

Point-of-Care Ultrasound Training in Pediatric Residency: A National Needs Assessment

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ABSTRACT BACKGROUND AND OBJECTIVES: As point-of-care ultrasound (POCUS) evolves into a standard tool for the care of children, pediatric residency programs need to develop POCUS training programs. Few POCUS training resources exist for pediatric residents, and little is known about POCUS training in pediatric residencies. We aim to describe pediatric residency leadership perspectives regarding the value of POCUS and to elucidate the current state of POCUS training in pediatric residency programs.

METHODS: A group of pediatric educators and POCUS experts developed a novel survey followed by cognitive interviews to establish response-process validity. The survey was administered electronically to pediatric residency associate program directors between December 2019 and April 2020. Program characteristics, including region, setting, and size, were used to perform poststratification for analyses. We performed comparative analyses using program and respondent characteristics.

RESULTS: We achieved a 30% (58 of 196) survey response rate. Although only a minority of respondents (26%) used POCUS in clinical practice, a majority (56%) indicated that all pediatric residents should be trained in POCUS. A majority of respondents also considered 8 of 10 POCUS applications important for pediatric residents. Only 37% of programs reported any POCUS training for residents, primarily informal bedside education. Most respondents (94%) cited a lack of qualified instructors as a barrier to POCUS training.

CONCLUSIONS: Most pediatric residency programs do not provide residents with POCUS training despite its perceived value and importance. Numerous POCUS applications are considered important for pediatric residents to learn. Future curricular and faculty development efforts should address the lack of qualified POCUS instructors.

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For decades, ultrasonography provided safe and effective imaging capabilities but remained limited to select medical specialties, including radiology, cardiology, and obstetrics.¹⁻⁴ More recently, improvements in the portability, cost, and quality of ultrasound technology has led to the development of point-of-care ultrasound (POCUS), defined as ultrasonography performed at the patient's bedside by the provider to answer a specific clinical question in real time.⁵ The trend toward widespread ultrasound accessibility began in emergency medicine ~30 years ago and accelerated over the past 10 years with affordable handheld ultrasound devices that produce high-quality images, now available to individual practitioners. As ultrasound migrates out of traditional imaging fields, graduate medical training programs must balance the desire to incorporate the potential benefits of POCUS with the risk of harm caused by improper training, supervision, and use.⁶

For the field of pediatrics, POCUS is an especially appealing imaging modality, given improved acoustic windows in children compared with adults and the lack of ionizing radiation or need for sedation. Although POCUS for procedural guidance has the largest evidence base for benefit in children, many other diagnostic POCUS applications, including management of soft tissue infections, evaluation of dehydration, and diagnosis of pneumonia, have also revealed promise.⁷⁻⁹ As a result, POCUS has expanded to multiple pediatric subspecialties, including emergency medicine, critical care, neonatology, hospital medicine, and rheumatology.¹⁰⁻¹⁴ Further expansion to pediatric primary care settings seems likely, given growing use of POCUS in family medicine practice and outpatient medicine.^{15,16} As POCUS evolves into a standard tool for the care of children, pediatric residency programs need to develop POCUS training programs to ensure safe and effective use of POCUS by pediatricians.¹⁷ Currently, few POCUS training resources exist for pediatric residents, and little is known about POCUS training in pediatric residencies.¹⁸⁻²⁰

The objective of this study was to describe pediatric residency leadership perspectives regarding the value of POCUS and to elucidate the current state of POCUS training in pediatric residency programs. We hypothesized that perspectives on POCUS and availability of POCUS training would differ on the basis of respondent and program characteristics. The information and insight obtained in this study could then be used to identify gaps in training and inform future curricular and faculty development.

METHODS

After a thorough literature review of POCUS training in graduate medical education and pediatrics, a novel survey instrument was developed. None of the survey items were adapted directly from existing literature or survey tools. The survey was reviewed by local experts in pediatric residency education and POCUS education for content validity. Next, the survey was piloted for additional feedback regarding content and understanding by associate program directors (APDs) and chief residents in the pediatric residency program at our institution as representatives of the population of interest and as leaders in pediatric residency education. After pilot testing and the implementation of small changes, 5 cognitive interviews were conducted by 2 authors involved in development of survey items (R.G. and K.O.), with additional APDs and chief residents to evaluate response-process validity.²¹ The final survey is included as a digital supplement (Supplemental Information 1). Survey items focused on 3 domains of POCUS training in pediatric residency: (1) residency leadership perspectives on the value of POCUS, (2) perceived importance of specific POCUS applications, and (3) the current approach to POCUS training. POCUS applications were divided into the following 10 categories with examples provided for clarity:

Procedural guidance: central-line and peripheral intravenous catheter

Soft tissue: cellulitis, abscess, and foreign body

Lung: pneumonia, pleural effusion, and pneumothorax

Cardiac: systolic function, pericardial effusion, and chamber size

Abdominal: appendicitis and intussusception

Trauma and/or resuscitation: focused assessment with sonography in trauma examination

Hepatobiliary: cholelithiasis

Renal and/or bladder: bladder volume

Musculoskeletal: fracture and joint effusion

Obstetrics and gynecology: intrauterine pregnancy

The survey was submitted to the Association of Pediatric Program Directors (APPD) Research and Scholarship Learning Community. The APPD Research and Scholarship Learning Community elected to distribute the survey to pediatric residency APDs rather than program directors (PDs) because of the number of surveys sent to PDs. We considered APDs an appropriate population for our study question because of their important role in pediatric residency leadership and knowledge of program curriculum. Between December 2019 and April 2020, the survey was distributed electronically to APDs via an online survey platform. APDs received an initial invitation to participate by e-mail with the survey link, followed by 3 reminder e-mails. For programs with multiple APDs, invitations were sent sequentially to each APD listed in the APPD database until a response from the program was recorded, with a maximum of 3 reminder e-mails to each APD. Responses were limited to 1 per program so the denominator for the survey response rate was the number of programs included in the APPD. Survey participation was voluntary, and no incentive was offered to participants.

Data were summarized by using descriptive statistics. Program characteristics provided by the APPD database, including region, setting, and size, were used to create poststratification weights to be used in analyses. Fisher's

exact tests were used to compare respondent and program characteristics, as appropriate. The Benjamini-Hochberg adjustment was used to correct for multiple comparisons, with a new critical *P* value <.002 considered statistically significant. The study was determined to be exempt by the local institutional review board with a waiver of written consent.

RESULTS

Residency Leadership Perspectives on POCUS

We achieved a 30% (58 of 196) survey response rate.²² There were no significant differences in program setting, geographic location, or size between respondents and nonrespondents (Table 1). The majority of respondents (94%) were APDs, a minority (26%) used POCUS in clinical practice, and a minority (20%) identified general pediatrics as their primary area of clinical practice. In Table 2, we list the respondent characteristics. A majority of respondents

(56%) expressed that all pediatric residents in their program should be trained in POCUS. A minority of respondents (33%) felt that only residents in their program interested in fields that routinely use POCUS should learn POCUS during residency, with emergency medicine and critical care the fields most often identified. The majority of respondents reported agreement with statements regarding the value and importance of POCUS for the care of pediatric patients (Fig 1). We did not find significant differences in respondent agreement with these statements on the basis of respondent characteristics (POCUS use and years of experience) or program characteristics (setting, size, presence of combined programs, and percentage of residents entering fellowship). A majority of respondents considered 8 POCUS applications important as part of pediatric residency training (Fig 2).

Current POCUS Training in Pediatric Residency

Only 37% of respondents reported their program provides any POCUS training for pediatric residents, with no statistically significant difference in the presence of POCUS training based on program characteristics (setting, size, presence of combined programs, or percentage of residents entering fellowship). Among all respondents, only 17% indicated that they offered a formal POCUS curriculum at their program, whereas 22% reported that their program provided informal bedside education for POCUS training. Procedural guidance and lung ultrasound were the most frequently reported POCUS applications taught to pediatric residents, but each application was reported by only 23% of respondents. In Table 3, we provide the characteristics of current POCUS training in pediatric residencies. Among potential barriers to POCUS

TABLE 1 Program Characteristics

	Total Eligible Program Representatives (<i>n</i> = 196), % (<i>n</i>)	Nonrespondents (<i>n</i> = 137), % (<i>n</i>)	Respondents (<i>n</i> = 58), % (<i>n</i>)	<i>P</i>	Respondents After Poststratification (<i>n</i> = 58), % (<i>n</i>)
Program setting ^a					
University based	45 (87)	42 (58)	50 (29)	.538	44 (29)
Community based	50 (97)	51 (70)	47 (27)	.538	50 (27)
Other	6 (11)	7 (9)	3 (2)	.538	5 (2)
Program size ^a					
<30 residents	32 (62)	37 (50)	21 (12)	.086	32 (12)
30–60 residents	44 (85)	41 (56)	50 (29)	.086	44 (29)
>60 residents	25 (48)	23 (31)	29 (17)	.086	25 (17)
Residency with combined programs (<i>n</i> = 55)					
No	—	—	33 (18)	—	36 (18)
Yes	—	—	67 (37)	—	64 (37)
Combined programs (<i>n</i> = 37)					
Pediatrics/IM	—	—	84 (31)	—	80 (31)
Pediatrics/neurology	—	—	76 (28)	—	68 (28)
Pediatrics/rehabilitation	—	—	11 (4)	—	11 (4)
Pediatrics/other	—	—	16 (6)	—	15 (6)
Residents entering fellowship (<i>n</i> = 53)					
0%–20%	—	—	0 (0)	—	0 (0)
21%–50%	—	—	57 (30)	—	60 (30)
51%–80%	—	—	42 (22)	—	39 (22)
81%–100%	—	—	2 (1)	—	1 (1)

IM, internal medicine; —, not applicable.

^a Characteristics missing from 1 program.

TABLE 2 Respondent Characteristics

	Respondents After Poststratification, % (n)
Years since residency training (n = 55)	
0–5 y	15 (10)
6–10 y	37 (20)
11–20 y	37 (20)
>20 y	12 (5)
Primary area of clinical practice (n = 55)	
Hospital medicine	26 (17)
General pediatrics	20 (11)
Emergency medicine	9 (7)
Neonatology	8 (5)
Critical care medicine	9 (4)
Other subspecialties	28 (11)
Uses POCUS in clinical practice (n = 55)	
No	74 (39)
Yes	26 (16)

training in pediatric residency, nearly all respondents (94%) identified lack of availability of qualified instructors and/or faculty. The next most common barriers included time constraints for providers to learn and practice POCUS, lack of guidelines or standards from governing societies, and lack of available necessary technology.

DISCUSSION

Our study represents the first pediatric-specific POCUS needs assessment in residency training. We found that although pediatric residency program leadership generally supports the value of POCUS for

the care of children, most programs have little to no formal POCUS training for their residents. Respondents identified several POCUS applications that they considered most important for pediatric residents to learn, but numerous barriers to implementation of POCUS training were identified, most notably the lack of qualified instructors.

Support for the value of POCUS was widespread among pediatric residency program leaders, regardless of personal POCUS use or years of experience. Perspectives favoring POCUS are not surprising given the numerous benefits of POCUS previously described and relatively

minor risks associated with ultrasound.⁶ Our findings mirror previous needs assessments performed in internal medicine and family medicine in which program leaders were also supportive of POCUS training for their residents.^{15,23} Still, a third of respondents in our study felt that POCUS training should be limited to residents who will use POCUS in subspecialty fields that regularly use POCUS. A similar individualized approach to pediatric resident training has been used for other focus areas in pediatrics, including global health and advocacy.^{24,25} However, the gradual dissemination of POCUS into more general pediatric fields, such as hospital medicine and primary care, may require more comprehensive pediatric resident POCUS education.^{10,16} Addressing barriers to POCUS education identified by this study will be important to make this possible.

In addition to general support for POCUS, pediatric residency leadership also identified specific POCUS applications they considered most important for pediatric residents to learn. Identification of specific POCUS applications relevant for individual medical specialties is a vital step in the development of structured POCUS training programs by defining the scope of practice and allowing residency program leaders to allocate limited resources to the most important areas. Numerous medical specialties have gone through this process, including pediatric emergency medicine, but no POCUS guidelines currently exist for general pediatrics training.²⁶ Procedural guidance was considered highly important by respondents in our study, which likely reflects the existing evidence that supports the use of POCUS for central-line placement in children.⁸ Central-line placement is not 1 of the 14 Accreditation Council for Graduate Medical Education–required procedures in pediatrics, and pediatric residents get little training for this procedure.^{27,28} However, POCUS guidance can be used for several of the procedures required by the Accreditation Council for Graduate Medical Education for pediatric residents, such as peripheral intravenous catheter

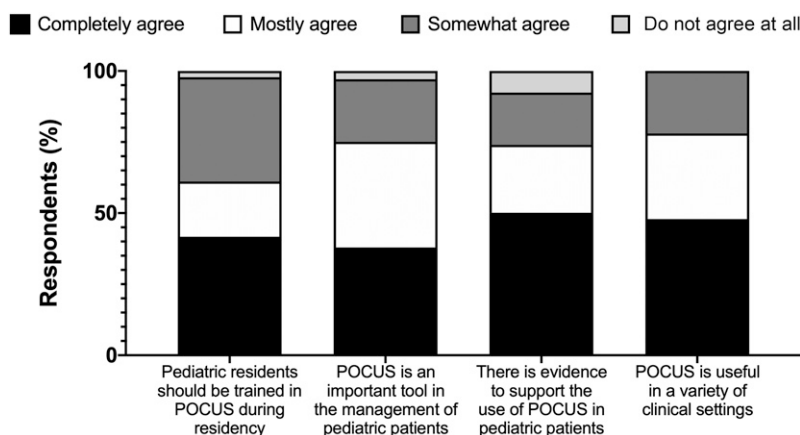


FIGURE 1 Respondent agreement with statements on the value and importance of POCUS (n = 58).

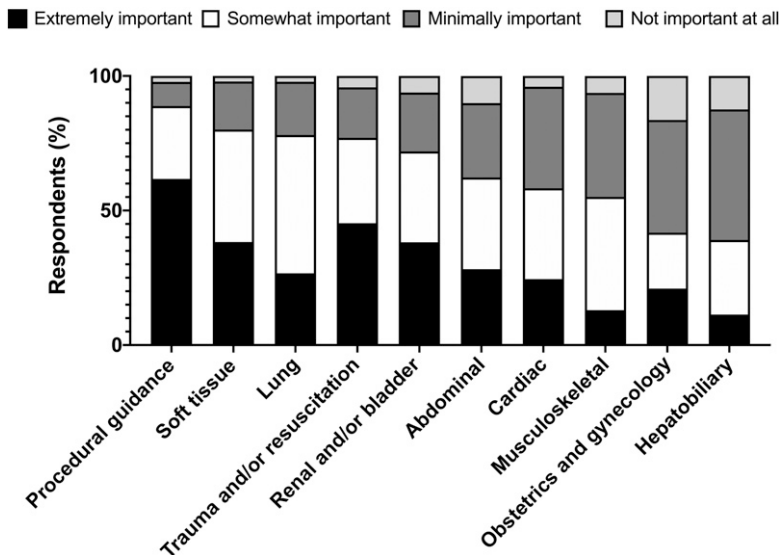


FIGURE 2 Perceived importance of specific POCUS applications for pediatric residency training ($n = 58$).

placement, bladder catheterization, and lumbar puncture.²⁹

In addition to procedural guidance, several diagnostic POCUS applications, specifically soft tissue and lung ultrasound, were also considered important for residents to learn by pediatric residency leadership. We also found that current POCUS training for pediatric residents includes lung ultrasound with the same frequency as procedural guidance. These findings are notable because other residency programs that have recently adopted POCUS training, including internal medicine and family medicine, emphasized POCUS for procedural guidance more than diagnostic POCUS.^{23,30} Such results suggest perhaps the role of POCUS in pediatrics, in particular, may be different from that in adult-aged patients. In fact, pediatric subspecialties, including emergency medicine and critical care, have expanded the scope of POCUS use from procedural guidance into numerous diagnostic applications.^{26,31,32} The concept of POCUS as the “ultrasound stethoscope,” and thus an extension of the physical examination, is not new but has only recently been expanded to the care of children, with numerous pediatric-specific applications relevant across clinical practice areas.^{17,33} Although the possibilities of diagnostic

POCUS continue to expand, trainees will need guidance of how and when to integrate the valuable diagnostic information that POCUS may provide into clinical decision-making and when radiology performed studies are necessary. Thus, professional organizations and residency training programs will have a key role in defining the scope of diagnostic POCUS and ensuring adequate training to support safe and effective practice.

Despite finding widespread support for POCUS training, our study highlighted a gap in education across the country because our results confirmed that few pediatric residency programs offer such training. In addition, there is a lack of structured POCUS education because informal bedside sessions are the most common format. Our findings are consistent with earlier studies in which researchers found minimal POCUS training for pediatric residents, including a survey of neonatology and pediatric critical care medicine fellowship directors in which <10% reported POCUS training for residents and a survey that included pediatric residency PDs in which only 13% reported a POCUS curriculum at their program.^{18,34} Respondents in our study identified numerous barriers to POCUS

training, in which the most common barrier was a lack of qualified instructors to teach POCUS. The deficit of faculty to teach POCUS is a widely cited barrier to the implementation of POCUS training across residency training programs.^{18,23,30,35} This finding supports the need for faculty development in POCUS and consideration of innovative approaches to POCUS training. For example, interprofessional educational approaches using the skills and expertise of sonography students have effectively been used to teach internal medicine residents POCUS.³⁶

Although our findings will help inform future development of POCUS training for pediatric residents, we acknowledge several limitations to this study. Our survey response rate was relatively low, which can, under certain circumstances, increase the concern for nonresponse bias.^{37,38} However, we showed that respondents did not differ from nonrespondents with regard to several program characteristics. Furthermore, we also created poststratification weights and used them in all of our analyses. Our novel survey tool was developed in consultation with local experts in resident education and POCUS to establish content validity, but important concepts in POCUS training may still have been missed. We also did not obtain input from other stakeholders, including pediatric residents or subspecialty fellowship PDs. Few APDs used POCUS in clinical practice, which may have limited their knowledge of the benefits of POCUS. In addition, as with any survey-based study, there may be differences between self-report and actual practice. Finally, our comparative analysis was limited by sample size and response rate, preventing definitive conclusions about important differences between programs.

CONCLUSIONS

Many pediatric residency programs do not provide residents with POCUS training despite its perceived value and importance among residency leaders. Numerous POCUS applications are considered important for pediatric residents to learn, particularly soft tissue and lung

TABLE 3 Characteristics of Current POCUS Training in Pediatric Residency

	Respondents After Poststratification, % (n)
Year (n = 58)	
PGY-1	24 (14)
PGY-2	21 (14)
PGY-3	17 (13)
Format (n = 58)	
Informal bedside education	22 (13)
Formal elective curriculum	6 (5)
Formal required curriculum	11 (5)
Independent study	10 (7)
Field teaching (n = 58)	
Emergency medicine	27 (16)
Critical care medicine	21 (12)
Hospital medicine	7 (5)
Cardiology	6 (3)
Primary care	3 (2)
Global health	2 (1)
POCUS application (n = 58)	
Procedural guidance	23 (13)
Lung	23 (13)
Trauma/resuscitation	21 (11)
Soft tissue	17 (11)
Cardiac	14 (10)
Renal/bladder	8 (7)
Abdominal	8 (5)
Musculoskeletal	6 (4)
Hepatobiliary	0.4 (1)

PGY, postgraduate year.

ultrasound and by those pursuing careers in emergency medicine and critical care. In future curriculum and faculty development efforts, researchers need to address the lack of qualified POCUS instructors among residency programs. In addition, this topic area could benefit from data collection from current trainees and recent program graduates.

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