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Pediatric Emergency Medicine Physicians' Use of Point-of-Care Ultrasound and Barriers to Implementation: A Regional Pilot Study

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Pediatric Emergency Medicine Physicians' Use of Point-of-Care Ultrasound and Barriers to Implementation: A Regional Pilot Study

ABSTRACT

Objectives. Point-of-care ultrasound (POCUS) has been identified as a critical skill for pediatric emergency medicine (PEM) physicians. The purpose of this study was to profile the current status of PEM POCUS in pediatric emergency departments.

Methods. An electronic survey was distributed to PEM fellows and attending physicians at four major pediatric academic health centers. The 24-item questionnaire covered professional demographics, POCUS experience and proficiency, and barriers to the use of POCUS in pediatric emergency departments. We used descriptive and inferential statistics to profile respondent's PEM POCUS experience and proficiency, and Rasch analysis to evaluate barriers to implementation.

Results: Our return rate was 92.8% (128/138). Respondents were attending physicians (68%). and fellows (28%). Most completed pediatric residencies prior to PEM fellowship (83.6%). Almost all had some form of ultrasound education (113/128, 88.3%). About half (46.9%) completed a formal ultrasound curriculum. More than half (53.2%) said their ultrasound education was pediatric-specific. Most participants (67%) rated their POCUS proficiency low (Levels 1-2), while rating proficiency in other professional competencies (procedures 52%, emergency stabilization 70%) high (Levels 4-5). There were statistically significant differences in POCUS proficiency between those with formal vs. informal ultrasound education, ($p \leq 0.001$) and those from pediatric vs. emergency medicine residencies ($p \leq .05$). Participants identified both personal barriers: discomfort with POCUS skills (76.7%), insufficient educational time to learn POCUS (65%), and negative impact of POCUS on efficiency (58.5%); and institutional barriers to the use of ultrasound: consultants won't use ultrasound findings from emergency department (60%), insufficient mentoring (64.7%), and POCUS not being a departmental priority (57%).

Conclusions: While POCUS utilization continues to grow in PEM, significant barriers to full implementation still persist. One significant barrier relates to the need for dedicated time to learn and drill POCUS to achieve sufficient levels of proficiency for use in practice.

Pediatric Emergency Medicine Physicians' Use of Point-of-Care Ultrasound and Barriers to Implementation: A Regional Pilot Study

INTRODUCTION

Point-of-care ultrasound (POCUS) is defined as medical sonography performed and interpreted for medical decision making or procedural guidance by the bedside clinician.[1] This imaging modality has been in use by general emergency physicians since the 1980's, and has been deemed a critical component of the practice of emergency medicine (EM) by the American College of Emergency Physicians, the American Board of Emergency Medicine, the Society of Academic Emergency Medicine, and the American Institute of Ultrasound in Medicine.[2-4] The recently updated ACEP policy statement includes detailed guidelines for the use of POCUS in EM and outlines POCUS training recommendations for all practicing EM residents in the United States.[5] The Accreditation Council for Graduate Medical Education (ACGME) EM Milestones which track trainee development bi-annually in established core competencies denotes POCUS as one of the 23 milestones for EM residents (Figure 1a).[6]

More recently, POCUS has gained recognition in the field of pediatric emergency medicine (PEM) as an ideal imaging modality as it is painless, noninvasive, rapid, and dynamic.[7-13]Most importantly, ultrasound does not use ionizing radiation, which has the potential for harmful effects over the course of a lifetime.[14-18] POCUS has been a testable content specification for the American Board of Pediatrics PEM board exam since 2009, and in 2013 consensus PEM POCUS education guidelines and a model curriculum were published.[19-20] In 2015, the American Academy of Pediatrics (AAP) issued a policy statement supporting the use of POCUS by PEM physicians.[8-9]

In the past decade, a few studies have looked to profile the use of POCUS in PEM, particularly through the lens of POCUS education and utilization.[10,11,13,21] One study attempted to characterize the use of POCUS by PEM physicians through a survey of PEM fellowship directors, asking them to report the amount of POCUS training in PEM fellowships.[21] Other studies profiled POCUS education and its use in the emergency department from a broader

perspective, using PEM fellowship program directors, PEM medical directors, and PEM fellows.[10,11,13]

Despite the increased interest in incorporating bedside ultrasound imaging into the care of pediatric patients, we wondered whether the use of POCUS was actually gaining significant traction in PEM. Our study sought to profile the current state of POCUS in PEM by directly asking practitioners in major academic pediatric emergency departments about their POCUS education, experience, perceived skill with the modality, and barriers to its use in their departments.

METHODS

Population of interest. Ultimately, we are interested in profiling pediatric emergency medicine physicians across the United States and Canada. However, for practical reasons such as increasing study buy-in and maximizing response rates, we chose to focus on studying the profile of a smaller, regional group for this pilot study. We selected four academic children's hospitals from Ohio, Michigan, and Pennsylvania on the basis of their close geographical proximity to our site, their size, their academic interest in pediatric POCUS, and involvement in POCUS education at the resident and fellowship level. We also selected sites based on whether they had ultrasound expertise in the form of a designated ultrasound director. By remaining regional, we were able to enlist the support of co-investigators at each site, which helped to promote a substantial survey return rate.

Survey Design. The questionnaire used for gathering data for this study was developed by a panel of ultrasound educators at the principal investigator site. After the questionnaire was designed, it was evaluated, tested, and discussed by the site investigators and manuscript authors, all of whom had content expertise in either EM-POCUS or PEM-POCUS, ultrasound education or survey design. DG, JM, and RS DH are experts in PEM-POCUS directors at their respective academic health centers. DB has considerable expertise in EM-POCUS. RS and JK are experts in research and survey design, data collection and survey implementation. Minor modifications

were made based on feedback from the site investigators regarding content, clarity, and the importance of each question.

The final version of the questionnaire was 24-items and contained both multiple-choice and open-ended items. The questionnaire covered four specific content domains: 1) How and when the survey participant received their POCUS education (6-items); 2) Their confidence and perceived level of proficiency in using POCUS with children; (4-items); 3) How often and for what purpose they used POCUS in practice, and if they did not, what they perceived as barriers to more widespread use of POCUS (6-items); and, 4) Basic participant demographics (8-items).

To assess survey participant's pediatric POCUS proficiency, we designed a competency-based self-assessment fashioned after the ACGME milestones. This pediatric POCUS assessment was adapted from the ACGME emergency medicine patient care (PC12) milestone for bedside ultrasound (Figure 1a, 1b).[6] As a check for the inevitable rating inflation that arises from self-assessment,[22] we also included two well established ACGME PEM Milestones – Emergency Stabilization (PC5) and General Approach of Procedures (PC9) (Figure 1c, 1d).[23] Subjects used behavioral anchors to rate their level of proficiency using a 1 to 5 scale. A "1" on this scale represents the proficiency of a beginning intern or subspecialty fellow, whereas a "5" represents the proficiency of an expert.

Participants were asked to rate both personal barriers to the use of POCUS in their practice, and barriers imposed by their institution. Barriers were rated using Likert response sets: (1=Strongly Disagree, 2=Disagree, 3= Neutral, 4=Agree, and 5=Strongly Agree).[24] A final version of the questionnaire was distributed to and approved by the site investigators prior to study implementation (Appendix 1).

Survey Implementation. The survey was administered through a web-based survey service (SurveyMonkey, Palo Alto, CA) over 4 weeks in Autumn of 2015. Site investigators were responsible for identifying and surveying eligible participants at their home institutions. We sent an initial email with an explanatory introduction and survey link to the site investigators, who then forwarded it to their eligible participants. Site investigators followed up with weekly

reminder e-mails for 4 weeks. At the conclusion of data collection, survey responses were de-identified. No incentives were offered for survey completion.

Data Analysis. We calculated frequencies and percentages of respondent demographics to profile their POCUS education, experience, and perceived level of proficiency in three domains of physician competency. We ran additional analyses involving inferential statistics including Chi-Square, and independent t-tests to compare sub-groups within the survey sample including: comparisons of those who received formal vs. informal ultrasound education; attendings vs. fellows, and pediatrics vs. emergency medicine training pathways. These analyses were performed using IBM SPSS for Windows (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Cohen's d effect sizes (es) were calculated for each significant statistical test using the effect size calculators from Psychometrica.[25]

Finally, we performed a Rasch analysis to profile responses regarding individual and institutional barriers to the use of POCUS in practice. Rasch Analysis was used to convert the ordinal level rating scale data (Likert ratings of barriers) into interval level data using Winsteps Rasch measurement software (version 3.75.0, Winsteps Inc, Beaverton, Oregon).[26] The conversion to Rasch logits using the "Rating Scale Model" provides the reader with a measure of the difficulty each barrier poses, relative to the other barriers. A large, negative logit value represents a significant challenge to POCUS implementation, while a large, positive logit represents an insignificant challenge. This study was deemed exempt by the principal investigator's Institutional Review Board.

RESULTS

The eligible population for this study included 138 attendings and fellows across four sites. We received 128 questionnaires, 123 of which were thoroughly completed for a response rate of 89% (123/138). Over sixty percent of respondents were female (78 of 128, 61%). Respondents represented the four hospitals studied almost equally, with slightly higher percentages of respondents from Children's Hospitals A (98%) and B (94%) and slightly fewer from Children's Hospitals C (85%) and D (86%). We received surveys from 87 (68%) attending physicians, 54 of

whom had been in practice for six or more years, and 36 fellows (28%), evenly distributed over three years of fellowship. Most of our respondents had completed pediatric residencies followed by PEM fellowships (107/128, 83%). The remainder had completed emergency medicine residencies followed by PEM fellowships (16/128, 12.5%). Less than half of our respondents had completed formal ultrasound education through medical school, residency or fellowship (60/128, 47%). Slightly more than 40% had completed informal ultrasound training through CME, or independent study. Most of our respondents learned ultrasound through didactics (70.3%), simulation in a skills lab (52.3%), or structured rotations/scanning shifts supervised by POCUS trained faculty (39.1%). Only 12% of our respondents reported having no ultrasound education at all. Among those who completed ultrasound education, over half (68 of 128, or 53.2%) learned ultrasound specific to pediatrics (Table 1).

We found that respondents rated their level of competency on goal-directed focused ultrasound (mean= 2.14, SD=1.13) significantly lower than they did procedures (mean= 3.45, SD=1.59; t=-9.02, df=122, $p \leq .001$, es=.94) or emergency stabilization (mean=3.98, SD=1.14; t=-14.88, df=122, $p \leq .001$, es=1.63) (Table 2). In comparing subgroups on their ratings of competency on goal-directed focused ultrasound, we found that those who had received formal ultrasound training (mean=2.56, SD =1.16) rated themselves significantly higher than those who received informal or no training (mean=1.75, SD=.93; t=4.25, df=121, $p \leq .001$, es=.77) Furthermore, we found that those who came from an emergency medicine residency pathway (mean=2.88, SD=1.50) rated themselves significantly higher than those who came from a pediatric residency pathway (mean=2.03, SD=.1.02; t=2.18, df=121, $p \leq .05$, es=.66). (Note: Effect sizes of .77-1.63 are considered large to very large. An effect size of .66 is considered medium).

When comparing fellows to attending faculty, we found that ratings of competency on goal-directed focused ultrasound to be equally low for both groups (Fellow mean: 2.28, SD=1.09; Attending mean: 2.08, SD1.14; t=-.884, df=121, p=.38). The same was true for the procedures competency (Fellow mean: 3.17, SD=1.08; Attending mean: 3.56, SD. 1.75; t=1.26, df=121, p=.21). However, attendings rated their competency of emergency stabilization significantly higher than did fellows (Attending mean: 4.31, SD1.06; Fellow mean: 3.17, SD=.91; t=5.66, df=121, p,.001, es=1.12).

When asked about barriers to the use of point-of-care ultrasound in their pediatric emergency medicine practice, 49 of 128 (38%) said that they experience barriers at both the personal and institutional level. The number who reported experiencing no barriers was 35 of 128 (27%). The remaining 44 (34%) reported experiencing one barrier or the other. The most significant barriers to the use of ultrasound in practice were personal: *comfort with ultrasound skills*, and *time to learn ultrasound*. Institutionally, participants suggest that the most significant barrier was a *lack of sub-specialist consultants who would use ultrasound findings from an emergency department physician*. The least significant barrier was *availability of ultrasound equipment* since almost all respondents said that they had direct access to an ultrasound machine within their department (Table 3).

DISCUSSION

Our study objective was to describe the current POCUS milieu through investigation of a select group of pediatric hospitals with established PEM POCUS programs. Almost 90% of subjects reported some form of POCUS education, with the majority having significant pediatric-focused instruction. Yet despite this training, study participants rated their POCUS proficiency much lower than they did other professional competencies expected of PEM physicians: general procedural skills and emergency stabilization. Notably, those who had experienced formal ultrasound training programs and those who were trained in emergency medicine residency programs rated their level of POCUS proficiency higher than did those with informal education or those from pediatric residencies. We found no difference in ratings of ultrasound proficiency between current fellows and attending physicians.

These findings are important because they have ramifications for how we should be preparing future physicians to use goal-directed focused ultrasound in the pediatric emergency department. PEM practitioners reported having difficulty learning PEM POCUS through informal, self-directed learning programs due to competing demands for their time. POCUS is a complex and highly technical imaging modality that involves both cognitive and psychomotor skill sets.[7-9] Accordingly, developing PEM POCUS skills requires dedicated formal and substantial education

programs with dedicated time to learn and practice, and the provision of assessment and feedback to the learner.

The finding that emergency medicine residency graduates report higher levels of proficiency in PEM POCUS than those from pediatric residencies, suggest the need for pediatric residency programs to develop clearly defined learning competencies framed in a structure similar to the ones we adapted from emergency medicine.

The ACGME milestones provide a structure for the competencies expected of physicians at designated stages of professional development. The milestones represent knowledge, skills, and attitudes organized in a developmental framework from less to more advanced.[6,23, 27-28] We adapted the ACGME Emergency Medicine Ultrasound Milestones (PC12) for use in profiling PEM practitioners use of POCUS in practice. The adaptation became an instrument for self-assessment on PEM POCUS. Perhaps a PEM POCUS milestone will be useful in the future for providing structure to the professional development of ultrasound skills for PEM practitioners.

The use of POCUS among pediatric care providers is growing, yet significant barriers exist to its use in the emergency department. The barriers that we identified mirror those identified at the undergraduate and graduate medical education level in PEM, as well as other specialties.[10-11,29-32] Most of our respondents reported personal barriers related to a lack of ultrasound education earlier in their careers and inadequate amounts of time to learn and practice PEM-POCUS skills now that they are in practice. These findings compare directly to the findings from a 2012 study of PEM fellowship program directors who identified the most significant barriers to the use of PEM POCUS to be a lack of time to learn the imaging modality, and a lack of experienced PEM POCUS educators.[10]

Beyond personal barriers, our findings suggest that there are institutional and cultural barriers preventing POCUS from being fully accepted in PEM departments. The most significant of these involves a lack of confidence in the PEM physician's ability to acquire and interpret POCUS images, among practitioners from other specialties. This problem is potentially compounded by the general lack of interest in POCUS by pediatric emergency departments, and the concern that

its use interferes with clinical efficiency. These institutional barriers along with the aforementioned personal barriers have a negative impact on the broader scale adoption of POCUS among pediatric emergency medicine practitioners.

Barriers to PEM-POCUS at both the personal and institution level might be overcome by establishing site champions/ultrasound directors at hospitals, hiring formally POCUS trained faculty, providing accessible formal continuing education programs, incentivizing department credentialing metrics, and billing for scans.[7-9] Future research should provide a more in-depth look into the efforts to surmount both individual and institutional barriers to PEM-POCUS. Additionally, administrative barriers such as those tied to reimbursement should be the subject of further research.

LIMITATIONS

The primary limitation to this study occurred from the trade-offs we made to achieve a respectable return rate of our questionnaires. First, we restricted our study population to a regional level, which may have implications for generalizability to a national population. An additional limitation is that we relied on survey respondents to self-assess professional competencies. There is a considerable body of literature that highlights the unreliability of self-assessment.[33-35] For this study, however, we incorporated additional self-assessments of professional competencies as a check for inflated self-assessment on POCUS. Because participants rated their proficiency low on POCUS when compared to other professional proficiencies, we believe that our respondents' self-assessments reflect that they feel their POCUS skills are lacking relative to their other clinical skills.

CONCLUSIONS

Despite having significant ultrasound education, our respondents rated their competency in PEM POCUS low relative to other professional competencies. Characteristics of those with higher ratings of PEM POCUS competency included those who had formal ultrasound education and those from emergency medicine residency programs. The most significant barriers to PEM POCUS implementation included both personal barriers in the form of confidence in PEM

POCUS skills, and lack of dedicated time to learn and practice. Institutional barriers include a culture that does not support the use of PEM POCUS, including lack of confidence in POCUS results among colleagues from other medical disciplines, and a fear that the use of PEM POCUS negatively impacts clinical productivity. The broader adoption of PEM POCUS will require formal ultrasound education programs containing clearly articulated learning goals such as milestones designed specifically for PEM POCUS.

REFERENCES

1. Moore CL, Copel JA. Current concepts: Point-of-Care Ultrasonography. NEJM. 2011;364(8):749-57.

2. Moak J. SAEM Endorses the 2008 ACEP Ultrasound guidelines. Available at: http://sinaiem.us/news/saem-endorses-the-2008-acep-ultrasound-guidelines. Accessed August 14, 2016.

3. American Institute of Ultrasound in Medicine. Recognition of American College of Emergency Physicians Policy Statement "Emergency Ultrasound Guidelines". Approved November 5, 2011. Available at: www.aium.org/OfficialStatements/45. Accessed September 9, 2016.

4. Akhtar S, Theodoro D, Gaspari R, Tayal P, Sierzenski P, Lamantia J, et al. Resident Training in Emergency Ultrasound: Consensus Recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference. Acad Emerg Med. 2009;16(Suppl 2):S32-6.

5. American College Emergency Physicians. Ultrasound Guidelines: Emergency, Point-of-Care, and Clinical Ultrasound Guidelines. Approved June 2016. Available at: https://www.acep.org/Clinical---Practice-Management/Ultrasound/. Accessed October 26, 2016.

6. Accreditation Council for Graduate Medical Education and the American Board of Emergency Medicine. The Emergency Medicine Milestone Project (2015). Available at: http://www.acgme.org/Portals/0/PDFs/Milestones/EmergencyMedicineMilestones.pdf. Accessed September 15, 2016.

7. McLario DJ, Sivitz AB. Point-of-Care Ultrasound in Pediatric Clinical Care. JAMA Pediatr. 2015;169(6):594-600.

8. Marin JR, Abo AM, Doniger SJ, Fischer JW, Kessler DO, Levy JA, et al. Point-of-Care Ultrasonography by Pediatric Emergency Physicians. Ann Emerg Med. 2015;65(6):472-8.

9. Marin JR, Lewiss RE, Shook JE, Ackerman JD, Chun TH, Conners GP, et al. Point-of-Care Ultrasonography by Pediatric Emergency Medicine Physicians. Pediatrics. 2015;135(4):e113-122.

10. Marin JR, Zuckerbraun NS, Kahn JM. Use of Emergency Ultrasound in United States Pediatric Emergency Medicine Fellowship Programs in 2011. J Ultrasound Med. 2012;31(9):1357-63.

11. Cohen JS, Teach SJ, Chapman JI. Bedside Ultrasound Education in Pediatric Emergency Medicine Fellowship Programs in the United States. Pediatr Emerg Care. 2012;28(9):845-50.

12. Levy JA, Noble VE. Bedside Ultrasound in pediatric emergency medicine. Pediatrics. 2008;121(5):e1404-12.

13. Chamberlain MC, Reid SR, Madhok M. Utilization of emergency ultrasound in pediatric emergency departments. Pediatr Emerg Care. 2011;27(7):628-32.

14. Brenner DJ, Hall EJ. Computed tomography – an increasing source of radiation exposure. N Engl J Med. 2007;357(22):2277-84.

15. Pearce MS, Salotti JA, Little MP, McHugh K, Lee C, Kim KP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukemia and brain tumors: a retrospective cohort study. Lancet. 2012;380(9840):499-505.

16. Zacharias C, Alessio AM, Otto RK, Iyer RS, Phillips GS, Swanson JO, et al. Pediatric CT: strategies to lower radiation dose. Am J Roentgenol. 2013;200(5):950-56.

17. Goske MJ, Applegate KE, Bulas D, Butler PF, Callahan MJ, Coley BD, et al. Alliance for Radiation Safety in Pediatric Imaging. Image Gently: progress and challenges in CT education and advocacy. Pediatr Radiol. 2011;41(2):461-66.

18. Brody AS, Frush DP, Huda W, Brent RL. American Academy of Pediatrics Section on Radiology: Radiation risk to children from computed tomography. Pediatrics. 2007;120(3):677-682.

19. American Board of Pediatrics Content Outline Pediatric Emergency Medicine – Subspecialty In-Training, Certification, and Maintenance of Certification Examinations. Available at: ttps://www.abp.org/sites/abp/files/pdf/ pediatric_emergency_medicine_content_outline.pdf. Accessed November 23, 2016.

20. Viera RL, Hsu D, Nagler J, Chen L, Gallagher R, Levy JA. Pediatric Emergency Medicine Fellow Training in Ultrasound: Consensus Educational Guidelines. Acad Emerg Med. 2013;20(3):300-306.

21. Ramirez-Schrempp D, Dorman DH, Tien I, Liteplo AS. Bedside ultrasound in pediatric emergency medicine fellowship programs in the United States: little formal training. Pediatr Emerg Care. 2008;24(10):664-7.

22. Regehr G, Eva K. Self-assessment, Self-direction, and the Self-regulating Professional. Clin Orthop Relat Res. 2006;449:34-8.

23. Accreditation Council for Graduate Medical Education, the American Board of Pediatrics, and the American Board of Emergency Medicine 2015. The Pediatric Emergency Medicine Milestone Project. Available at: http://www.acgme.org/Portals/0/PDFs/Milestones/PediatricEmergencyMedicineMilestones.pdf. Accessed September 15, 2016.

24. Likert R. A Technique for the Measurement of Attitudes. Arch Psychol. 1932;140:1-55.

25. Lenhard A, Lenhard W. Computation of Effect Sizes #4: Calculation of d and r from the test statistics of dependent and independent t-tests. Psychometrica Freeware. Available at: https://www.psychometrica.de/effect_size.html. Accessed March-April, 2017.

26. Salzberger T. Does the Rasch model convert an ordinal scale into an interval scale? Rasch Meas Trans. 2010;24:1273–1275.

27. Beeson MS, Carter WA, Christopher TA, Heidt JW, Jones JH, Meyer LE, et al. The Development of the Emergency Medicine Milestones. Acad Emerg Med. 2013;20(7):724-9.

28. Beeson MS, Holmboe ES, Korte RC, Nasca TJ, Brigham T, Russ CM, et al. Initial Validity Analysis of the Emergency Medicine Milestones. Acad Emerg Med. 2013;22(7):838-44.

29. Bahner DP, Goldman E, Way D, Royall NA, Liu JT. The State of Ultrasound Education in U.S. Medical Schools: Results of a National Survey. Acad Med. 2014;89:1681-6.

30. Dinh VA, Fu JY, Lu S, Chiem A, Fox JC, Blaivas M. Integration of Ultrasound in Medical Education at United States Medical Schools: A National Survey of Directors' Experiences. J Ultrasound Med. 2016;35(2):413-9.

31. Mosier JM, Malo J, Stolz LA, Bloom JW, Reyes NA, Snyder LS, et al. Critical Care Ultrasound Training: A Survey of US Fellowship Directors. J Crit Care. 2014;29(4):645-9.

32. Kornblith AE, vanSchaik S, Reynolds T. Useful But Not Used: Pediatric Critical Care Physician Views on Bedside Ultrasound. Pediatr Emerg Care. 2015;31(3):186-9.

33. Kruger J, Dunning D. Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. J Pers Soc Psychol. 1999;77(6):1121-34.

34. Ward M, Gruppen L, Regehr G. Measuring self-assessment: Current state of the art. Adv Health Sci Edu. 2002;7:63-80.

35. Davis DA, Mazmanian PE, Fordis M, Harrison RV, Thorpe KE, Perrier L. Accuracy of physician self-assessment compared with observed measures of competence: a systematic review. JAMA. 2006;296(9):1094-1102.

Table 1. Demographic Profile of 128 Pediatric Emergency Medicine Physicians from Four Academic Children's Hospitals in the Midwest Region of the United States.

Demographics	Number (Percentage)
Gender	
Female	78 (61)
Male	45 (35)
No Response	5 (4)
Hospital	
Site A	43 (34)
Site B	30 (23)
Site C	23 (18)
Site D	30 (23)
No Response	2 (2)
Current Position	
Attending	87 (68)
Years in Practice (post training)	
· Zero – Five	17 (13)
· Six – Fifteen	35 (27)
· Greater than 15	35 (27)
Fellow	36 (28)
- Fellowship Year 1	13 (10)
- Fellowship Year 2	11 (8.6)
- Fellowship Year 3	12 (9.4)
No response	5 (4)
Training Pathway	
Pediatrics or IM-Peds Residency with PEM Fellowship	107 (83.6)
Emergency Medicine Residency with PEM Fellowship	16 (12.5)

No response	5 (4)
Ultrasound Education	
Formal US Education Program (In medical school, residency, or fellowship)	60 (46.9)
Informal US Education Program (Self-taught, Bedside instruction, CME as an attending)	53 (41.4)
No US Education	15 (11.7)
Proportion of US Education specific to Pediatrics	
All US training is in pediatrics (100%)	34 (26.6)
Most	34 (26.6)
Some	24 (18.8)
None is Pediatrics (0%)	21 (16.4)
No US Education at all	15 (11.7)

Table 2. Frequencies and Percentages of Pediatric Emergency Medicine Fellows and Attendings Self- Rating of Levels of Achievement on Three Milestone Assessments Relevant to a PEM Practitioner: 1) Goal-directed Ultrasound, 2) Clinical Procedures, and 3) Emergency Stabilization of Pediatric Patients.

Level of Achievement	**Goal-Directed Focused Ultrasound of Pediatric Patients**	**Procedures with Pediatric Patients**	**Emergency Stabilization of Pediatric Patients**
1	42 (33)	21 (16)	4 (3)
2	44 (34)	23 (18)	14 (11)
3	21 (16)	12 (9)	15 (12)
4	10 (8)	14 (11)	38 (30)
5	6 (5)	53 (41)	52 (40)
Missing	5 (4)	5 (4)	5 (4)
TOTAL	128 (100)	128 (100)	128 (100)

Table 3. Pediatric Emergency Medicine Fellows' and Attendings' Ratings of Potential Barriers (Individual and Institutional) to Integration of Point-of-Care Ultrasound Into Their Clinical Practice.

Potential barrier	**Rasch Logits**	**SE**	**Rank**	**SD (1)**	**D (2)**	**N (3)**	**A (4)**	**SA (5)**
P-2 I do not feel comfortable enough with my ultrasound skills to use this modality clinically	-.91	.13	1	3 (3.9)	7 (9.1)	8 (10.4)	35 (45.5)	24 (31.2)
P-3 I do not have sufficient educational time to dedicate to learning pediatric emergency ultrasound	-.65	.12	2	1 (1.3)	11 (14.3)	15 (19.5)	34 (44.2)	16 (20.8)
I-6 There is a lack of sub-specialists/ consultants who would use emergency ultrasound findings for medical decision-making	-.54	.13	3	2 (3.1)	12 (18.5)	12 (18.5)	20 (30.8)	19 (29.2)
P-5 I feel that using emergency ultra-sound during my clinical shifts negatively impacts my efficiency and patient flow.	-.50	.12	4	3 (3.9)	10 (13.0)	19 (24.7)	32 (41.6)	13 (16.9)
I-4 There is not sufficient mentorship or emergency ultrasound trained faculty to use this modality effectively and safely	-.40	.13	5	4 (6.2)	12 (18.5)	7 (10.8)	30 (46.2)	12 (18.5)
I-5 The use of pediatric emergency ultrasound is not a priority in my department	-.40	.13	5	2 (3.1)	11 (16.9)	15 (23.1)	25 (38.5)	12 (18.5)

I-7 We encounter resistance to usage of emergency ultrasound from other departments at our site (eg. surgery, radiology, etc).	-.20	.12	7	5 (7.7)	15 (23.1)	14 (21.5)	16 (24.6)	15 (23.1)
I-3 There is no structured curriculum to educate the physicians on how to use pediatric emergency ultrasound	-.17	.12	8	6 (9.2)	12 (18.5)	12 (18.5)	27 (41.5)	8 (12.3)
I-2 There is a lack of funding to further emergency ultrasound pursuits and education	.28	.12	9	12 (18.5)	16 (24.6)	14 (21.5)	17 (26.2)	6 (9.2)
P-1 I do not ascribe significant value to using emergency ultrasound clinically in my patients	.68	.12	10	20 (26.0)	30 (39.0)	13 (16.9)	9 (11.7)	5 (6.5)
P-4 I do not work enough clinical shifts to effectively practice my emergency ultrasound skills	.72	.12	11	16 (20.8)	36 (46.8)	14 (18.2)	8 (10.4)	3 (3.9)
I-1 There is no functional ultrasound machine available for use	2.10	.19	12	42 (64.6)	18 (27.7)	3 (4.6)	0 (0)	2 (3.1)

Notes: Data are based on respondent ratings (using Likert Response Sets) of barriers to the use of ultrasound in practice. Responses of agreement (Strongly Agree or Agree) were considered more significant barriers than responses of disagreement (Strongly Disagree or Disagree).

Barriers are listed from most (1) to least (12) significant.

Fit statistics were all within the acceptable range of -2.0 to +2.0.

SE = Standard Error

SD = Strongly Disagree

D = Disagree

N = Neutral

A = Agree

SA = Strongly Agree

Figure 1A.

Goal-directed Focused Ultrasound (Diagnostic/Procedural) (PC12) **Uses goal-directed focused Ultrasound for the bedside diagnostic evaluation of emergency medical conditions and diagnoses, resuscitation of the acutely ill or injured patient, and procedural guidance.**				
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Describes the indications for emergency ultrasound	Explains how to optimize ultrasound images and identifies the proper probe for each of the focused applications Performs an eFAST	Performs goal-directed focused ultrasound exams Correctly interprets acquired images	Performs a minimum of 150 focused ultrasound examinations	Expands ultrasonography skills to include: advanced echo, TEE, bowel, adnexal and testicular pathology, and transcranial Doppler

Figure 1B.

Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Describe the indications for emergency ultrasound	Explain how to optimize ultrasound images and identify the proper probe for each of the focused ultra sound applications I also can perform a FAST/eFAST exam	Perform goal-directed focused US exams and correctly interpret acquired images	Perform a minimum of 150 focused ultrasound examinations	Consistently achieve scans at the technical level of an imaging professional, meaning I would feel comfortable documenting the results, making a clinical decision based on my findings, saving the images to the chart, and billing the patient for my images

Figure 1C.

General Approach to Procedures: Performs the indicated procedure on all appropriate patients and takes steps to avoid potential complications, and recognizes the outcome and/or complications resulting from the procedure – PC9				
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Identifies pertinent anatomy and physiology for a specific procedure; uses appropriate Universal Precautions	Performs patient assessment, obtains informed consent, and ensures monitoring equipment is in place in accordance with patient safety standards; knows indications, contraindications, anatomic landmarks, equipment, anesthetic and procedural techniques, and potential complications for common ED procedures; performs the indicated common procedure on a patient with moderate urgency who has identifiable landmarks and a low-to-moderate risk for complications; performs post-procedural assessment and identifies any potential complications	Determines a back-up strategy if initial attempts to perform a procedure are unsuccessful; correctly interprets the results of a diagnostic procedure	Performs indicated procedures on any patients with challenging features (e.g., poorly identifiable landmarks, at extremes of age or with co-morbid conditions; performs the indicated procedure, takes steps to avoid potential complications, and recognizes the outcome and/or complications resulting from the procedure	Teaches procedural competency and corrects mistakes

Figure 1D.

Emergency Stabilization: Prioritizes critical initial stabilization action and mobilizes hospital support services in the resuscitation of a critically-ill or injured patient and reassesses after stabilizing intervention – PC5				
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Recognizes abnormal vital signs	Recognizes when a patient is unstable requiring immediate intervention; performs a primary assessment on a critically-ill or injured patient; discerns relevant data to formulate a diagnostic impression and plan	Manages and prioritizes critically-ill or injured patients; prioritizes critical stabilization actions in the resuscitation of a critically-ill or injured patient; reassesses after implementing a stabilizing intervention; evaluates the validity of a DNR order	Recognizes in a timely fashion when further clinical intervention is futile; integrates hospital support services into a management strategy for a problematic stabilization situation	Develops policies and protocols for the management and/or transfer of critically-ill or injured patients