RESEARCH ARTICLE

Variation in Proportion of Blood Cultures Obtained for Children With Skin and Soft Tissue Infections

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ABSTRACT

OBJECTIVES: To identify variation in the proportion of blood cultures obtained for pediatric skin and soft tissue infections (SSTIs) among children's hospitals.

METHODS: We conducted a retrospective cohort study using the Pediatric Health Information System database, which we queried for emergency department (ED)–only and hospital encounters between 2012 and 2017 for children aged 2 months to 18 years with diagnosis codes for SSTI. The primary outcome was proportion of SSTI encounters during which blood cultures were obtained. Encounters with and without blood cultures were compared for length of stay, costs, and 30-day ED revisit and readmission rates, adjusted for patient factors and hospital clustering. We also identified encounters with bacteremia using billing codes for septicemia and bacteremia.

RESULTS: We identified 239 954 ED-only and 49 291 hospital SSTI encounters among 38 hospitals. Median proportions of ED-only and hospital encounters with blood cultures were 3.2% (range: 1%– 11%) and 51.6% (range: 25%–81%), respectively. Adjusted ED-only encounters with versus without blood culture had higher costs ($1266 vs $460, $P < .001$), higher ED revisit rates (3.6% vs 2.9%, $P < .001$), and higher admission rates (2.0% vs 0.9%, $P < .001$). Hospital encounters with blood culture had longer length of stay (2.3 vs 2.0 days, $P < .001$), higher costs ($5254 vs $4425, $P < .001$), and higher readmission rates (0.8% vs 0.7%, $P = .027$). The overall proportion of encounters with bacteremia was 0.6% for ED-only encounters and 1.0% for hospital encounters.

CONCLUSIONS: Despite multiple studies in which low clinical value was demonstrated and current Infectious Diseases Society of America guidelines arguing against the practice, blood cultures were obtained frequently for children hospitalized with SSTIs, with substantial variation across institutions. Few bacteremic encounters were identified.

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Skin and soft tissue infections (SSTIs) are common among pediatric patients in both ambulatory and hospital settings, resulting in an estimated 390 000 annual emergency department (ED) visits[1] and being the seventh-most common reason for pediatric hospitalization[2] in the United States. In multiple single-center studies of children with uncomplicated SSTI in the post–*Hemophilus influenzae* vaccine era, researchers have reported low rates of bacteremia, with true-positive rates of 0% to 2.9% and false-positive (contaminant) rates of 0% to 5.4%.[3–7] Current Infectious Diseases Society of America (IDSA) guidelines recommend against routine blood cultures for SSTI cases.[8]

Despite these recommendations, blood cultures are still commonly obtained for pediatric SSTIs, with reported rates of 34% in ED cases,[4] 46% in a combined inpatient and outpatient setting,[6] and 70% to 94% in hospital cases.[3,5,7] The degree of practice variation in obtaining blood culture for cases of SSTI among children's hospitals is uncertain. Less is known about the association of obtaining blood culture with subsequent health care costs and use for SSTI cases. Wathen and Halloran[4] reported higher likelihood of hospitalization for ED cases of SSTI with versus without blood culture. Malone et al[5] and Trenchs et al[7] reported longer length of stay (LOS) among hospitalized children with SSTI with versus without blood culture. To our knowledge, multicenter studies examining these outcomes for children with SSTIs have not been conducted.

In this multicenter study, our aims were (1) to identify the variation in the proportion of blood cultures obtained for pediatric SSTIs among children's hospitals, (2) to assess the association of obtaining blood culture in SSTI cases with health care costs and use, and (3) to measure the proportion of pediatric SSTI encounters with bacteremia.

METHODS

Study Design and Setting

We conducted a retrospective cohort study using the Pediatric Health Information System (PHIS) database (Children's Hospital Association, Lenexa, KS). PHIS is a comparative pediatric database that includes clinical and billing data for all inpatient, observation, ED, and ambulatory surgery encounters for participating children's hospitals. PHIS captures up to 41 *International Classification of Diseases, Ninth Revision* (ICD-9) or *International Classification of Diseases, 10th Revision* (ICD-10) diagnosis codes and up to 41 ICD-9 and ICD-10 procedure codes. All Patient Refined Diagnosis Related Groups (APR-DRG; 3M Health Information System, Minneapolis, MN) are also available for all encounters.

Study Cohort

The PHIS database was queried for encounters in years 2012 through 2017 with APR-DRG 383, "cellulitis and other bacterial skin infections." We chose this APR-DRG as the starting point to focus on children treated for SSTI as the main clinical issue addressed during their ED visit or hospitalization. Index ED-only and hospital encounters were included if patients were aged 2 months to 18 years and if primary or secondary diagnosis contained ICD-9 codes for erysipelas, cellulitis, impetigo, other localized skin infection or superinfection, or matched ICD-10 codes (Supplemental Table 5). Diagnosis codes were assigned at the time of discharge. Encounters were excluded if the patient was transferred in from another facility or received any ICU treatment. Additionally, to only include immunocompetent children, we excluded those with complex chronic conditions (CCCs) involving immunodeficiency, malignancy, or transplant (Supplemental Table 6), identified by using Feudtner methodology version 2.[9] There were 38 children's hospitals with continuous data within PHIS during the study period.

We collected patient demographics, including age, sex, race, number of CCCs (other than those excluded), payer source, and discharge disposition. For hospital encounters, we also collected the assigned APR-DRG severity of illness score and the case mix index as measures of severity.[10]

Outcome Measures

The primary outcome measure was the proportion of blood cultures obtained for SSTI encounters at each hospital, adjusted for hospital-level differences in patient demographics and clinical characteristics. Blood cultures were identified by using billing data in PHIS. Secondary outcomes included hospital costs per encounter (estimated from charges by using each hospital's annual ratio of costs to charges), 30-day all cause ED revisit rate, and 30-day all cause readmission rate. For hospital encounters, we also measured LOS. All secondary outcomes were adjusted for patient demographics, number of CCCs (other than those excluded), and, for hospital encounters, severity of illness and case mix index. Lastly, we identified bacteremia cases by searching encounters for ICD-9 codes for bacteremia (790.7) or septicemia (038.x) and matched ICD-10 codes (Supplemental Table 7).

Analysis and Statistics

ED-only and hospital encounters with versus without blood culture were compared for differences in demographics and clinical characteristics by using χ^2 or Wilcoxon rank-sum tests as appropriate. In unadjusted analyses, outcomes (including encounter costs, rates of 30-day ED revisit, and hospital admission or readmission) were also compared by using these tests. In adjusted analyses, we compared encounters with versus without blood culture using generalized linear mixed effects models with random intercepts for each hospital. Models were adjusted for age, sex, race, payer, count of CCCs, and disposition. Because of the nonnormal distribution of cost, we used an exponential distribution for modeling. All analyses were performed by using SAS version 9.4 (SAS Institute, Inc, Cary, NC), and P values $<.05$ were considered statistically significant. Because of the use of deidentified data, this study was considered exempt from review by the policies of the primary author's institutional review board.

Sensitivity Analysis

To attempt to evaluate for confounding by indication (whereby patients may have had unmeasured variables that affected both the

likelihood of collecting a blood culture and the outcomes measures), we performed the adjusted analysis above on the group of patients without any CCCs and on the group of patients with ≥1 CCC.

Secondary Analysis

To assess for differences between ED-only and hospital encounters on the basis of specific diagnoses of SSTI, ICD-10 diagnoses were separated into 3 broad groups: "cellulitis," "abscess," and "other" (Supplemental Table 8). The secondary analysis was limited to ICD-10 encounters because of increased specificity of ICD-10 diagnosis codes compared with ICD-9 codes and the fact that multiple ICD-10 codes mapped to the same ICD-9 code, which precluded creating a grouping system using both sets of codes. Demographics for ED-only and hospital encounters with versus without blood culture were compared, along with differences in diagnosis groupings.

RESULTS

Patient Characteristics

After exclusions, we identified 239 954 ED-only and 49 291 hospital SSTI encounters among 38 children's hospitals (Supplemental Fig 2). Patient demographics and clinical characteristics are summarized in Table 1. Among both ED-only and hospital encounters, blood cultures were drawn more frequently in those patients who were <1 year of age, male, Hispanic, discharged with home health services, or had ≥1 CCCs. Among hospital encounters, blood cultures were drawn more frequently in patients with higher severity of illness.

TABLE 1 Patient Characteristics for ED-Only and Hospital SSTI Encounters

	ED Only		Inpatient and Observation	
	No Blood Culture	Blood Culture	No Blood Culture	Blood Culture
Encounters, *n* (%)	232 392 (96.9)	7562 (3.2)	23 851 (48.4)	25 440 (51.6)
Age, *n* (%)				
60–364 d	16 476 (95.8)	718 (4.2)	2892 (40.3)	4288 (59.7)
1–5 y	104 882 (97.2)	3026 (2.8)	10 075 (48)	10 920 (52)
6–10 y	55 758 (97)	1704 (3)	4827 (50.6)	4717 (49.4)
11–14 y	29 866 (96.2)	1182 (3.8)	3242 (51.9)	3010 (48.1)
15–18 y	25 410 (96.5)	932 (3.5)	2815 (52.9)	2505 (47.1)
Sex, *n* (%)				
Male	117 163 (96.6)	4099 (3.4)	12 506 (47.4)	13 879 (52.6)
Female	115 223 (97.1)	3463 (2.9)	11 343 (49.5)	11 559 (50.5)
Race, *n* (%)				
Non-Hispanic white	81 271 (96.1)	3288 (3.9)	11 806 (49.7)	11 960 (50.3)
Non-Hispanic African American	76 290 (98)	1557 (2)	5241 (49.2)	5417 (50.8)
Hispanic	53 597 (96.7)	1853 (3.3)	4338 (45.8)	5141 (54.2)
Other	21 234 (96.1)	864 (3.9)	2466 (45.8)	2922 (54.2)
Payer, *n* (%)				
Government	161 210 (97.3)	4540 (2.7)	15 040 (48.3)	16 081 (51.7)
Private	64 696 (95.8)	2842 (4.2)	8074 (48.1)	8721 (51.9)
Other	6486 (97.3)	180 (2.7)	737 (53.6)	638 (46.4)
Disposition, *n* (%)				
Home health	44 (95.7)	2 (4.3)	107 (40.1)	160 (59.9)
Home	228 263 (97.2)	6534 (2.8)	23 520 (48.3)	25 141 (51.7)
Other	3550 (81.1)	826 (18.9)	140 (58.3)	100 (41.7)
Skilled facility	535 (72.8)	200 (27.2)	84 (68.3)	39 (31.7)
CCC count, *n* (%)				
0	229 179 (96.9)	7226 (3.1)	22 267 (49)	23 180 (51)
1	2765 (90.6)	287 (9.4)	1222 (43)	1618 (57)
2	372 (91)	37 (9)	259 (37.1)	439 (62.9)
3+	76 (86.4)	12 (13.6)	103 (33.7)	203 (66.3)
APR-DRG severity of illness, *n* (%)				
Minor	—	—	19 322 (51)	18 573 (49)
Moderate	—	—	4084 (40.9)	5909 (59.1)
Major	—	—	426 (32.9)	868 (67.1)
Extreme	—	—	19 (17.4)	90 (82.6)

P values for all comparisons are <.001. —, not applicable.

Proportion of Blood Cultures Obtained

The adjusted median hospital-level proportion of blood culture was 3% (interquartile range [IQR]: 2–5) for ED-only SSTI encounters and 51% (IQR: 43–61) for hospital SSTI encounters. There was substantial variation in the proportion of blood cultures obtained among institutions for ED-only (range: 1%–11%) and hospital (range: 25%–81%) encounters (Fig 1).

Secondary Outcomes

In unadjusted analysis, ED-only encounters with versus without blood culture had higher median costs ($925 vs $260, $P <$ .001), 30-day ED revisit rate (4.9% vs 4.2%, $P = .006$), and 30-day admission rate (2.8% vs 1.1%, $P < .001$). Unadjusted hospital encounters with versus without blood culture had longer LOS (1.9 vs 1.6 days, $P < .001$), higher median costs ($4030 vs $3291, $P < .001$), and a higher 30-day readmission rate (1.3% vs 1%, $P = .019$), although 30-day ED revisit rates were not different (1.5% vs 1.4%, $P = .54$).

In adjusted analysis, ED-only encounters with versus without blood culture had higher median costs and higher odds of 30-day ED revisit and 30-day admission (Table 2). Hospital encounters with blood culture had longer LOS, higher median hospital costs, and higher odds of 30-day readmission (Table 2).

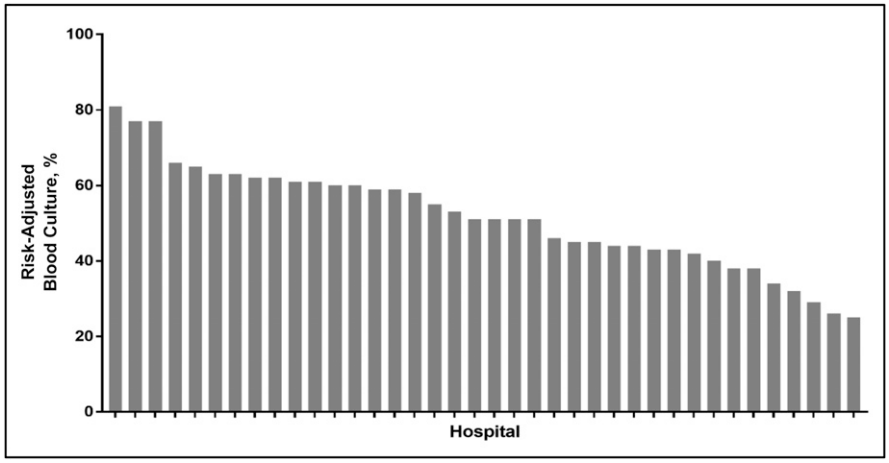

FIGURE 1 Proportion of inpatient and observation SSTI encounters with blood cultures obtained by institution, adjusted for demographics, number of CCCs, and severity of illness.

In adjusted analysis for patients with and without ≥1 CCCs, results were largely unchanged for those with no CCCs compared with the entire cohort, with the exception that the difference in readmission rates for hospital encounters was no longer statistically significant (Table 3).

Proportion of Encounters With Bacteremia

We identified 47 out of 7622 (0.6%, 95% confidence interval [CI]: 0.4%–0.8%) ED-only encounters with blood cultures drawn that also had codes for bacteremia and septicemia. We identified 266 out of 25 440 (1.0%, 95% CI: 0.9%–1.2%) hospital encounters with blood cultures drawn that had codes for bacteremia and septicemia. The median proportion of bacteremic episodes identified for hospital encounters was 1.0% (IQR: 0.6–1.5), although the median proportion ranged from 0.1% to 4.3% across institutions.

Patient factors associated with bacteremia included younger age (60–364 days), discharge with home health services, and presence of 3 or more CCCs (Supplemental Table 9).

Secondary Analysis

The patient characteristics and breakdown of diagnosis groupings for ICD-10 ED-only and hospital encounters are summarized in Table 4. The ED-only encounters had principal diagnoses of 40.7% cellulitis, 27.8% abscess, and 31.4% other, whereas hospital encounters separated into 61.7% cellulitis, 32.8% abscess, and 5.5% other categories.

The most frequent specific diagnoses in the cellulitis category for both ED-only and hospital encounters were cellulitis of limbs and face. The most frequent diagnosis in the abscess category in both groups was "cutaneous abscess of buttocks." The most frequent diagnosis in the other category in both groups was "impetigo," although this was much more frequently diagnosed in ED-only (21.2%) compared with hospital (1.3%) encounters.

DISCUSSION

In our multicenter study, half of children hospitalized for SSTIs had blood cultures drawn, and there was substantial variation across children's hospitals in the proportion of blood cultures obtained. Blood cultures were drawn much less frequently for SSTI cases treated only in the ED setting but still with significant variation across institutions. Encounters with versus without blood cultures had significantly higher adjusted health care use, with higher costs and ED revisit and admission rates for ED encounters and higher costs, LOS, and readmission rates for hospital encounters. The proportion of SSTI encounters with bacteremia was ≤1% in both ED and hospital settings.

The overall high proportion of blood cultures obtained for hospital SSTI encounters is somewhat surprising, given that both the 2014 and 2005 IDSA guidelines recommended against the practice in most patients.[8,11] The finding is, however, consistent with previous single-center studies published during or after the years included in our study, in which researchers also reported high proportions of SSTI encounters with blood cultures.[4–7] The high degree of variation in proportion of blood cultures obtained also suggests that local and institutional factors play an important role at the individual hospital level and are a good target for local quality improvement efforts.[12] In studies of other disease processes, including bronchiolitis[13] and asthma,[14] researchers have reported high proportions of low-value practice with high

TABLE 2 Adjusted Outcomes for ED-Only and Hospital SSTI Encounters With Versus Without Blood Culture

	ED Only			Inpatient and Observation		
	No Blood Culture, n = 232 392	Blood Culture, n = 7562	P	No Blood Culture, n = 23 851	Blood Culture, n = 25 440	P
LOS in d, mean (95% CI)	Not for ED	Not for ED	Not for ED	2.0 (1.8–2.2)	2.3 (2.1–2.5)	<.001
Hospital costs in $, mean (95% CI)	459.5 (395.2–523.8)	1266.0 (1087.4–1444.6)	<.001	4424.7 (3871.8–4977.6)	5253.6 (4597.4–5909.8)	<.001
30-d ED revisit, % (95% CI)	2.9 (1.3–4.5)	3.6 (1.8–5.4)	<.001	1.2 (0.4–2)	1.2 (0.4–2)	.580
30-d readmission, % (95% CI)	0.9 (0–2.7)	2.0 (0–5.7)	<.001	0.7 (0–1.5)	0.8 (0–1.8)	.027

TABLE 3 Sensitivity Analysis: Adjusted Outcomes for ED-Only and Hospital SSTI Encounters With Versus Without Blood Culture, Performed in Patients With No CCCs and With 1 or More CCCs

	ED Only			Inpatient and Observation		
	No Blood Culture	Blood Culture	*P*	No Blood Culture	Blood Culture	*P*
No CCCs	*n* = 229 179	*n* = 7226	—	*n* = 22 267	*n* = 23 180	—
LOS in d, mean (95% CI)	Not for ED	Not for ED	Not for ED	1.9 (1.7–2.1)	2.2 (2–2.4)	<.001
Hospital costs in $, mean (95% CI)	382.1 (333.5–430.7)	1057.7 (921.7–1193.7)	<.001	3949 (3466.6–4431.4)	4656.5 (4087.3–5225.7)	<.001
30-d ED revisit, % (95% CI)	3.3 (1.9–4.7)	4.1 (2.5–5.7)	<.001	1.3 (0.5–2.1)	1.4 (0.6–2.2)	.761
30-d readmission, % (95% CI)	0.7 (0–1.9)	1.6 (0–4.5)	<.001	0.7 (0–1.7)	0.8 (0–1.8)	.060
One or more CCC	*n* = 3213	*n* = 336	—	*n* = 1584	*n* = 2260	—
LOS in d, mean (95% CI)	Not for ED	Not for ED	Not for ED	2.3 (2.1–2.5)	2.8 (2.6–3)	<.001
Hospital costs in $, mean (95% CI)	485.3 (431.6–539)	1124.4 (954.9–1293.9)	<.001	5272.4 (4713.4–5831.4)	6507.1 (5840.9–7173.3)	<.001
30-d ED revisit, % (95% CI)	3.1 (2.3–3.9)	2.9 (1.1–4.7)	.897	0.1 (0–30.5)	0.1 (0–36.2)	.528
30-d readmission, % (95% CI)	0.2 (0–22.2)	0.3 (0–37.9)	.140	1.0 (0.4–1.6)	1.3 (0.7–1.9)	.0293

—, not applicable.

institutional variation despite evidence-based practice guidelines.

The overall low rate of blood culture obtainment in ED-only settings can be partially understood by differences observed in diagnoses, for example, the much higher ED incidence of encounters for impetigo, a condition unlikely to be associated with bacteremia and thus unlikely to be evaluated with blood culture. Additionally, although we attempted to adjust for clinical factors such as number of CCCs, there are a number of unmeasured factors, such as extent of infected tissue, degree of lymphangitis, or ability to tolerate oral medications, that may have influenced both blood culture and hospitalization rates.

The higher health care use associated with encounters with versus without blood culture may be due to increased direct costs of cultures and indirect costs of associated interventions, such as other blood testing and intravenous medications. Other potential contributors to higher costs include downstream effects of the blood cultures. In many of the single-center SSTI studies, false-positive culture results were more frequent than true-positive culture results.[3–5,7] Murofushi et al[15] studied the economic impact of false-positive blood culture results obtained in an ED setting and reported that 75% of cases had associated adverse events, including ED revisits, unnecessary admissions, and additional testing. Thus, some of the higher ED revisit rates we observed in those with versus without blood culture could have been attributable to false-positive culture results. Conversely, the lower ED revisit rate in those without blood culture suggests that there were not widespread adverse consequences from missed bacteremia.

With our retrospective study design, it is certainly possible that the higher health care use we observed in those patients with blood cultures was due to confounding by indication. For example, unmeasured differences in illness severity or patient complexity could have contributed to both the higher rate of blood culture and higher health care use. In our sensitivity analysis, removing patients with CCCs did not significantly affect the outcomes, which argues against at least the medical complexity captured in CCCs being a major source of confounding.

It should also be noted that in the adjusted analysis, some of the statistically significant differences in outcomes we identified in patients with versus without blood culture, such as the 0.7% absolute difference in ED revisits for ED encounters or the 0.1% difference in readmission rate for hospital encounters, are of questionable clinical significance. But other outcomes we identified, such as significantly higher costs and a 0.3 day longer LOS for hospital encounters, are certainly clinically relevant. And given that the single-center studies of blood cultures and SSTIs have reported that even true-positive blood cultures resulted in no changes in clinical management,[3,6,7] any increase in health care use associated with blood cultures means their use in SSTI cases is likely exposing patients to unnecessary costs and harms.

Our median proportion of 50% of blood cultures obtained for hospital encounters was lower than most previous single-center studies, in which researchers reported proportions of 70% to 94%.[3,5,7] As noted above, however, the variation by institution in our study was high, with multiple children's hospitals having rates of blood culture similar to those reported in the previous studies, suggesting a strong role for institutional culture in determining practice. The proportion of blood cultures obtained for ED encounters (3%) was much lower than the 34% reported in the ED-based single-center study by Wathen and Halloran.[4] A significant difference between their study cohort and ours is that although the Wathen study was based in an ED, 36% of patients were subsequently admitted, and the authors report that hospitalization was strongly associated with likelihood of blood culture.

In several previous single-center studies, researchers have reported higher health care use among SSTI encounters with versus without blood culture, similar to our findings. Malone et al[5] and Trenchs et al[7] reported an ∼1 day longer LOS in SSTI patients with blood culture. Wathen and Halloran[4] reported that ED encounters with

TABLE 4 Secondary Analysis, Patient Characteristics for ED-Only and Hospital *ICD-10* SSTI Encounters With Diagnosis Groupings

	ED Only		Inpatient and Observation	
	No Blood Culture	Blood Culture	No Blood Culture	Blood Culture
Encounters, *n* (%)	89 562 (97.2)	2600 (2.8)	7929 (52.4)	7216 (47.7)
Age, *n* (%)				
60–364 d	6180 (96.5)	221 (3.5)	877 (43.9)	1122 (56.1)
1–5 y	38 786 (97.5)	1000 (2.5)	3229 (52.1)	2966 (47.9)
6–10 y	22 614 (97.4)	602 (2.6)	1733 (54.4)	1450 (45.6)
11–14 y	12 001 (96.3)	461 (3.7)	1111 (53.9)	951 (46.1)
15–18 y	9981 (96.9)	316 (3.1)	979 (57.4)	727 (42.6)
Sex, *n* (%)				
Male	45 952 (97)*	1402 (3)*	4190 (51.4)†	3968 (48.6)†
Female	43 607 (97.3)	1198 (2.7)	3739 (53.5)	3248 (46.5)
Race, *n* (%)				
Non-Hispanic white	30 864 (96.4)	1158 (3.6)	3911 (54.1)	3313 (45.9)
Non-Hispanic African American	28 626 (98.2)	513 (1.8)	1663 (53.7)	1431 (46.3)
Hispanic	21 972 (97.1)	663 (2.9)	1498 (48.1)	1615 (51.9)
Other	8100 (96.8)	266 (3.2)	857 (50)	857 (50)
Payer, *n* (%)				
Government	61 199 (97.6)	1513 (2.4)	4917 (52)‡	4531 (48)‡
Private	25 281 (96.1)	1014 (3.9)	2742 (52.4)	2491 (47.6)
Other	3082 (97.7)	73 (2.3)	270 (58.2)	194 (41.8)
Disposition, *n* (%)				
Home health	9 (100)	0	32 (47.8)	35 (52.2)
Home	88 722 (97.6)	2181 (2.4)	7806 (52.2)	7135 (47.8)
Other	615 (61.2)	390 (38.8)	28 (51.9)	26 (48.1)
Skilled facility	216 (88.2)	29 (11.8)	63 (75.9)	20 (24.1)
CCC count, *n* (%)				
0	88 253 (97.3)	2467 (2.7)	7342 (53.2)	6457 (46.8)
1	1138 (90.8)	115 (9.2)	433 (44.9)	532 (55.1)
2	143 (91.7)	13 (8.3)	115 (43.2)	151 (56.8)
3+	28 (84.8)	5 (15.2)	39 (33.9)	76 (66.1)
APR-DRG severity of illness, *n* (%)				
Minor	—	—	6481 (54.8)	5339 (45.2)
Moderate	—	—	1270 (45.4)	1528 (54.6)
Major	—	—	166 (35.1)	307 (64.9)
Extreme	—	—	12 (22.2)	42 (77.8)
Diagnosis group, *n* (%)				
Cellulitis	35 859 (95.4)	1733 (4.6)	4633 (49.5)	4719 (50.5)
Abscess	24 963 (97.5)	651 (2.5)	2860 (57.6)	2101 (42.4)
Other	28 740 (99.3)	216 (0.7)	436 (52.4)	396 (47.6)

P values for all comparisons are <0.001, with the exceptions noted. —, not applicable.
* $P = .03$, † $P = .008$, ‡ $P = .04$.

versus without blood culture had higher likelihood of complete blood count and hospitalization. We are unaware of previous studies in which researchers examine ED revisit or hospital readmission rates.

The proportion of bacteremia episodes we identified in both ED and hospital encounters (0.6% and 1.0%, respectively) was low and within the range of rates of true-positive blood culture results obtained in single-center studies (0%–2.9%).[3–7] In the previous studies, researchers used much smaller patient cohorts of 300 to 500 patients and were thus subject to a much bigger effect on percentages from any positive culture results. One limitation of our methodology is that we are unable to determine if the positive blood culture results we identified were true- versus false-positives because we used ICD-9 and ICD-10 codes, for which there are no codes for false-positive or contaminant cultures. If we assume that some of the positive blood culture results we identified were false-positives, our proportions of 0.6% and 1% would be low compared with previous studies, given reported contaminant rates of 0% to 5.4%.[3–7]

Additionally, we should note that the accuracy of diagnostic codes for bacteremia has not been extensively validated in children. Foradori et al,[16] as part of their investigation of invasive bacterial infections in infants <60 days with SSTI using the PHIS database, examined 10% of their study cohort by chart review for validation of the diagnoses of invasive infections, including bacteremia. They identified no cases of missed invasive infection among 279 patients, although the positive predictive value was only 27% because of high rate of contaminant specimens. Wiese et al[17] performed a validation study of diagnostic codes for serious infections among older adults receiving Medicaid in Tennessee. They reported a positive predictive value of 82.6% for the combined outcome of bacteremia and sepsis, although they did not separate out the 2 categories. Gradel et al[18] performed a validation study of ICD-10 codes for bacteremia within a national patient registry in Denmark and reported correct identification of 64.9% of bacteremia cases. Thus, although these populations are different from those we studied, it is certainly possible we missed some cases of true bacteremia with our methodology. As noted above, however, in previous studies, the identification of bacteremia did not result in changes in management.[3,6,7] So even a modest underestimate of the rate of bacteremia would not significantly impact the clinical utility of obtaining blood cultures for SSTI in

most children. Blood culture results are thus most important in the context that fear of missed bacteremia is a likely driver of obtaining cultures for some providers. It is our hope that a multicenter study reporting low proportions of bacteremia will re-enforce current guidelines and spur further quality improvement efforts to dispense with routine blood cultures for uncomplicated pediatric SSTIs.

Our study has several limitations. Given the retrospective design, we are unable to determine causation for any identified associations, such as the higher health care use for encounters with versus without blood cultures. The use of administrative data is potentially subject to errors in coding or retrieving information in the database and may not contain all clinically relevant features that could influence the outcomes we measured. For example, we were unable to determine the patient temperature or extent and severity of skin involvement during the encounter, factors likely to influence blood culture obtainment. Similarly, we are unable to account for initial diagnostic uncertainty (ie, concern for osteoarticular infections) that may have prompted a blood culture order. Additionally, for hospital encounters, we are unable to determine if blood cultures were obtained in the ED or on the ward, potentially limiting the ability of institutions to focus quality improvement efforts. Lastly, as mentioned above, we are unable to determine the true- versus false-positive blood culture rates with our methodology using ICD-9 and ICD-10 codes to identify bacteremia and may have over- or underestimated the true rate of bacteremia.

CONCLUSIONS

The results of our large multicenter study highlight that blood culture remains a commonly performed test among children with uncomplicated SSTIs, despite current IDSA guidelines recommending against the practice. Areas for potential further study include broad quality improvement efforts to decrease routine use of blood cultures in pediatric SSTIs, identification of other patient factors predictive of bacteremia in SSTI, and validation of methods for identifying bacteremia using administrative data sets.

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