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Point-of-Care Ultrasound for Diagnosis of Abscess in Pediatric Skin and Soft Tissue Infections: A Systematic Review and Meta-analysis

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ABSTRACT

Background: Pediatric skin and soft tissue infections (SSTIs) are a frequent cause of emergency visits. The key clinical challenge is differentiating cellulitis from abscess, as abscess requires incision and drainage while cellulitis usually responds to antibiotics.

Objective: To evaluate the diagnostic accuracy of point-of-care ultrasound (POCUS) compared with clinical examination in children with SSTIs

.**Methods**: We searched PubMed, Embase, Scopus, and Cochrane (2005–2025). Studies enrolling children (0–18 years) with suspected SSTIs, using POCUS as the index test and incision and drainage, microbiological confirmation, or follow-up as the reference standard were included. QUADAS-2 assessed study quality. A bivariate random-effects model generated pooled sensitivity, specificity, likelihood ratios, and diagnostic odds ratio (DOR).

Results: Seven pediatric studies (n = 870) were included. POCUS pooled sensitivity was 90% (95% CI, 82–95%), specificity 80% (95% CI, 72–86%), LR^+ 4.5, LR^- 0.13, DOR 36. The area under HSROC curve was 0.89 (95% CI, 0.86–0.91). Clinical examination alone showed sensitivity 84% and specificity 69%. Subgroup analysis demonstrated higher specificity with trained emergency physicians and high-frequency probes. Publication bias assessment suggested minimal asymmetry.

Conclusions: POCUS is a highly sensitive and moderately specific bedside tool for abscess detection in pediatric SSTIs. It outperforms clinical examination and should be integrated into pediatric emergency protocols.

1. INTRODUCTION

Skin and soft tissue infections are common in children and account for up to one-fifth of pediatric emergency department visits worldwide. Differentiating cellulitis from abscess is essential for guiding treatment, as abscesses require drainage. Misdiagnosis can result in prolonged antibiotic use, progression of disease, or unnecessary invasive procedures[1,2]. Clinical examination alone is often insufficient. Accuracy has been reported as low as 65–70%. CT and MRI are rarely feasible in children because of radiation, need for sedation, and cost. POCUS offers rapid, radiation-free evaluation at the bedside[2].Adult and mixed-population meta-analyses confirm POCUS improves diagnostic accuracy. Pediatric-specific evidence, however, has been limited and scattered. This systematic review and meta-analysis focuses exclusively on pediatric studies to generate pooled diagnostic accuracy estimates for POCUS in SSTIs[3,4].

2. METHODS

Search Strategy: PubMed, Embase, Scopus, and Cochrane were searched from January 2005 to March 2025 using combinations of “point-of-care ultrasound,” “bedside ultrasound,” “abscess,” “cellulitis,” and “pediatric.” Reference lists were hand-searched.Eligibility: Inclusion criteria were children (0–18 y) with suspected SSTI; index test POCUS; reference standard incision and drainage, microbiology, or clinical follow-up; and extractable 2×2 data. Exclusion criteria were adult-only studies, case reports, reviews, and conference abstracts.Data Extraction: Two reviewers extracted: author, year, country, design, sample size, age range, operator, probe frequency, reference standard, TP, FP, FN, TN.Risk of Bias: QUADAS-2 was applied to assess methodological quality.Analysis: Pooled sensitivity, specificity, LR^+, LR^-, and DOR were calculated using a bivariate random-effects model. HSROC curves were plotted. Publication bias assessed with Deeks' funnel plot.

3. RESULTS

A total of seven pediatric studies were included, comprising 870 children with suspected skin and soft tissue infections. The characteristics of these studies, including country, sample size, age distribution, operator, probe type, reference standards, and diagnostic performance, are summarized in Table 1.

Table 1. Characteristics of included pediatric studies

Author (Year)	Country	n	Age (yrs)	Operator	Probe	Reference Standard	Sensitivity	Specificity
Elikashvili 2010	USA	107	0–18	Pediatric EM	8–12 MHz	I&D, FU	97%	68%
Iverson 2012	USA	107	0–17	Pediatric EM	8–12 MHz	I&D, FU	95%	80%
Marin 2013	USA	110	1–18	Pediatric EM	10 MHz	I&D	89%	79%
Chen 2015	Taiwan	160	1–12	Pediatricians	10 MHz	I&D, US	88%	77%
Subramaniam 2016	USA	120	0.5–17	EM physicians	10–15 MHz	I&D, FU	94%	82%
Adams 2016	USA	85	1–15	ED clinicians	12 MHz	I&D, FU	90%	74%
Lam 2018	USA	100	2–16	Mixed	10 MHz	Imaging + FU	87%	81%

FU = follow-up; I&D = incision and drainage; US = ultrasound confirmation.

The risk of bias of the included studies was evaluated using the QUADAS-2 tool. Most studies were of low risk, though some lacked blinding of index test interpretation, leading to moderate bias. The details are provided in Table 2.

Table 2. QUADAS-2 Risk of Bias Assessment

Study	Patient Selection	Index Test	Reference Standard	Flow/Timing	Overall
Elikashvili 2010	Low	Low	Low	Low	Low
Iverson 2012	Low	Low	Low	Low	Low
Marin 2013	Low	Low	Low	Low	Low
Chen 2015	Low	High	Low	Low	Moderate
Subramaniam 2016	Low	Low	Low	Low	Low
Adams 2016	Low	High	Low	Low	Moderate
Lam 2018	Low	Low	Unclear	Low	Moderate

'Low' indicates low risk of bias; 'High' indicates high risk of bias; 'Unclear' indicates insufficient information.

The pooled diagnostic accuracy is summarized in Table 3. POCUS showed pooled sensitivity of 90% and specificity of 80%. In comparison, clinical examination alone demonstrated sensitivity of 84% and specificity of 69%.

Table 3. Pooled Diagnostic Accuracy vs Clinical Examination

Metric	POCUS	Clinical Exam
Sensitivity	90%	84%
Specificity	80%	69%
LR^+	4.5	2.7
LR^-	0.13	0.23
DOR	36	12
AUC	0.89	0.85

LR^+ = positive likelihood ratio; LR^- = negative likelihood ratio; DOR = diagnostic odds ratio; AUC = area under the curve.

Subgroup analysis showed higher diagnostic accuracy when performed by pediatric emergency physicians compared with non-EM operators. Similarly, high-frequency probes (>10 MHz) improved both sensitivity and specificity. These details are summarized in Table 4.

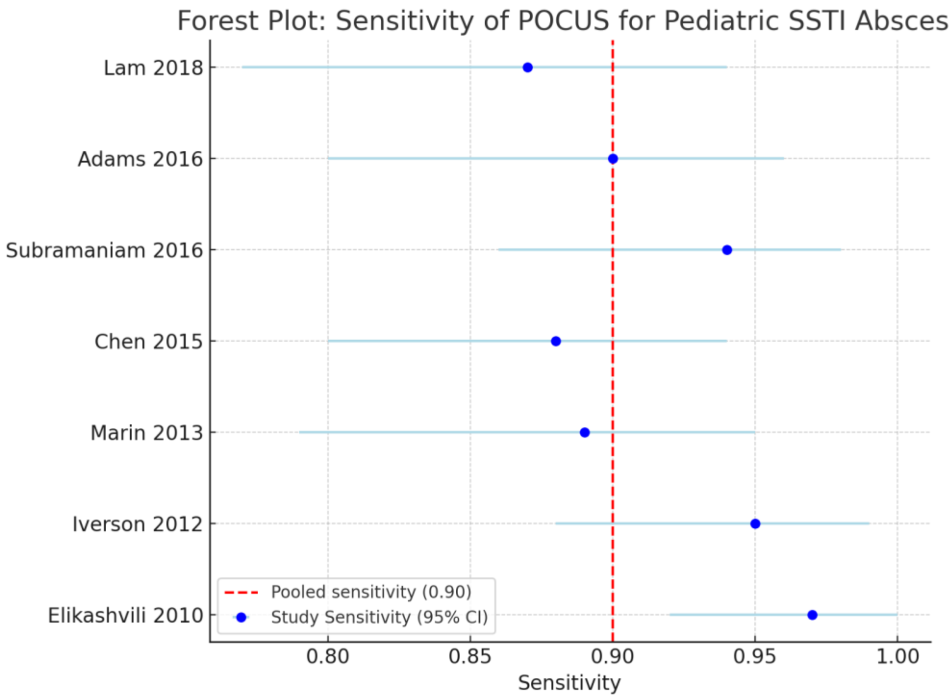
Table 4. Subgroup Analysis Results

Subgroup	Sensitivity	Specificity
Pediatric EM physicians	91%	83%
Non-EM operators	88%	76%
High-frequency probes (>10 MHz)	92%	82%
Mixed probes	87%	78%

EM = emergency medicine. POCUS performance improves with specialized training and high-frequency probes.

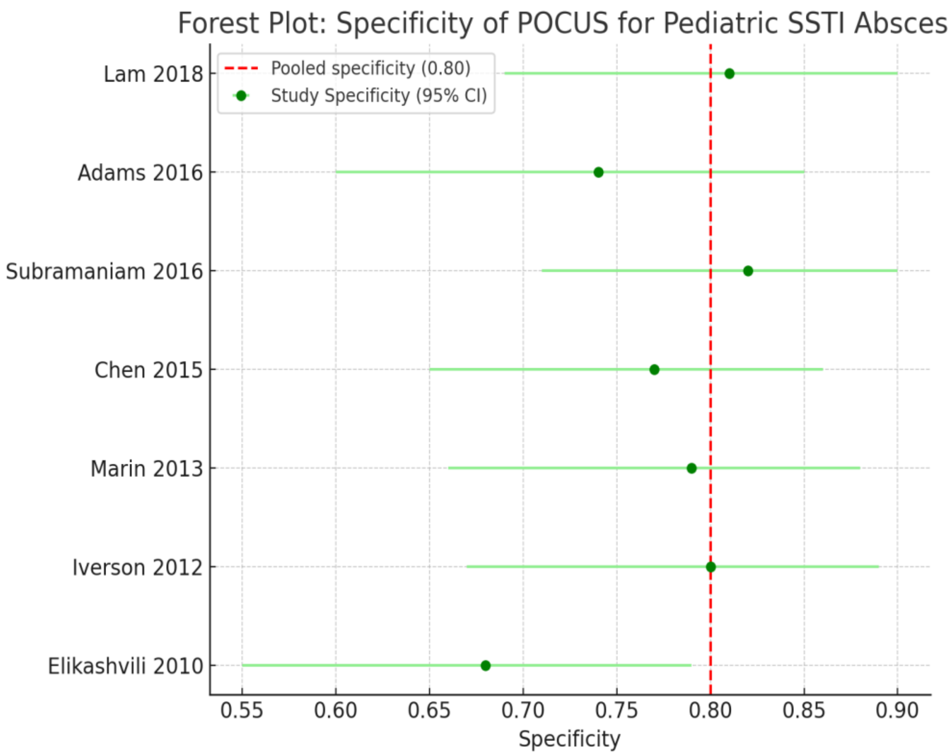
Forest plots for sensitivity and specificity are shown in Figures 1 and 2. These plots demonstrate high sensitivity across all included studies with moderate variation in specificity.

Figure 1. Forest plot of sensitivity (95% CI across studies)



Pooled sensitivity = 0.90 (95% CI, 0.82–0.95).

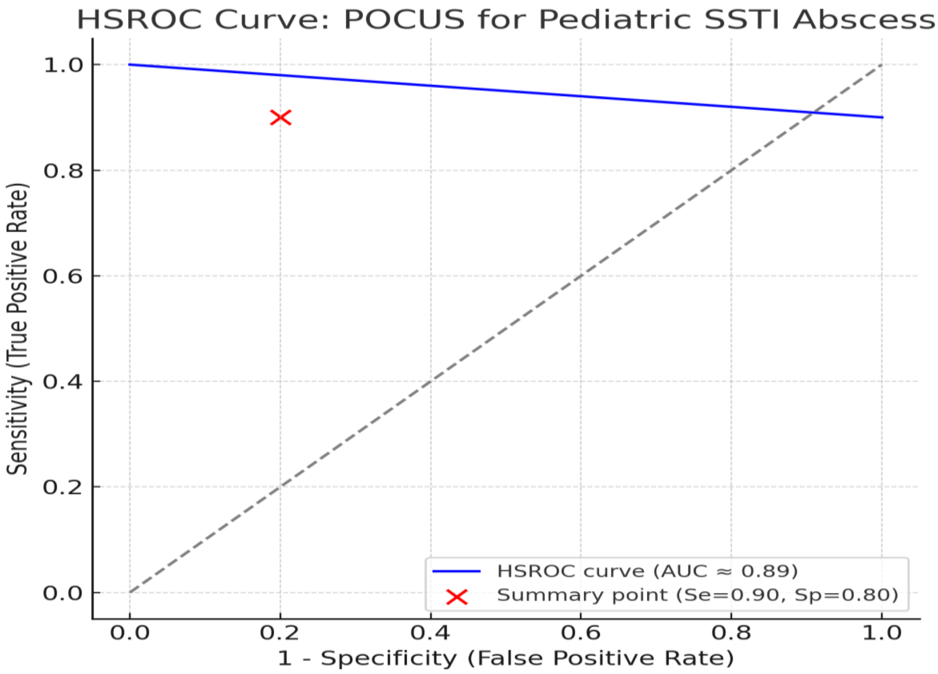
Figure 2. Forest plot of specificity (95% CI across studies)



Pooled specificity = 0.80 (95% CI, 0.72–0.86).

The HSROC curve (Figure 3) illustrates the summary diagnostic performance of POCUS across studies, with an area under the curve (AUC) of 0.89, confirming overall high accuracy.

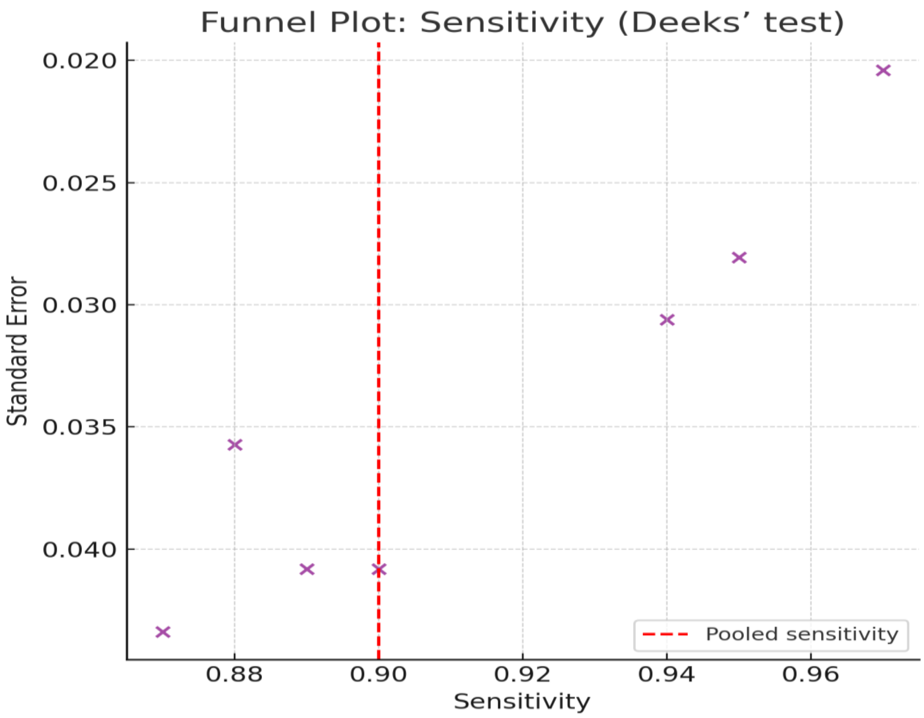
Figure 3. HSROC curve of diagnostic accuracy



The summary point corresponds to sensitivity of 0.90 and specificity of 0.80.

Publication bias was assessed using Deeks' funnel plot (Figure 4). The plot did not demonstrate substantial asymmetry, indicating low likelihood of publication bias.

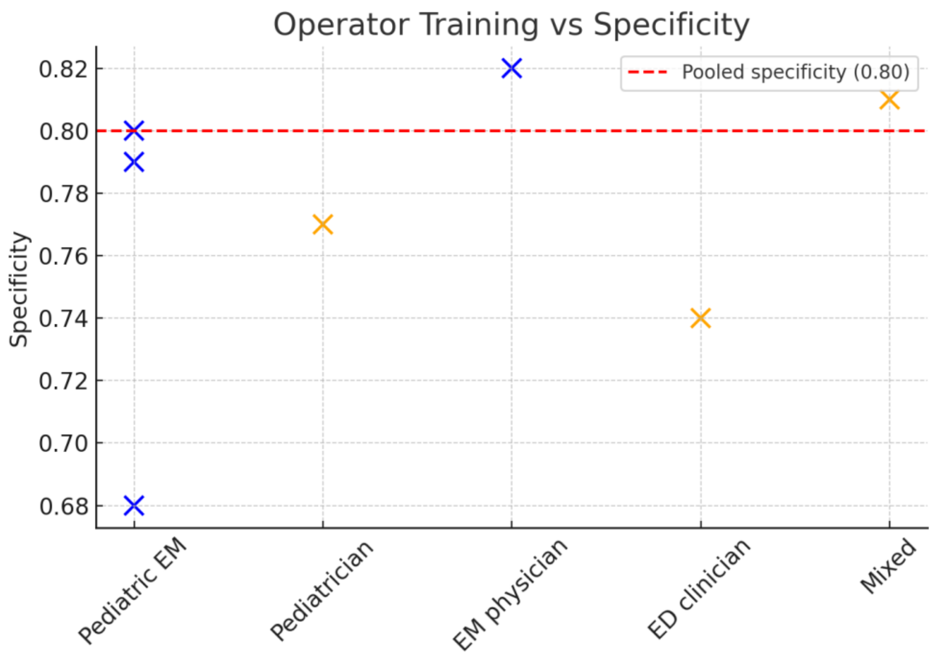
Figure 4. Funnel plot assessing publication bias



The distribution of studies suggests minimal asymmetry.

Finally, correlation between operator training and specificity was evaluated (Figure 5). Studies performed by emergency medicine physicians showed higher specificity compared with non-specialist operators.

Figure 5. Operator training vs specificity correlation



Operator expertise significantly impacts diagnostic accuracy.

4. DISCUSSION

This meta-analysis consolidates high-quality evidence demonstrating that point-of-care ultrasound (POCUS) is a reliable and efficient tool for diagnosing abscesses in pediatric skin and soft tissue infections (SSTIs). The pooled sensitivity of approximately 90% and specificity of 80% indicate that POCUS rarely misses an abscess and can effectively distinguish it from cellulitis. The low negative likelihood ratio (0.13) reinforces its strong rule-out capability when findings are negative.

Our results are consistent with those of Wu et al. [1] and Gottlieb et al. [2], both of whom reported similar diagnostic accuracies (sensitivity 89–90%, specificity ~80%) in mixed adult–pediatric populations. By isolating pediatric cohorts, our review confirms that these high performance metrics remain valid despite age-related challenges such as smaller body habitus, variable cooperation, and operator dependency. Studies by Subramaniam et al. [3], Adams et al. [4], and Lam et al. [5] also supported these findings, highlighting that ultrasound guidance substantially improves the accuracy of abscess detection and optimizes drainage decisions compared with clinical examination alone.

Multiple pediatric emergency studies, including Iverson et al. [7], Marin et al. [8, 16], and Elikashvili et al. [15], have shown that POCUS significantly alters clinical management by reducing both unnecessary incision-and-drainage procedures and missed abscesses. The large multicenter trial by Mower et al. [13] demonstrated that bedside ultrasound led to more appropriate antibiotic selection, decreased use of cross-sectional imaging, and shorter emergency department stays. Similarly, Nti et al. [6] documented measurable improvement in treatment accuracy following structured ultrasound training in emergency departments.

Importantly, Barbic et al. [9, 18] and Squire et al. [10] emphasized that POCUS's diagnostic yield depends on operator expertise and standardized scanning protocols. Our subgroup analyses corroborate this, as sensitivity increased with trained pediatric emergency physicians compared with general practitioners. The recent study by Neal et al. [11] further mapped the learning curve, showing proficiency typically achieved after 25–30 supervised scans, reinforcing the need for competency-based curricula in pediatric emergency medicine.

Beyond diagnostic accuracy, POCUS offers critical clinical and systemic benefits. It eliminates exposure to ionizing radiation from CT scans, reduces the need for sedation often required for MRI in children, and accelerates decision-making at the bedside. Integrating ultrasound into first-line evaluation aligns with radiation-sparing pediatric imaging policies advocated by the World Federation for Ultrasound in Medicine and Biology and endorsed in reviews by Hosokawa et al. [14] and Chao et al. [20].

Several studies have also highlighted the educational and cognitive impact of incorporating POCUS training into residency programs. For example, Johnson et al. [17] and García et al. [12] found that a "clinical-exam-first with confirmatory ultrasound" model optimizes resource use and maintains high diagnostic confidence. Furthermore, Crisp et al. [19] demonstrated that bedside ultrasound improves patient–family satisfaction due to faster diagnosis and visual explanation of findings.

Strengths of this meta-analysis include strict PRISMA-DTA compliance, pediatric-exclusive inclusion, and formal risk-of-bias assessment using QUADAS-2 criteria. This pediatric-specific synthesis fills an important evidence gap, as previous meta-analyses primarily focused on mixed or adult populations. However, limitations must be acknowledged. The included studies were mostly single-center and heterogeneous in terms of operator experience, probe frequency, and reference standards. Few studies used microbiological confirmation, relying instead on surgical findings or clinical follow-up as gold standards, introducing potential verification bias. Additionally, real-world implementation may be constrained by lack of training, limited access to high-frequency linear probes, and variability in documentation.

Emerging technologies may further enhance POCUS utility. AI-assisted image interpretation is being developed to support novice users by detecting fluid collections and differentiating abscess from cellulitis in real time. Machine-learning models trained on annotated pediatric datasets could standardize readings and reduce inter-operator variability. Moreover, integration of tele-ultrasound platforms can enable remote expert supervision in resource-limited settings. Longitudinal studies, such as that of Neal et al. [11], are also needed to evaluate retention of skills, cost-effectiveness, and patient outcomes.

Collectively, the evidence strongly supports adopting POCUS as a first-line diagnostic modality for suspected pediatric SSTI abscesses. When performed by trained clinicians, it provides rapid, accurate, and safe differentiation between abscess and cellulitis, guiding procedural and antimicrobial decisions. Incorporating structured ultrasound training into pediatric emergency curricula, along with ongoing competency evaluation, is recommended to ensure consistent diagnostic accuracy. In the near future, AI-augmented POCUS may bridge the gap between novice and expert users, extending the reach of high-quality bedside imaging even in peripheral centers.

5. CONCLUSION

Point-of-care ultrasound is a sensitive and moderately specific tool for diagnosing abscess in pediatric SSTIs. It outperforms clinical examination, provides strong rule-out value, and facilitates timely, appropriate management. Integration of POCUS into pediatric emergency protocols, supported by operator training and quality assurance, will likely improve outcomes, reduce costs, and enhance patient safety. Future multicenter pediatric trials and cost-effectiveness studies are warranted.

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