as a predictor of current response to treatment. These limitations are common when conducting retrospective studies on data collected for a different purpose. Future use of natural language processing and coding could allow extraction of more detailed data regarding presence of respiratory viral symptoms or level of severity. Finally, weather features and CDC influenza patterns were not available at the zip code level and models assume the patient was at the address given to registration to determine prior exposures.

CONCLUSIONS

We were able to develop a machine learning model for predicting hospital admission for pediatric asthma using only data available at the time of triage. Discrimination and calibration were similar to previous models incorporating data beyond triage. The gradient boosting machines model was the most accurate at predicting need for admission. The addition of weight, SES, and weather data improved the performance of this model. These models could be used for differential triage of low-risk patients and high-risk patients as a strategy to improve efficiency. Study of these models in real time, to evaluate the dynamic power of multidimensional machine learning for predicting which patients are at high risk for admission at the time of ED triage, is warranted.

References

1. Akinbami LJ, Moorman JE, Garbe PL, Sondik EJ. Status of childhood asthma in the United States, 1980–2007. Pediatrics 2009;123(Suppl 3):S131–45.
2. Akinbami LJ, Moorman JE, Bailey C, et al. Trends in asthma prevalence, health care use, and mortality in the United States, 2001-2010. NCHS Data Brief 2012;94:1–8.
3. Barnett SB, Nurmagambetov TA. Costs of asthma in the United States: 2002-2007. J Allergy Clin Immunol 2011;127:145–52.
4. Barak-Corren Y, Fine AM, Reis BY. Early prediction model of patient hospitalization from the pediatric emergency department. Pediatrics 2017;139.;pii:e20162785.
5. Peck JS, Benneyan JC, Nightingale DJ, Gaehde SA. Predicting emergency department inpatient admissions to improve same-day patient flow. Acad Emerg Med 2012;19:E1045–54.
6. Cheuk DK, Chau TC, Lee SL. A meta-analysis on intravenous magnesium sulphate for treating acute asthma. Arch Dis Child 2005;90:74–7.
7. Qureshi F, Pestian J, Davis P, Zaritsky A. Effect of nebulized ipratropium on the hospitalization rates of children with asthma. N Engl J Med 1998;339:1030–5.
8. Rowe BH, Spooner C, Ducharme FM, Bretzlaff JA, Bota GW. Early emergency department treatment of acute asthma with systemic corticosteroids. Cochrane Database Syst Rev 2001;(1): CD002178
9. Mehta SV, Parkin PC, Stephens D, Keogh KA, Schuh S. Oxygen saturation as a predictor of prolonged, frequent bronchodilator therapy in children with acute asthma. J Pediatr 2004;145:641–5.
10. Keogh KA, Macarthur C, Parkin PC, et al. Predictors of hospitalization in children with acute asthma. J Pediatr 2001;139:273–7.
11. Keahey L, Bulloch B, Becker AB, et al. Initial oxygen saturation as a predictor of admission in children presenting to the emergency department with acute asthma. Ann Emerg Med 2002;40:300–7.
12. Gorelick M, Scribano PV, Stevens MW, Schultz T, Shults J. Predicting need for hospitalization in acute pediatric asthma. Pediatr Emerg Care 2008;24:735–44.
13. Ducharme FM, Chalut D, Plotnick L, et al. The Pediatric Respiratory Assessment Measure: a valid clinical score for assessing acute asthma severity from toddlers to teenagers. J Pediatr 2008;152(476–80):480.e1.
14. Arnold DH, Gebretsadik T, Moons KG, Harrell FE, Hartert TV. Development and internal validation of a pediatric acute asthma prediction rule for hospitalization. J Allergy Clin Immunol Pract 2015;3:228–35.
15. Alnaji F, Zemek R, Barrowman N, Plint A. PRAM score as predictor of pediatric asthma hospitalization. Acad Emerg Med 2014;21:872–8.
16. Kerem E, Tibshirani R, Canny G, et al. Predicting the need for hospitalization in children with acute asthma. Chest 1990;98:1355–61.
17. Ducharme FM, Zemek R, Chauhan BF, et al. Factors associated with failure of emergency department management in children with acute moderate or severe asthma: a prospective, multicentre, cohort study. Lancet Respir Med 2016;4:990–8.
18. Geelhoed GC, Landau LI, Le Souef PN. Evaluation of SaO2 as a predictor of outcome in 280 children presenting with acute asthma. Ann Emerg Med 1994;23:1236–41.
19. Gouin S, Robidas I, Gravel J, Guimont C, Chalut D, Amre D. Prospective evaluation of two clinical scores for acute asthma in children 18 months to 7 years of age. Acad Emerg Med 2010;17:598–603.
20. Gorelick MH, Stevens MW, Schultz TR, Scribano PV. Performance of a novel clinical score, the Pediatric Asthma Severity Score (PASS), in the evaluation of acute asthma. Acad Emerg Med 2004;11:10–8.

21. Lemanske RF Jr, Busse WW. Asthma: clinical expression and molecular mechanisms. J Allergy Clin Immunol 2010;125:S95–102.
22. Qiu H, Yu IT, Tse LA, Chan EY, Wong TW, Tian L. Greater temperature variation within a day associated with increased emergency hospital admissions for asthma. Sci Total Environ 2015;505:508–13.
23. Szefler SJ, Gergen PJ, Mitchell H, Morgan W. Achieving asthma control in the inner city: do the National Institutes of Health Asthma Guidelines really work? J Allergy Clin Immunol 2010;125:521–6; quiz 527–8.
24. Kattan M, Stearns SC, Crain EF, et al. Cost-effectiveness of a home-based environmental intervention for inner-city children with asthma. J Allergy Clin Immunol 2005;116:1058–63.
25. Gruchalla RS, Pongracic J, Plaut M, et al. Inner City Asthma Study: relationships among sensitivity, allergen exposure, and asthma morbidity. J Allergy Clin Immunol 2005;115:478–85.
26. Johnston NW, Johnston SL, Duncan JM, et al. The September epidemic of asthma exacerbations in children: a search for etiology. J Allergy Clin Immunol 2005;115:132–8.
27. Maffey AF, Barrero PR, Venialgo C, et al. Viruses and atypical bacteria associated with asthma exacerbations in hospitalized children. Pediatr Pulmonol 2010;45:619–25.
28. Gerke AK, Yang M, Tang F, Foster ED, Cavanaugh JE, Polgreen PM. Association of hospitalizations for asthma with seasonal and pandemic influenza. Respirology 2014;19:116–21.
29. Goto T, Camargo CA Jr, Faridi MK, Yun BJ, Hasegawa K. Machine learning approaches for predicting disposition of asthma and COPD exacerbations in the ED. Am J Emerg Med 2018;36:1650–4.
30. Asthma Surveillance in DC Emergency Departments. Available at: https://childrensnational.org/~/media/cnhs-site/files/departments/impactdc/asthmasurveillance.ashx?la=en. Accessed May 14, 2018.
31. Gilboy N, Tanabe P, Travers DA. The Emergency Severity Index Version 4: changes to ESI level 1 and pediatric fever criteria. J Emerg Nurs 2005;31:357–62.
32. Z-score Data Files. Available at: https://www.cdc.gov/growthcharts/zscore.htm. Accessed September 11, 2018.
33. Station Data Inventory, Access & History: Washington Reagan National Airport. National Centers for Environmental Information: National Oceanic and Atmospheric Administration.
34. FluView Interactive. Centers for Disease Control. Available at: https://www.cdc.gov/flu/weekly/fluviewinteractive.htm. Accessed January 15, 2017.
35. American Community Survey (ACS). US Census Bureau, 2017. Available at: https://www.census.gov/programs-surveys/acs/. Accessed January 15, 2017.
36. Aragona E, El-Magbri E, Wang J, et al. Impact of obesity on clinical outcomes in urban children hospitalized for status asthmaticus. Hosp Pediatr 2016;6:211–8.
37. Black MH, Zhou H, Takayanagi M, Jacobsen SJ, Koebnick C. Increased asthma risk and asthma-related health care complications associated with childhood obesity. Am J Epidemiol 2013;178:1120–8.
38. Chamberlain JM, Patel KM, Ruttimann UE, Pollack MM. Pediatric risk of admission (PRISA): a measure of severity of illness for assessing the risk of hospitalization from the emergency department. Ann Emerg Med 1998;32:161–9.
39. Guidelines for the Diagnosis and Management of Asthma (EPR-3). National Heart, Lung, and Blood Institute, 2007. Available at: https://www.nhlbi.nih.gov/health-topics/guidelines-for-diagnosis-management-of-asthma. Accessed August 18, 2018.

Reliability of HEARTSMAP as a Tool for Evaluating Psychosocial Assessment Documentation Practices in Emergency Departments: A Methodologic Issue

Related articles appear on pages 1375 and 1473.

To the Editor:

We were interested to read the paper by Gill and colleagues.[1] The authors aimed to determine the reliability of HEARTSMAP as a standardized tool for evaluating the quality of psychosocial assessment documentation of pediatric mental health presentations to the emergency department (ED). The inter-rater agreement among reviewers was assessed by using Cohen Kappa statistic.[1] The authors achieved these results that the near perfect inter-rater agreement (κ = 0.99–1.00) regarding the presence of documentation and good to perfect agreement (κ = 0.71–1.00) regarding whether sufficient information was documented to score a severity level for every component of an emergency psychosocial assessment and also, they reported that the inter-rater agreement regarding whether referrals or resources were documented for identified needs was good to very good (κ = 0.62–0.98).[1]

Initially, kappa value has two important limitations as follow: First, the value of kappa extremely depends on the prevalence in each category, which means that it can be possible to have different kappa values having the same percentage for both concordant and discordant cells. Table 1 demonstrates that in both (A) and (B) position, the prevalence of concordant cells are 90% and of discordant cells, 10%; however, we get different kappa values (0.4 as moderate and 0.8 as very good, respectively). Kappa value also depends on the number of categories.[2–5] In such a situation that we have more than two categories, applying weighted kappa can be suggested.

The authors concluded the HEARTSMAP tool can be reliably used to assess pediatric psychosocial assessment documentation across a diverse range of EDs; however current documentation practices are variable and often inadequate, and the HEARTSMAP tool can aid in quality improvement initiatives to standardize and optimize care for the growing burden of pediatric mental illness. Taking into account the above-mentioned limitations of kappa value to assess reliability, such a conclusion may be a misleading message. Therefore, misinterpretation cannot be avoided.[2–5]

In this letter, we discussed limitations of kappa value to assess reliability. Any conclusion in reliability analysis should be supported by the above-mentioned methodologic and statistical issues.

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References

1. Gill C, Arnold B, Nugent S, et al. Reliability of HEART-SMAP as a tool for evaluating psychosocial assessment documentation practices in emergency departments for pediatric mental health complaints. Acad Emerg Med 2018 https://doi.org/10.1111/acem.13506
2. Szklo M, Nieto FJ. Epidemiology Beyond the Basics. 2nd ed. Burlington (MA): Jones & Bartlett, 2007.
3. Sabour S. Reliability of smartphone-based teleradiology for evaluating thoracolumbar spine fractures: statistical issue to avoid misinterpretation. Spine J 2017;17:1200.
4. Sabour S. Emergency Severity Index (ESI) triage; mobile or paper? Methodological issue on validity and reliability analysis. Intern Emerg Med 2017;12:271–2.
5. Sabour S, Ghassemi F. Interrater reliability of intensive care unit electroencephalogram revised terminology: pitfalls and challenges of using kappa value. J Clin Neurophysiol 2013;30:210.

In Reply:

Related articles appear on pages 1375 and 1471.

We thank the authors for their interest in our work and highlighting the limitations of the kappa value. Cohen's kappa statistic is calculated as a ratio of observed and expected (chance) agreement,[1] and we concur that this value is dependent on the number of categories and prevalence in each. Indeed, prevalence approaching 0 or 100% results in high chance agreement, which typically reduces or handicaps the kappa value as the authors correctly identified in the example provided. Thus, such an argument is often raised for justifying a low kappa value in the face of high observed agreement. We do not, however, see how that invalidates a high kappa value.

Applying the above principles to our study, despite high chance agreement between reviewers in several categories while using HEARTSMAP to evaluate psychosocial documentation, our high observed agreement between reviewers overcame this handicap and resulted in kappa values representative of good to perfect agreement (Table 1). Therefore, we are confident that our measure of agreement substantiates our conclusion that the HEARTSMAP tool can be reliably used to assess pediatric psychosocial documentation in the emergency department.[2]

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Table 1
Proportion of Documentation Scored by Two Reviewers as Present and Sufficient to Assign a Severity Level Using the HEARTSMAP Tool, With Cohen's Kappa (κ) Applied to Calculate Inter-rater Reliability by Comparing Observed and Expected (Chance) Agreement

	Present					Sufficient				
Section	R1	R2	Pe	Po	κ	R1	R2	Pe	Po	κ
Home	0.81	0.81	0.90	1.00	1.00	0.52	0.55	0.50	0.90	0.79
Education	0.68	0.68	0.56	1.00	1.00	0.44	0.49	0.50	0.93	0.86
Alcohol/drugs	0.78	0.78	0.66	1.00	1.00	0.83	0.84	0.72	0.96	0.85
Relationships	0.62	0.62	0.53	1.00	1.00	0.44	0.45	0.51	0.89	0.78
Thoughts	0.77	0.77	0.64	1.00	0.99	0.88	0.90	0.80	0.96	0.82
Anxiety	0.61	0.61	0.52	1.00	1.00	0.31	0.36	0.55	0.92	0.83
Safety	0.95	0.95	0.90	1.00	1.00	0.92	0.94	0.86	0.97	0.75
Sexual health	0.24	0.25	0.63	1.00	0.99	0.56	0.56	0.51	1.00	1.00
Mood	0.88	0.88	0.78	1.00	1.00	0.63	0.67	0.54	0.91	0.79
Abuse	0.31	0.31	0.58	1.00	1.00	0.63	0.62	0.53	0.88	0.74
Professionals	0.88	0.88	0.79	1.00	1.00	0.98	0.98	0.96	0.99	0.71

R1 = Reviewer 1; R2 = Reviewer 2; Pe = expected (chance) agreement; Po = observed agreement.

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References

1. McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb) 2012;22:276–82.
2. Gill C, Arnold B, Nugent S, et al. Reliability of HEART-SMAP as a tool for evaluating psychosocial assessment documentation practices in emergency departments for pediatric mental health complaints. Acad Emerg Med 2018 https://doi.org/10.1111/acem.13506