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The role of a point-of-care ultrasound in the emergency department

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Abstract

Background: Pediatric ED visits for superficial skin and soft tissue infections (SSTI) have steadily increased, and point-of-care ultrasound (POCUS) remains an effective modality for improving management and shortening ED lengths of stay.

Objective: We wanted to see how a soft tissue POCUS curriculum affected POCUS utilization, ED LOS, and cost-effectiveness.

Methods: A pre- and post-interventional study of pediatric patients aged 0 to 17 years was carried out. Patients who presented to the emergency department with an international classification of disease 9 or 10 code for abscess or cellulitis were included. Data were collected one year before and one year after the implementation of the curriculum, with a one-year washout training period in between. The training included continuing medical education, more than 25 quality assurance examinations, and a post-test. We compared diagnostic imaging type, ED LOS, and mean charges in SSTI patients.

Results: We examined data from 119 patients, 38 before and 81 after the intervention. The total number of POCUS examinations performed pre- to post-curriculum intervention increased significantly, from 26 to 59 ($p = 0.0017$). The average total charges were reduced from $3,762 (270) to $2,622 (158; $p = 0.0009$). There was a significant trend toward a decrease in average ED LOS, which was 282 (standard error of mean [SEM] 19) minutes vs 185 (13) minutes ($p = 0.0001$).

Conclusions: Implementing a soft tissue POCUS curriculum in a pediatric emergency department was linked to increased POCUS use, decreased LOS, and lower costs. These findings emphasize the significance of POCUS education and application in the treatment of pediatric SSTI.

Keywords: Pediatric, Soft tissue, Ultrasound, Training, Curriculum, Emergency department, Point-of-care ultrasound, Infection, Curriculum, Pediatrics, Education

I. Introduction

SSTIs, such as abscesses and cellulitis, are common diagnoses in the pediatric population, with recent

literature indicating a steady increase in emergency department (ED) visits [1, 2, 15-17]. SSTI treatment frequently depends on the location and depth of infection, as well as whether there is a fluid collection that necessitates incision and drainage [1].

POCUS is extremely accurate at distinguishing abscess from cellulitis and can be used to guide acute management [1]. POCUS is being used in the pediatric emergency department to diagnose SSTI, and recent research has shown that when combined with physical examination, it can increase sensitivity and specificity for diagnosing SSTI [1-4]. When compared to a physical exam alone, this includes abscess and cellulitis. The POCUS application for SSTI has been shown to improve patient outcomes in the acute care setting by improving diagnostic accuracy for ruling in abscess while reducing unnecessary invasive intervention [3, 13, 14]. Furthermore, children who received POCUS for SSTI had shorter ED lengths of stay (LOS) than children who received radiology-performed ultrasound (RUS) [3].

As pediatric POCUS practice evolves, the effectiveness of training programs established to support various applications such as SSTI is critical to implementation success. There are numerous training curricula available, but few evaluate the impact on patient care and management processes to support the routine use of POCUS for diagnostic evaluations in the pediatric emergency department [4, 6].

We aimed to assess the impact of a soft tissue POCUS curriculum on the management of pediatric SSTI by comparing POCUS utilization, ED length of stay, and cost analysis before and after the implementation of a structured POCUS curriculum.

II. Materials and methods

Study setting and population

This was a pre- and post-study conducted one year before and after the implementation of a POCUS SSTI training curriculum in a pediatric emergency department. The research was conducted at an academic pediatric emergency department with over 60,000 annual visits.

Study participants

Pediatric patients (0-17 years old) with an SSTI diagnosis who presented to the ED between July 1st, 2016, and June 30th, 2017 (pre-implementation) and July 1st, 2018, to June 30th, 2019 (post-implementation) met the study's inclusion criteria. While the training curriculum was being implemented, there was a 12-month washout period from July 1st, 2017 to June 30th, 2018. During the washout period, participants were trained and were able to complete the curriculum while receiving routine SSTI care. The pre- and post-assessment groups remained constant throughout the study. Patients were included if they had a final diagnosis of SSTI as identified in the electronic medical record by ICD revision codes, 9th (ICD-9 682.2, 682.3, 682.6, 682.8, 682.9, 685.0,685.1, 686.8, 686.9, 709.8, and 709.9) and 10th (ICD-10 682.2, 682.3, 682.6, 682.8, 682.9, 685.0,685.1, 686. (ICD-10 L03.319, L03.119, L03.11, L03.81, L03.818, L05.01, L05.91, L08.9, L99, L03.221, L03.22, L03.317, L03.312).

Patients with a secondary diagnosis, complicated infection, or requiring hospitalization or surgical intervention were excluded (Fig. 1). We gathered patient demographic data, diagnostic imaging type (including POCUS and radiology ultrasound exams), and patient disposition.

Soft tissue POCUS training

Pediatric emergency medicine faculty and fellows received soft tissue POCUS training to improve their knowledge, skill, and comfort in using this tool in clinical patient management. During the study, 14 fellowship-trained pediatric emergency faculty and 8 pediatric emergency fellows were trained. Faculty were required to complete 1-hour didactic sessions, hands-on instruction with supervision by a fellowship-trained POCUS expert, 4 hours of continuing medical education (CME), a competency assessment, and 25 quality assured soft tissue POCUS examinations as previously described [3, 5]. Techniques, equipment

selection, soft tissue anatomy, image acquisition, differentiating various SSTI and soft tissue edema pathology, differentiating common types of soft tissue foreign body, and clinical integration were all covered during the didactic sessions. Clinical scans in the emergency department were part of the hands-on training. Asynchronous CME was obtained by faculty through institutional and departmental POCUS workshops.

Sonography and image software

POCUS exams were performed with a Zonare ZS3 (Mindray, Shenzhen, China) equipped with a linear transducer. Images from the ultrasound system were wirelessly saved to an image archiving and workflow solution designed to provide immediate feedback and quality assurance (Qpath, Telexy Healthcare, Maple Ridge, BC, Canada).

Radiology ultrasound was performed in a pediatric radiology department adjacent to the main ED that was open 24 hours a day. Sonographic technicians work in the ultrasound department, acquiring images and uploading them to the institution's picture archiving and communicating system (PACS) for review and interpretation by a board-certified pediatric radiologist.

Billing

Using the corresponding CPT codes for SSTI for POCUS and RUS, data on charges to the patients' payer were collected through the institution's professional billing services and the finance office of our hospital system. These charges, which included the technical and professional components of radiology services, were used to calculate the cost. POCUS rates were determined by payer-negotiated reimbursement via the institution's finance office, which included technical and professional fees billed via a third-party billing service.

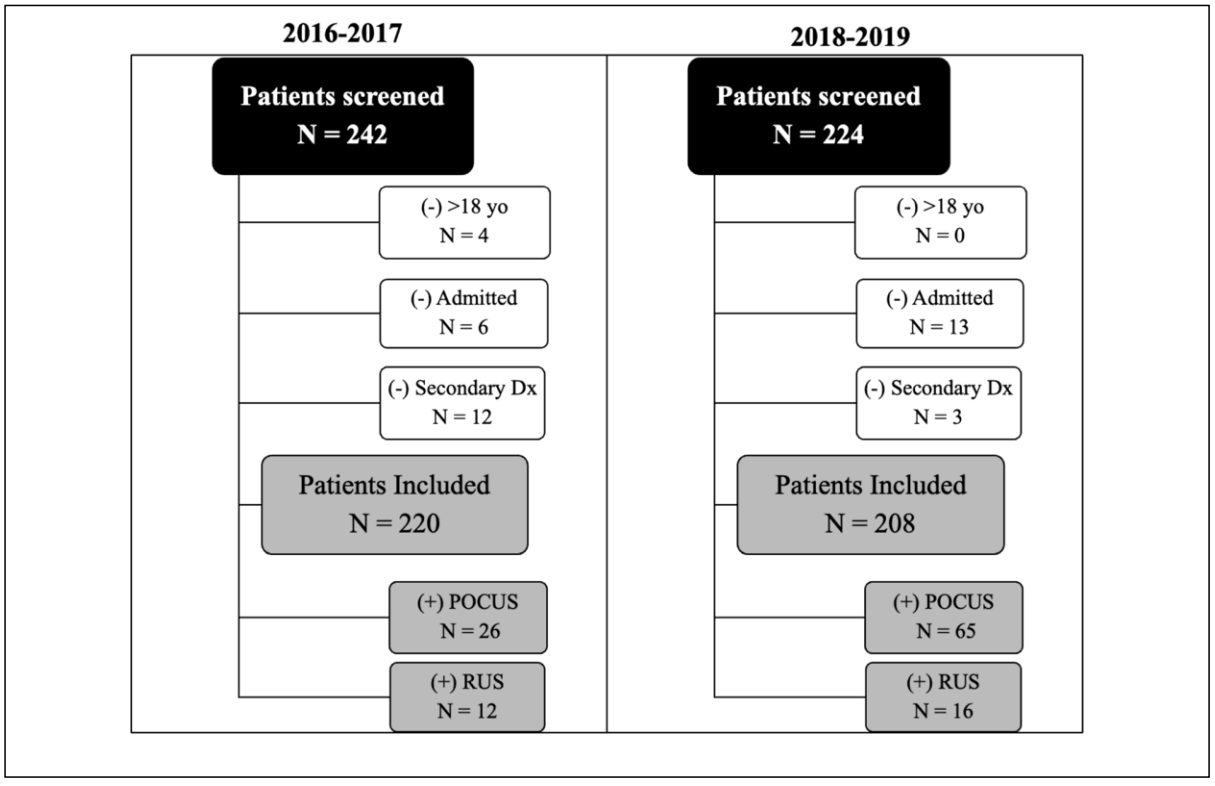

Fig. 1 Patient participant flowchart with inclusion and exclusion applied to patient selection pre - and post-intervention of SSTI curriculum

Statistical analysis

We reported descriptive summary statistics such as mean and standard error of the mean for continuous measures. To test for differences over time, the Wilcoxon test was used. We reported frequency and percentages for categorical measures. The Chi-square test was used to determine differences in ultrasound examination proportions. P 0.05 was deemed significant. SAS 9.4 was used for all statistical analysis. The study was powered by a sample size of 91 based on a 95% confidence level and an alpha of 5% assuming a target population of 100, which was based on approximately 50% of the estimated population of SSTI patients.

III. Results

In the pre-intervention cohort, 242 patients were identified based on ICD-9 and ICD-10 codes for abscess or cellulitis, with 220 patients meeting inclusion criteria. As part of their ED workup, 38 out of 220 (17.3%) received ultrasound imaging, 26 out of 38 (68.4%) received POCUS, 12 (31.6%) received radiology-performed US, and 11 (28.9%) received both.

Following the intervention, 224 patients were screened, with 208 meeting the inclusion criteria. As part of their ED workup, 55 out of 208 (26.4%) received ultrasound imaging, 39 out of 55 (71.0%) received POCUS, 16 (29.1%) received radiology-performed US, and 6 (10.9%) received both. When comparing age and race, there was no significant difference between pre- and post-intervention groups. In the pre-intervention cohort, the average age of patients with ultrasound imaging was 7.92 (standard error of mean [SEM] 0.99), and in the post-intervention cohort, it was 6.83 (0.65). The majority of study participants were Caucasian, with 71% in the pre-intervention cohort and 58% in the post-intervention cohort being Caucasian. The proportion of female patients included increased significantly from pre- to post-intervention, increasing by 42%.

Table 1 Demographics and characteristics of SSTI between pre- and post-intervention patients.

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Demographics			
	2016–2017 *N* = 38	**2018–2019 *N* = 81**	*P-value*
Age in years (± SEM)	7.92 (± 0.99)	6.83 (± 0.65)	0.3252
Gender (%)			0.0075
Female	16 (42.11)	55 (67.90)	
Male	22 (57.89)	26 (32.10)	
Race (%)			0.1873
Asian	0 (0.0)	1 (1.23)	
Black	10 (26.32)	33 (40.74)	
White	27 (71.05)	47 (58.02)	
Unknown	1 (2.63)	0 (0.0)	
SSTI infection			0.1378
Cellulitis	26 (69.4)	60 (73.4)	
Abscess	10 (26.5)	17 (20.2)	
Other	2 (5.31)	4 (4.94)	
SSTI location (%)			0.1727
Upper extremity	6 (15.7)	13 (16.0)	
Lower extremity	18 (47.4)	36 (44.4)	
Buttock	9 (23.7)	11 (13.6)	
Cyst	3 (7.9)	11 (13.6)	
Other	2 (5.3)	10 (12.3)	

P = < 0.05 denotes statistical significance

Min minimum, *Max* maximum

vs 67% (p = 0.0075). Cellulitis was the most common diagnosis both before and after intervention, with 69.4% and 73.4% of patients diagnosed with cellulitis and 26.5% and 20.2% of patients diagnosed with abscess, respectively (Table 1). The vast majority of infections occurred in the lower extremities (Table 1).

Total mean charges were $3,762 (270) vs. $2,622 (158; p = 0.009; Table 2). In the pre- and post-intervention cohorts, the mean charge for imaging was significantly lower for patients with POCUS after training than for patients with RUS ($3,491 (345) vs $2,193 (116), p = 0.0001 and $4,349 (376) vs $4,291 (175), p = 0.1411, respectively); see Fig. 2.

The rate of patients receiving ultrasound increased from pre- to post-intervention, 17.3% vs 38.9% (p = 0.00001), and the frequency of patients receiving POCUS increased, 26 (68.4%) vs 59 (72.8%, p = 0.6188).

Overall, men's ED LOS decreased significantly from 282 (19) minutes before intervention to 185 (13) minutes after intervention, p = 0.0001. (Table 2). Patients receiving POCUS had significantly shorter LOS in the pre- and post-intervention cohorts when compared to patients receiving radiology ultrasound (161 (13) vs. 140 min, p = 0.0001, and 266 (28) vs. 239 (21), p = 0.0001, respectively) (Table 2, Fig. 3).

Table 2 Clinical experience. Description of imaging types, ED length of stay, and charges for corresponding imaging

Imaging (*N* = 119)			
Imaging type	**2016–2017**	**2018–2019**	***P-value***
Total ultrasound (%)	38 (17.3)	81 (38.9)	0.00001
POCUS alone (%)	26 (68.4)	59 (72.8)	0.6188
POCUS + RUS (%)	0 (0.0)	6 (7.4)	0.3714
POCUS + CT (%)	1 (2.6)	0 (0.0)	0.6286
RUS alone (%)	10 (26.3)	16 (19.7)	0.9305
RUS + CT (%)	1 (2.6)	0 (0.0)	0.6286
Mean ED charges, $	3,762 (± 270)	2,622 (± 158)	0.0009
POCUS charge (± SEM)	3,491 (± 345)	2,193 (± 116)	0.0001
RUS charge (± SEM)	4,349 (± 376)	4,291(± 175)	0.1411
Mean ED LOS, minutes	282 (± 19)	185 (± 13)	0.0001
POCUS LOS (± SEM)	161 (± 13)	140 (± 10)	0.0001
RUS LOS (± SEM)	266 (± 28)	239 (± 21)	0.0001

P < 0.05 denotes statistical significance

Min minimum, *Max* maximum

IV. Discussion

POCUS is increasingly being used in pediatric emergency departments to guide acute treatment decisions in patients with SSTI [3, 4]. The clinical impact of POCUS training curriculums on patient management is poorly understood. Previous research indicates that the use of POCUS can supplement clinical evaluation for the management of ED patients with SSTI [3, 19].

We show the clinical impact of a soft tissue POCUS curriculum on pediatric ED patients with a presenting SSTI in this novel study, which can influence provider use of POCUS, improve ED metrics, and reduce cost burden. As a result, we discovered that a streamlined curriculum for faculty and fellows was associated with a higher frequency of POCUS, significantly lower total mean charges, and a trend toward shorter ED LOS.

Unsurprisingly, the rate of POCUS examinations was higher in the post-intervention group (65/208) 31.2% vs. 26/220 (11.8%), p = 0.6188. Prior research has shown that SSTI training programs can improve technical ability and POCUS utilization in the emergency department [1, 8]. Surprisingly, a small proportion of patients in the post-intervention cohort (7.5%) received both POCUS and RUS evaluation. This is significant because, while the majority of the faculty and fellows were confident in

acquiring and interpreting the images, a few indeterminate scans may have necessitated additional evaluation and impression by the radiologist. CT scanning for additional evaluation.

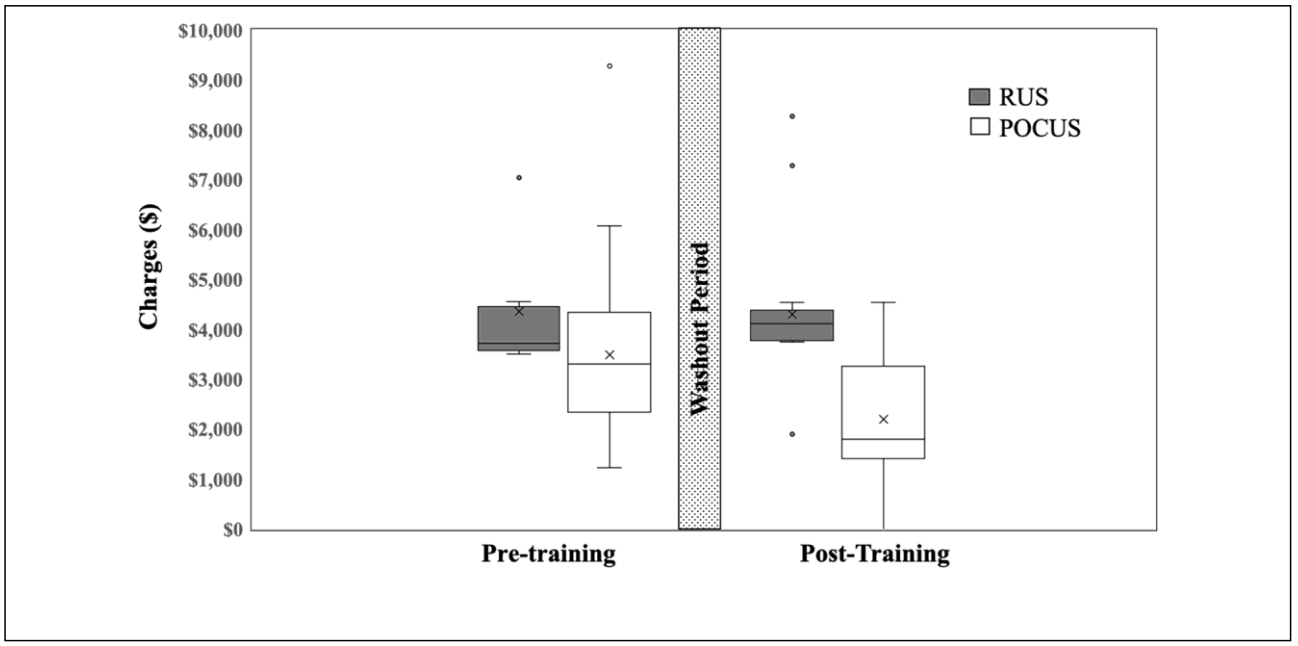

Fig. 2 Box plot of ED charges pre- and post-intervention between POCUS and radiology ultrasound (RUS) with 1-year washout period (gray bar).Circular symbol =outliers; X=mean

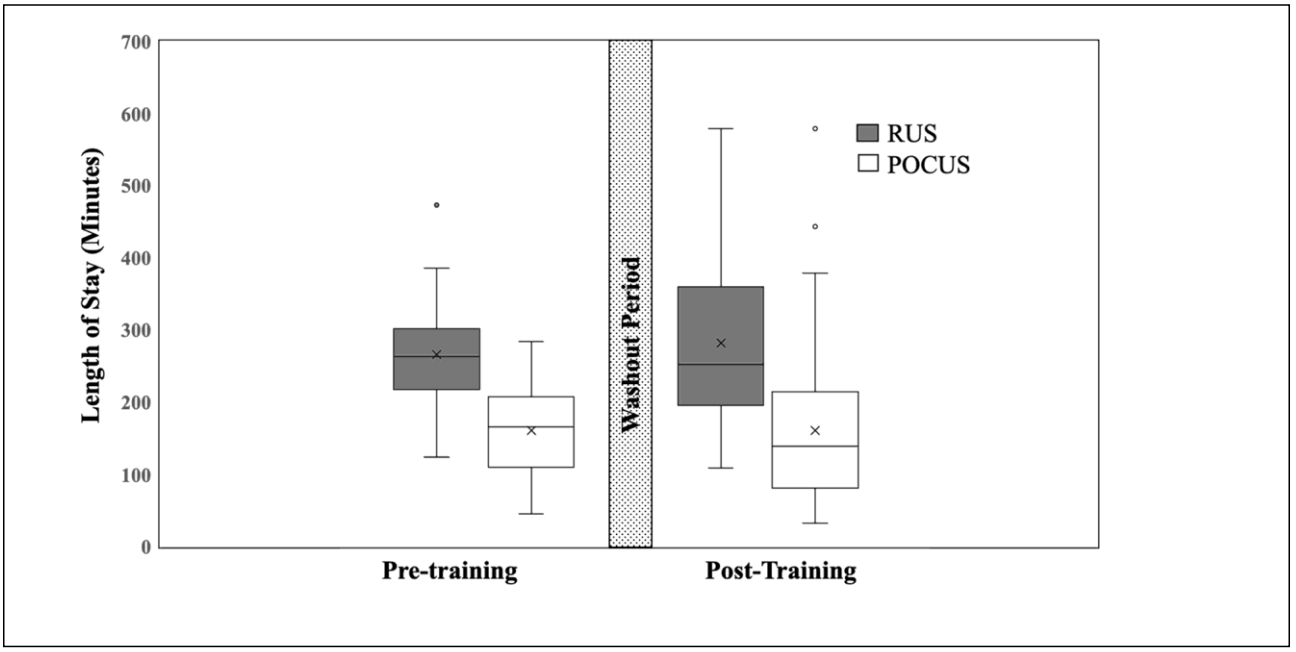

Fig. 3 Box plot of ED length of stay (LOS) in pre- and post-intervention between POCUS and radiology ultrasound (RUS) with 1-year washoutperiod (gray bar). Circular symbol=outliers; X=mean

It is common practice to use complex SSTI [15]. While two patients required additional CT scans prior to the intervention, no CT scans were used following the training. It is possible that this was related to the curriculum's implementation, but it is more likely that it was due to the exclusion of patients with complex SSTI. Nonetheless, the use of CT scans for non-complex SSTI was discontinued following the intervention. In our patient cohort, further review of patient charts revealed no complications as a result

of clinical management of SSTI.

The use of ultrasound for bedside clinical evaluation appears to be cost-effective [10-12, 18]. Common emergency-specific applications, such as the FAST, not only reduce reliance on imaging, such as computed tomography (CT), for evaluation in stable patients, but also promote an efficient and cost-effective approach to patient care [9]. Similarly, we discovered that total mean charges were significantly lower from pre- to post-intervention, $3,762 vs. $2,622, p = 0.009. In this cost-effectiveness analysis, the cost difference between using ultrasound alone and radiology ultrasound was estimated to be $1,100. As POCUS grows in popularity, its cost-effectiveness is likely to vary from institution to institution and at different points in time due to internal fee adjustments based on factors such as professional and technical fees. During the time period of the retrospective data analysis, we discovered no cost variation.

Similarly to previous POCUS studies, our data suggest that, while limited, the inclusion of POCUS promotes cost-effective care alongside ED efficiency [10].

SSTI can be performed clinically without POCUS, but its use can improve patient care in the acute care setting [1-3]. Because of the stringent inclusion criteria used in data collection and the lower frequency of ultrasound use for SSTI evaluation at our institution, our retrospective cohort sample was significantly smaller than other studies. Another major advantage of POCUS is the potential to improve ED patient experience metrics. This is most evident in SSTI evaluation, as previously documented in the literature, where SSTI evaluation by POCUS reduced LOS when compared to radiology-performed ultrasound [11]. Similarly to Lin et al., our study found a trend toward a significant decrease in ED LOS, 282 minutes pre-intervention vs. 185 minutes post-intervention, p = 0.001. While this study adjusted for relevant clinical variables, it also included potential confounding diagnoses that could affect LOS and cost-effectiveness. Furthermore, factors such as triage and registration, peak times, and staffing may have had little impact on the LOS time collected.

V. Limitations

This study has several limitations to consider. This study is based on a one-group pre- and post-intervention assessment with no control group for comparison. Furthermore, this type of study may have confounding factors that are unrelated to the intervention, which may affect the study's validity. The fact that the majority of our patients were Caucasian raises questions about whether this can be generalized. Furthermore, the lack of external validity in single-center studies may limit the true impact of soft target POCUS training. Importantly, the smaller sample size, which excluded a significant portion of the patient population, may understate the true effect of the training curriculum. However, evidence supports the beneficial impact of soft tissue training on SSTI management in the pediatric emergency department [3]. Soft tissue POCUS necessitated the presence of a trained faculty or fellow who was confident enough in their skill and interpretation to apply US findings clinically while avoiding full radiology ultrasound evaluation. Despite the fact that the majority of our physicians were credentialed during this study, not all were confident enough to use the study on a regular basis; however, this is likely to change as we gain a better understanding of the long-term effects of POCUS implementation curriculums on clinical outcomes and patient experience.

VI. Conclusions

After instructing pediatric emergency medicine faculty and fellows on how to use POCUS for SSTI, clinical use of this application increased while remaining cost-effective and decreasing LOS for patients presenting to the ED with SSTI. This implies that investing in POCUS training for applications like SSTI can improve the patient experience while lowering costs and avoiding unnecessary invasive procedures.

Summary

Soft tissue evaluation is a high-yield POCUS application that can improve management while augmenting patient care in the pediatric acute care setting. This study emphasizes the significance of developing a curriculum to improve its use by clinicians. In this regard, our findings revealed increased utilization, which had an impact on patient care efficiency and cost-effectiveness.

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