PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Management of Febrile Neonates in US Pediatric Emergency Departments

Shabnam Jain, John Cheng, Elizabeth R. Alpern, Cary Thurm, Lisa Schroeder, Kelly Black, Angela M. Ellison, Kimberly Stone and Evaline A. Alessandrini

Pediatrics; originally published online January 27, 2014;
DOI: 10.1542/peds.2013-1820

Management of Febrile Neonates in US Pediatric Emergency Departments

AUTHORS: Shabnam Jain, MD, MPH,[a] John Cheng, MD,[a] Elizabeth R. Alpern, MD, MSCE,[b] Cary Thurm, PhD,[c] Lisa Schroeder, MD,[d] Kelly Black, MD, MSc,[e] Angela M. Ellison, MD, MSc,[f] Kimberly Stone, MD, MS, MA,[g] and Evaline A. Alessandrini, MD, MSCE[h]

[a]Emory University and Children's Healthcare of Atlanta, Atlanta, Georgia; [b]Lurie Children's Hospital of Chicago, Chicago, Illinois; [c]Children's Hospital Association, Overland Park, Kansas; [d]Children's Mercy Hospital, Kansas City, Missouri; [e]Sanford Children's Hospital, Sioux Falls, South Dakota; [f]Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; [g]University of Washington School of Medicine and Seattle Children's Hospital, Seattle, Washington; and [h]Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

KEY WORDS

neonate, fever, emergency department

ABBREVIATIONS

CI—confidence interval
CSF—cerebrospinal fluid
ED—emergency department
ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*
IQR—interquartile range
NEC—not elsewhere classified
NOS—not otherwise specified
PED—pediatric emergency department
PHIS—Pediatric Health Information System
SI—serious infection

(Continued on last page)

WHAT'S KNOWN ON THIS SUBJECT: Recommended management of febrile neonates (≤28 days) includes blood, urine, and cerebrospinal fluid cultures with hospital admission for antibiotic therapy. No study has reported adherence to standard recommendations in the management of febrile neonates in US pediatric emergency departments.

WHAT THIS STUDY ADDS: There is wide variation in adherence to recommended management of febrile neonates. High rates of serious infections in admitted patients but low return rates for missed infections in discharged patients suggest additional studies needed to understand variation from current recommendations.

abstract

FREE

BACKGROUND: Blood, urine, and cerebrospinal fluid cultures and admission for antibiotics are considered standard management of febrile neonates (0–28 days). We examined variation in adherence to these recommendations across US pediatric emergency departments (PEDs) and incidence of serious infections (SIs) in febrile neonates.

METHODS: Cross-sectional study of neonates with a diagnosis of fever evaluated in 36 PEDs in the 2010 Pediatric Health Information System database. We analyzed performance of recommended management (laboratory testing, antibiotic use, admission to hospital), 48-hour return visits to PED, and diagnoses of SI.

RESULTS: Of 2253 neonates meeting study criteria, 369 (16.4%) were evaluated and discharged from the PED; 1884 (83.6%) were admitted. Recommended management occurred in 1497 of 2253 (66.4%; 95% confidence interval, 64.5–68.4) febrile neonates. There was more than twofold variation across the 36 PEDs in adherence to recommended management, recommended testing, and recommended treatment of febrile neonates. There was significant variation in testing and treatment between admitted and discharged neonates ($P < .001$). A total of 269 in 2253 (11.9%) neonates had SI, of whom 223 (82.9%; 95% confidence interval, 77.9–86.9) received recommended management.

CONCLUSIONS: There was wide variation across US PEDs in adherence to recommended management of febrile neonates. One in 6 febrile neonates was discharged from the PED; discharged patients were less likely to receive testing or antibiotic therapy than admitted patients. A majority of neonates with SI received recommended evaluation and management. High rates of SI in admitted patients but low return rates for missed infections in discharged patients suggest a need for additional studies to understand variation from the current recommendations. *Pediatrics* 2014;133:187–195

Febrile neonates (aged ≤28 days) are a high-risk group for serious infections (SIs) because of increased susceptibility to infections, difficulty with discriminatory clinical examination, and poor outcomes if not diagnosed or treated promptly. Therefore, most studies on evaluation and treatment of febrile young infants place neonates in a separate category.[1–5] Widely followed guidelines recommend a complete evaluation of febrile neonates, even if well appearing, for SIs and admission to the hospital for presumptive antibiotics.[6] A few authors have attempted to define low-risk criteria for treating these patients less conservatively.[7–9] A recent study of febrile neonates concluded that low-risk criteria are not sufficiently reliable to exclude the presence of SIs in febrile neonates in any age category under 28 days.[10] They recommend that all febrile neonates ≤28 days of age should therefore be hospitalized, undergo a full sepsis evaluation, and receive empirical intravenous antibiotic therapy. Garcia et al[11] evaluated whether 15 days was an appropriate cutoff for considering SI in the management of febrile neonates and concluded that febrile neonates 15 to 21 days of age had a rate of serious bacterial infection similar to that of younger infants and higher than that of older infants. Currently, widely cited practice guidelines recommend that evaluation of febrile neonates include a complete blood count, blood culture, urinalysis, urine culture, cerebrospinal fluid (CSF) studies (glucose, protein, cell count, Gram stain), and CSF culture.[6] Chest radiographs are not routinely recommended, although they are included in some criteria.[3] These guidelines also recommend that after a sepsis evaluation, febrile neonates be hospitalized for parenteral antibiotic therapy pending culture results.[6]

Management of febrile neonates is 1 of 60 quality measures recommended by a multidisciplinary stakeholder panel for emergency departments (EDs) caring for children.[12] Studies on variation and adherence to existing practice guidelines for evaluation and management of fever in young infants have been limited to surveys or adherence to recommended urine testing or have excluded neonates 0–28 days of age.[13–15] Belfer et al[16] conducted a survey-based study on compliance with guidelines for the management of febrile infants and found 54% compliance among pediatric emergency medicine directors. To our knowledge, no large multi-institutional study has reported actual practice for the management of febrile neonates in terms of variation and adherence to standard recommendations in pediatric emergency departments (PEDs) in the United States. The objectives for this study were to study variation in management of febrile neonates across US PEDs and report adherence to recommended practice; describe current practices in the management of febrile neonates, comparing admitted and discharged neonates; and describe the incidence of SI in febrile neonates in this cohort.

METHODS

Setting

Data for this retrospective cohort analysis were obtained from the Pediatric Health Information System (PHIS), an administrative database that contains inpatient, PED, ambulatory surgery, and observation data from pediatric hospitals in the United States. These hospitals are affiliated with the Children's Hospital Association, a business alliance of 44 North American freestanding children's hospitals. Contributing hospitals are located in 17 of the 20 major metropolitan areas and represent 85% of freestanding children's hospitals in the United States.[17] For the purposes of external benchmarking, participating hospitals provide demographics, procedures, resource utilization data (eg, pharmaceuticals, imaging, and laboratory), and *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnoses. Data are deidentified at the time of submission, but study identification numbers allow tracking of a patient across multiple visits to the same hospital.[18] Data are subjected to a number of reliability and validity checks before being included in the database. We excluded 8 PHIS hospitals because of incomplete data or data with quality problems. This research, using deidentified data sets, was not considered human subjects research in accordance with the Common Rule (45 CFR§46.104[f]) and the policies of Emory University and Children's Healthcare of Atlanta.

Study Population

We identified patients 0 to 28 days old evaluated in the PED at participating hospitals during calendar year 2010 with a diagnosis of fever, by using the following ICD-9-CM diagnosis codes: 780.6 (Fever and other physiologic disturbances of temperature regulation), 778.4 (Other disturbances of temperature regulation of newborn), 780.60 (Fever, unspecified), or 780.61 (Fever presenting with conditions classified elsewhere). Patients who were transferred to the PED from a different institution or had a previous visit to the PED within 48 hours (for a nonfebrile diagnosis) were excluded, because it was not possible to determine whether the subject had previous evaluations that would influence decisions about management at the current visit. In addition, patients with missing ED disposition or admission to ambulatory surgery were also excluded.

For each patient, the following data were evaluated: laboratory tests (blood, urine, and CSF cultures, both individually and in combinations) and chest radiographic studies performed, antibiotics given, diagnoses of SI (ICD-9-CM codes for included SIs listed in Table 1), disposition (admission to inpatient or observation status or discharge from ED), and whether there was a return visit within 48 hours. Because data are captured within PHIS by hospital day, to capture the ED management of eligible subjects whose ED evaluation crossed midnight, we included data within 2 calendar days of the ED presentation. Therapeutic evaluations examined included parenteral antibiotic treatment with ampicillin, gentamicin, or third-generation cephalosporin combinations. Process measures collected and their definitions were as follows:

- Recommended testing: performance of all 3 of blood, urine, and CSF cultures
- Recommended treatment: antibiotic therapy with a combination of ampicillin with a third-generation cephalosporin or gentamicin
- Recommended management: performance of recommended laboratory evaluation, treatment, and hospital admission

Outcome Data

To identify diagnoses for inclusion as SI, all diagnoses (primary and secondary) of patients meeting inclusion criteria were reviewed; invasive or life-threatening infections were considered SIs. Thus SIs included bacterial infections (based on organism identified in diagnosis, or those that are typically treated as bacterial illnesses in a neonate, such as pneumonia or cellulitis) and also invasive viral infections such as meningitis (Table 1).

We evaluated return visits to the ED within 2 days of an index ED visit to identify ultimate diagnosis and disposition (discharge or admission) on return.

Statistical Analysis

Statistical analysis was carried out using SAS software (version 9.3; SAS Institute, Inc, Cary, NC). Continuous variables were described as median and interquartile range (IQR). Categorical variables are expressed as proportions with confidence intervals (CIs) and were compared using χ^2 or Fisher exact tests. Variation between hospital rates was assessed using a generalized mixed model to test covariance parameters based on the residual pseudolikelihood (null hypothesis was no hospital random effects). The level of significance was set at .001 because of the size of the population.

RESULTS

A total of 41 890 neonates 0 to 28 days of age were seen at the PEDs of 36 participating PHIS hospitals in 2010; 2470 had an inclusionary ICD-9-CM fever diagnosis code. A total of 217 (8.8%) neonates were excluded; the remaining 2253 neonates formed the study cohort (Fig 1). Table 2 shows demographic features of the study cohort. The median age of patients was 18 days, 53% were male, and 62% had Medicaid as their insurance. Three hundred sixty-nine (16.4%) infants were seen and discharged from the ED, and the remaining 1884 (83.6%) were evaluated and admitted to the hospital.

Figure 2 shows variation in recommended testing, treatment, and management in the study population. Of the neonates with fever, 72.9% (95% CI, 71.1–74.7) received recommended testing; this ranged from 38.9% to

TABLE 1 List of Diagnoses Considered as SIs in Neonates With Fever (ICD-9-CM code in parentheses)

Acute pyelonephritis NOS (590.10)	*Haemophilus influenzae* infection NOS (041.5)	Pneumonia organism NOS (486)
Arm cellulitis (682.3)	Herpes simplex meningoencephalitis (054.3)	*Pseudomonas* infection NOS (041.7)
Bacteremia (790.7)	Inflammatory breast disease (611.0)	Pyelonephritis NOS (590.80)
Bacterial infection NEC (0418.9)	Influenza with pneumonia (487.0)	Renal/perirenal abscess (590.2)
Bacterial infection NOS (041.9)	*Klebsiella pneumoniae* infection (041.3)	*Staphylococcus aureus* infection (041.11)
Bacterial meningitis NOS (320.9)	Leg cellulitis (682.6)	*Salmonella* meningitis (003.21)
Bacterial pneumonia NOS (482.9)	Lung abscess (513.0)	*Salmonella* septicemia (003.1)
Buttock cellulitis (682.5)	Meningitis NOS (322.9)	Sepsis (995.91)
Cellulitis NEC (682.8)	MRSA (041.12)	Septic shock (785.52)
Congenital pneumonia (770.0)	MRSA septicemia (038.12)	Severe sepsis (995.92)
Escherichia coli infection NOS (041.4)	Newborn bacteremia (771.83)	Shock without trauma NEC (785.59)
Encephalitis/myelitis/EM NOS (323.9)	Newborn infective mastitis (771.5)	Streptococcal infection NEC (041.09)
Eyelid abscess (373.13)	Newborn omphalitis (771.4)	Streptococcal meningitis (320.2)
Face cellulitis (682.0)	Newborn septicemia (771.81)	Trunk cellulitis (682.2)
Gram-negative meningitis NEC (320.82)	Newborn urinary tract infect (771.82)	Urinary tract infection NOS (599.0)
Gram-negative bacterial infection NEC (041.85)	Orbital cellulitis (376.01)	Viral meningitis NEC (047.8)
Group B strep infection (041.02)	Other bacterial meningitis (320.89)	Viral meningitis NOS (047.9)
Group D strep infection (041.04)	Other staph infection (041.19)	

EM, encephalomyelitis; MRSA, methicillin resistant staphylococcus aureus.

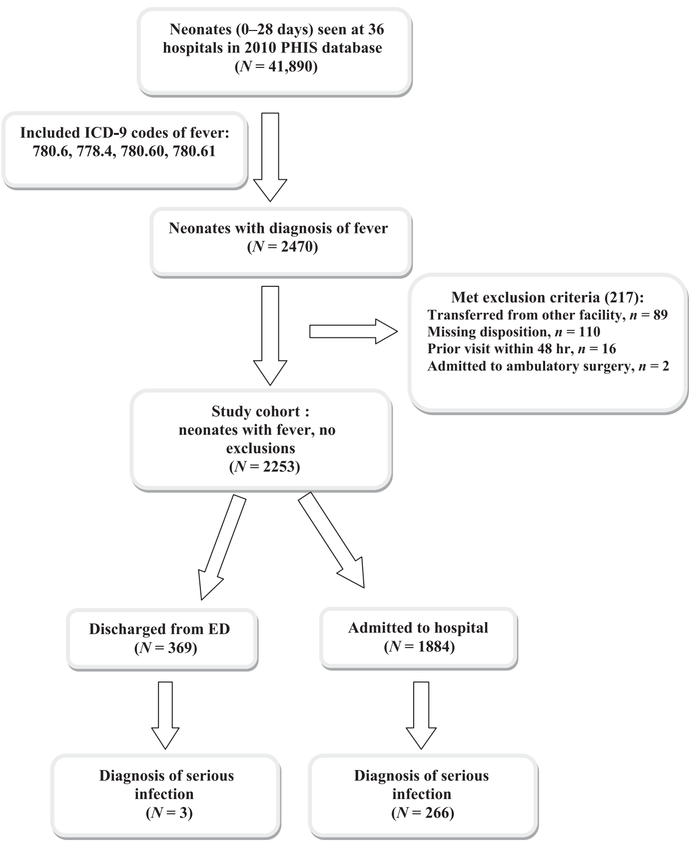

FIGURE 1
Derivation of study population of febrile neonates seen in 2010 at 36 pediatric EDs.

90.2%, showing a more than twofold variation across the 36 PEDs. Recommended treatment was provided to 79.4% (95% CI, 77.7–81.0) of febrile neonates, ranging from 38.9% to 100%, again showing a more than twofold variation across PEDs. Tables 3 and 4 show various combinations of testing (blood, urine, CSF) and treatment performed in the study population. Recommended testing varied significantly between discharged (8.4%; 95% CI, 6.0–11.7) and admitted neonates (85.6%; 95% CI, 83.9–87.1) ($P < .0001$). Recommended treatment also varied significantly between discharged neonates (3.2%; 95% CI, 1.9–5.6) and admitted neonates (94.4%; 95% CI, 93.2–95.3) ($P < .0001$). Of note, 64 of 2253 (2.8%; 95% CI, 2.2–3.6) febrile neonates were discharged from the PED without any recommended testing or treatment.

TABLE 2 Demographic Characteristics of Neonates ≤28 Days Old With Fever Diagnosis Within the Study Population

N = 2253 patients			
Median age, days (IQR)		18 (11–24)	
Demographic		*N*	%
Race	Non-Hispanic white	900	40.0
	Non-Hispanic black	463	20.5
	Hispanic	651	28.9
	Asian	47	2.1
	Other	192	8.5
Gender	Male	1194	53.0
Payer	Commercial	633	28.1
	Medicaid	1395	61.9

Overall, 1497 of 2253 (66.4%; 95% CI, 64.5–68.4) febrile neonates received recommended management; this ranged from 38.9% to 88.2%, showing a more than twofold variation across the 36 PEDs.

A total of 269 of 2253 (11.9%) neonates had 437 SIs. Table 5 shows the frequency of SIs, with the most common being urinary tract infections (27%), meningitis (18.8%), sepsis or bacteremia (14.4%), abscess or cellulitis (5.9%), and pneumonia (3%). Of the 269 neonates with SIs, 223 (82.9%; 95% CI, 77.9–86.9) received recommended management (testing, antibiotics, and admission). Of the 369 febrile neonates who were discharged at the index PED visit, 3 had a final diagnosis of SI. Two of these neonates were discharged at the first visit with an SI diagnosis and did not return to the same PED within 2 days after discharge. One neonate, initially discharged with a diagnosis of "Fever, unspecified," returned within 2 days to the PED, was admitted to the hospital, and was subsequently diagnosed with an SI; this infant is described later.

For patients discharged from the PED, we evaluated those who returned within 2 days of the discharge. Of the 369 patients seen and discharged from the PED, 10 returned to the same hospital PED within 2 days. Of these 10 patients, 3 were discharged from the hospital again, none of whom had a diagnosis of SI at the second visit, and 7 were admitted at the return visit. Five patients admitted at the return visit were subsequently discharged with various neonatal conditions (viral exanthem not otherwise specified [NOS]; fetal/neonatal jaundice NOS; viral infection not elsewhere classified [NEC]; neonatal candida infection/diaper rash/perinatal gastrointestinal system disorder NEC/rectal and anal disorder NEC; and fetal/neonatal jaundice NOS/prophylactic isolation/diaper rash), none of which was an SI. One patient was admitted and discharged with the only diagnosis of "NB temperature regulation disturbance NEC." Only 1 of the 7 patients admitted at the return visit had

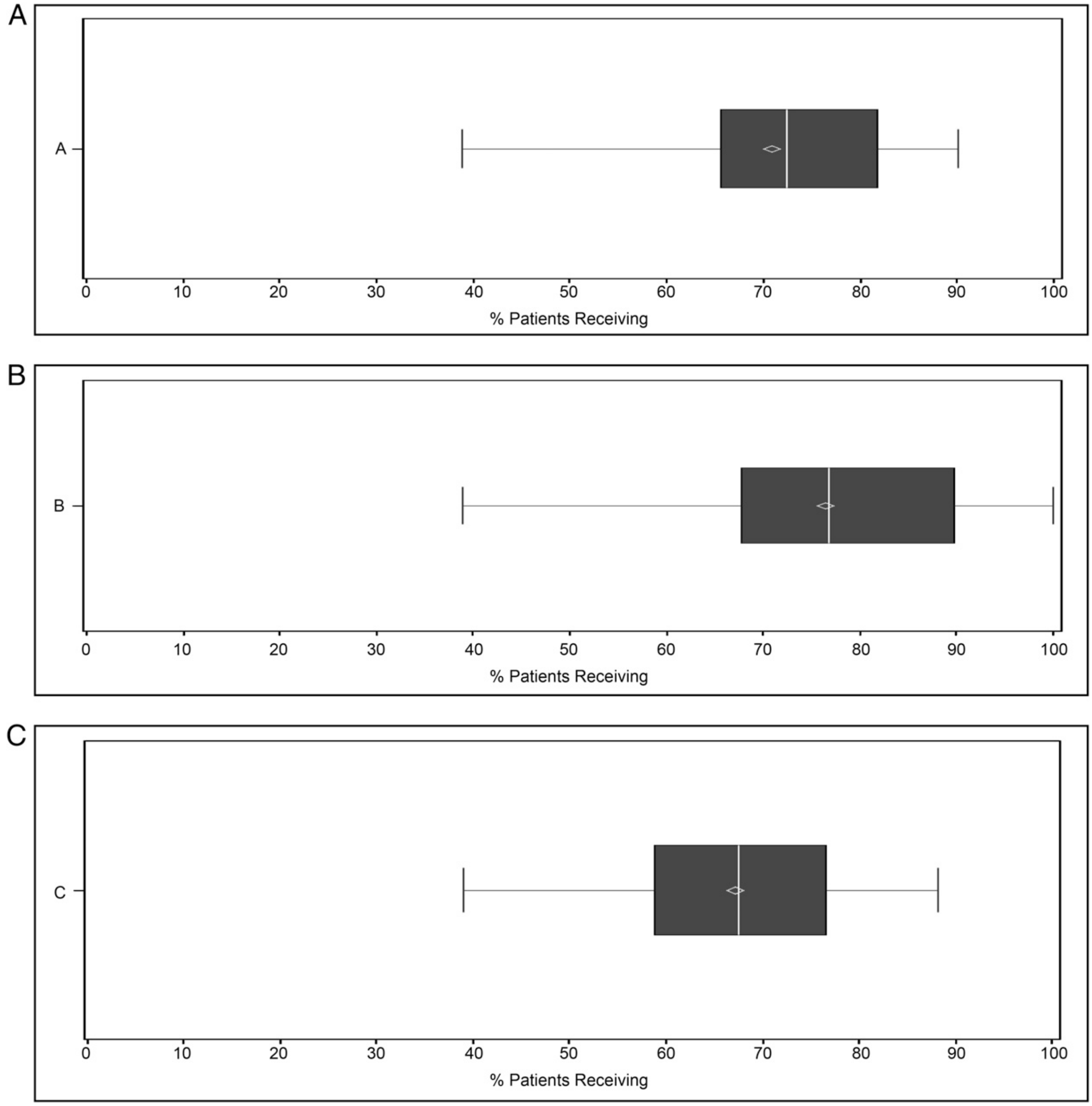

FIGURE 2
A, Variation across 36 hospitals in recommended testing of febrile neonates (obtaining blood, urine, and CSF cultures). Median hospital: 72.4% (IQR 65.6–81.6). B, Variation across 36 hospitals in recommended treatment of febrile neonates. Administration of recommended antibiotics (ampicillin with third-generation cephalosporin or gentamicin). Median hospital: 76.6% (IQR 67.8–89.8). C, Variation across 36 hospitals in recommended management of febrile neonates (blood, urine, and CSF cultures, antibiotics, and admission to hospital). Median hospital: 67.5% (IQR 58.9–76.5).

a diagnosis of SI (newborn bacteremia). This patient had blood and urine cultures obtained at the first ED visit and was discharged with a diagnosis of "Fever, unspecified," without parenteral antibiotics. At the second visit, the patient was admitted for intravenous antibiotics (ampicillin and cefotaxime) and subsequently discharged the next day with the diagnoses of "Newborn temperature regulation disturbance" (ICD-9-CM 778.4), "Newborn bacteremia" (ICD-9-CM 771.83), and "Other staph infection" (ICD-9-CM 9041.19). Thus, in this study, 1 in 369 (0.3%; 95% CI, 0.01–1.32) febrile neonates was discharged from the PED, returned to the same PED, and was subsequently diagnosed with an SI.

DISCUSSION

This is the first multicenter study evaluating management practices for febrile neonates across US PEDs. In this study, a majority of neonates 0 to 28 days old who presented with fever to a PED received recommended evaluation and treatment and were admitted to the hospital. However, adherence to

TABLE 3 Details of Evaluation of Febrile Neonates Across 36 US PEDs

	Overall (*n* = 2253)		Discharged From ED (*n* = 369)		Admitted to Hospital (*n* = 1884)		*P*
	%	95% CI	%	95% CI	%	95% CI	
Blood + urine + CSF culture[a]	72.9	71.1–74.7	8.4	6.0–11.7	85.6	83.9–87.1	<.0001
Blood + urine culture	7.3	6.2–8.4	15.2	11.9–19.2	5.7	4.7–7.8	<.0001
Blood culture only	1.1	0.7–1.6	3.0	1.7–5.3	0.7	0.4–1.2	.0005
Urine culture only	0.9	0.6–1.4	4.1	2.5–6.6	0.3	0.2–0.7	<.0001
CSF culture only	1.7	1.3–2.4	0.3	0.05–1.5	2.0	1.5–2.8	.0145
Other cultures or combinations	3.6	2.9–4.5	4.6	2.9–7.3	3.5	2.7–4.4	.2868
No cultures	12.5	11.2–13.9	64.5	59.5–69.2	2.3	1.7–3.1	<.0001
Chest radiograph	32.8	30.9–34.7	10	7.4–13.5	37.3	35.1–39.4	<.0001

a Recommended testing for neonatal fever.

recommendations for management of febrile neonates varied more than twofold between the hospitals, from as low as 38.9% to as high as 88.2%. One in 6 neonates with fever were discharged from the PED after varying degrees of laboratory testing and antibiotic therapy. Evaluation and treatment varied significantly between admitted and discharged febrile neonates. Most febrile neonates with an SI received recommended management.

Studies comparing office-based versus PED management of febrile children have shown differences in strategies in the 2 settings.[19,20] A study of 573 office-based practitioners across the United States showed that pediatric clinicians use individualized clinical judgment in treating febrile infants <3 months of age, including febrile neonates. In this office-based study, the authors reported that relying on clinical guidelines would not have improved care but would have resulted in more hospitalizations and laboratory testing.[20] However, no study has examined the practices exclusively for febrile neonates in the ED setting.

As proposed by the 2005 Institute of Medicine report, *Performance Measurement: Accelerating Improvement*, achieving quality in health care is a 3-step process that includes measurement, reporting, and improving.[21] In our study, measurement included recommended testing, treatment, and management for febrile neonates and is part of a report card of 60 measures recommended for assessing the quality of ED care for children.[12] We then used comparative data to report and understand differences in ED performance. In our study, two-thirds of febrile neonates were managed according to recommendations for testing and treatment followed by admission to the hospital. However, PEDs varied significantly in adherence to recommendations for management of febrile neonates, including those for testing, treatment, and admission to the hospital. Variation across hospitals may indicate hospital-level rather than patient-level factors affecting the management of these children. Delineating variation across hospitals is a critical first step for learning the source of variation. Once the source of variation is determined, interventions may be designed to reduce variation and improve adherence to recommended evidence-based guidelines.

Furthermore, although performing basic screening tests for potential SIs followed by admission for presumptive antibiotics has long been considered a standard practice, we found that 1 in 6 febrile neonates were discharged from the ED after varying levels of evaluation.[6] The reasons some neonates with fever were not evaluated with screening laboratory tests and were discharged from the hospital without antibiotics, whereas others received the recommended workup and admission for presumptive antibiotics, are unclear. There are some potential explanations for this finding. Patients may present for a complaint of "fever" by history but not actually have a fever documented at home or in the ED. Also, some patients' fever may be caused by overbundling and may resolve in the ED. Another potential reason is that patients could have had evaluations performed before presenting to the study hospitals; however, patients who were transferred from other facilities and those who had a visit within the previous 2 days were excluded from our study.

Although it seems surprising that as many as 1 in 6 febrile neonates were

TABLE 4 Details of Antibiotic Treatment of Febrile Neonates Across 36 US PEDs

	Overall (*n* = 2253)		Discharged From ED (*n* = 369)		Admitted to Hospital (*n* = 1884)		*P*
	%	95% CI	%	95% CI	%	95% CI	
Ampicillin + third-generation cephalosporin[a]	51.7	49.6–53.8	2.4	1.3–4.6	61.4	59.1–63.5	<.0001
Ampicillin + gentamicin[a]	19.7	18.1–21.4	0.8	0.3–2.4	23.4	21.5–25.3	<.0001
Ampicillin + gentamicin + third-generation cephalosporin[a]	8.0	7.0–9.2	0	0–1.0	9.6	8.4–11.0	<.0001
3rd-generation cephalosporin alone	1.9	1.4–2.5	3.8	2.3–6.3	1.5	1.0–2.1	.0055
Other parenteral antimicrobial therapy	0.4	0.2–0.8	0.3	0.05–1.5	0.4	0.2–0.8	.9999
No antibiotics	18.3	16.8–20.0	92.7	89.6–94.9	3.8	3.0–4.7	<.0001

a Recommended antibiotics for neonatal fever.

TABLE 5 Frequency of SIs in Febrile Neonates Across 36 US PEDs

Category and Diagnosis	ICD-9-CM Code	Frequency
Urinary tract infection, pyelonephritis, renal abscess		119 (27.2%)
Newborn urinary tract infection	771.82	93 (21.3%)
Pyelonephritis NOS	590.80	12 (2.7%)
Urinary tract infection NOS	599.0	9 (2.1%)
Acute pyelonephritis	590.10	4 (0.9%)
Renal or perirenal abscess	590.2	1 (0.2%)
Meningitis, meningoencephalitis, encephalitis		83 (19%)
Viral meningitis NEC	047.8	38 (8.7%)
Viral meningitis NOS	047.9	25 (5.7%)
Meningitis NOS	322.9	10 (2.3%)
Bacterial meningitis NOS	320.9	3 (0.7%)
Streptococcal meningitis	320.2	2 (0.5%)
Salmonella meningitis	003.21	1 (0.2%)
Herpes simplex meningoencephalitis	054.3	1 (0.2%)
Gram-negative meningitis NEC	320.82	1 (0.2%)
Encephalitis, myelitis, encephalomyelitis NOS	323.9	1 (0.2%)
Other bacterial meningitis	320.89	1 (0.2%)
Sepsis, bacteremia		63 (14.4%)
Newborn septicemia	038.12	31 (7.1%)
Newborn bacteremia	771.83	23 (5.3%)
Bacteremia	790.7	3 (0.7%)
Salmonella septicemia	003.1	1 (0.2%)
MRSA septicemia	038.12	1 (0.2%)
Septic shock	785.52	1 (0.2%)
Shock without trauma NEC	785.59	1 (0.2%)
Sepsis	995.91	1 (0.2%)
Severe sepsis	995.92	1 (0.2%)
Cellulitis, abscess, skin infections		26 (5.9%)
Newborn omphalitis	771.4	7 (1.6%)
Trunk cellulitis	682.2	5 (1.1%)
Face cellulitis	682.0	4 (0.9%)
Eyelid abscess	373.13	2 (0.5%)
Orbital cellulitis	376.01	2 (0.5%)
Inflammatory breast disease	611.0	1 (0.2%)
Arm cellulitis	682.3	1 (0.2%)
Buttock cellulitis	682.5	1 (0.2%)
Leg cellulitis	682.6	1 (0.2%)
Cellulitis NEC	682.8	1 (0.2%)
Newborn infective mastitis	771.5	1 (0.2%)
Pneumonia, lung abscess		13 (3%)
Pneumonia organism NOS	486.0	6 (1.4%)
Congenital pneumonia	770.0	3 (0.7%)
Bacterial pneumonia NOS	482.9	2 (0.5%)
Influenza with pneumonia	487.0	1 (0.2%)
Lung abscess	513.0	1 (0.2%)
Other		133 (30.4%)
E coli infection NOS	041.1	61 (14%)
Gram-negative bacterial infection NEC	041.85	13 (3.0%)
Group D streptococcus infection	041.04	11 (2.5%)
MRSA	041.12	11 (2.5%)
K pneumoniae infection	041.3	8 (1.8%)
S aureus infection	041.11	7 (1.6%)
Group B streptococcus infection	041.02	6 (1.4%)
Other staphylococcus infection	041.19	4 (0.9%)
Pseudomonas infection NOS	041.7	3 (0.7%)
Bacterial infection NEC	0418.9	3 (0.7%)
Streptococcus infection NEC	041.09	2 (0.5%)
H influenzae infection NOS	041.5	2 (0.5%)
Bacterial infection NOS	041.9	2 (0.5%)

Each patient could have more than 1 ICD-9-CM diagnosis code. MRSA, methicillin-resistant *Staphylococcus aureus.*

discharged from the ED with or without a diagnostic evaluation and empirical antibiotic therapy, only a very small proportion returned to the same ED within 2 days, and even fewer of those discharged had a subsequent diagnosis of SI. While taking into account the constraints of using administrative data, PED physicians may be considering other clinical and sociodemographic factors in their decision-making in evaluation of febrile neonates, much like pediatricians in primary care settings.[20] The high rate of SIs in admitted patients in this cohort underscores the need for ongoing monitoring of adherence to recommendations for these high-risk patients. However, the low rate of return for missed SIs in discharged patients suggests the need for additional study of the reasons for the wide variation in recommended testing, treatment, and management that we have documented. Furthermore, this apparent low rate of missed SI underscores the need for additional prospective studies to elucidate the reasons for variation in management, with subsequent use of these data to inform effective and efficient evidence-based management strategies in the future.

Our study is based on aggregate hospital administrative data using ICD-9-CM codes; this can lead to several limitations. ICD-9-CM codes are commonly used in analyses of administrative data sets; their accuracy has been validated for some conditions, such as urinary tract infections, but not specifically for neonatal fever, and overall there remains wide variability in the accuracy of using these codes to identify patients.[22] Furthermore, selection bias could have resulted in both overinclusion of patients (eg, a patient presents with a complaint of fever, without a true fever documented at home or in the ED, but the diagnosis given is fever) and underinclusion (a child with fever is given another diagnosis and therefore not included). Additionally, some of the variation noted may have resulted from clinical and other factors that were not available for study. For example, some neonates with fever may not have had the recommended management for clinical or history reasons not captured in the database. Another potential reason is that patients may have had evaluations performed before presenting to the study hospitals; however, patients who were transferred from other facilities and those who had a visit within the previous 48 hours were excluded from our study. In admitted patients, in an attempt to catch all interventions performed in the PED, we chose to include the calendar day after initial ED presentation to account for patients who presented late in the calendar day. Therefore, our data set was unable to differentiate laboratory evaluations and antibiotic therapy performed in the ED from those performed the same or next day in the inpatient setting, which may have resulted in some inpatient interventions being included as being performed in the ED. This inclusion would have underestimated the variation found. Finally, we may have underestimated the rate of SI in discharged neonates because we were able to capture only discharged patients returning to the same hospital and those who returned within the 2-day period after the initial ED visit (although it is likely that patients with missed SI would present fairly rapidly in this very young age group).

CONCLUSIONS

We have found wide variation across US PEDs in adherence to recommended management of febrile neonates. One in 6 febrile neonates were discharged from the PED after varying degrees of laboratory evaluation and antibiotic treatment, and discharged patients were less likely to receive testing or antibiotic therapy than admitted patients. The rate of SIs in our cohort was nearly 12%; the majority of patients with SI received recommended evaluation and management. Understanding variation in care is a critical first step in designing future studies to refine and improve adherence to recommended evidence-based management and quality of care for children needing emergency care.

REFERENCES

1. Baker MD, Bell LM, Avner JR. Outpatient management without antibiotics of fever in selected infants. *N Engl J Med*. 1993;329(20):1437–1441
2. Baskin MN, O'Rourke EJ, Fleisher GR. Outpatient treatment of febrile infants 28 to 89 days of age with intramuscular administration of ceftriaxone. *J Pediatr*. 1992;120(1):22–27
3. Dagan R, Powell KR, Hall CB, Menegus MA. Identification of infants unlikely to have serious bacterial infection although hospitalized for suspected sepsis. *J Pediatr*. 1985;107(6):855–860
4. Jaskiewicz JA, McCarthy CA, Richardson AC, et al Febrile infants at low risk for serious bacterial infection: an appraisal of the Rochester criteria and implications for management. Febrile Infant Collaborative Study Group. *Pediatrics*. 1994;94(3):390–396
5. Van den Bruel A, Thompson MJ, Haj-Hassan T, et al. Diagnostic value of laboratory tests in identifying serious infections in febrile children: systematic review. *BMJ*. 2011;342:d3082
6. Baraff LJ, Bass JW, Fleisher GR, et al; Agency for Health Care Policy and Research. Practice guideline for the management of infants and children 0 to 36 months of age with fever without source. *Ann Emerg Med*. 1993;22(7):1198–1210
7. Chiu CH, Lin TY, Bullard MJ. Identification of febrile neonates unlikely to have bacterial infections. *Pediatr Infect Dis J*. 1997;16(1):59–63
8. Ferrera PC, Bartfield JM, Snyder HS. Neonatal fever: utility of the Rochester criteria in determining low risk for serious bacterial infections. *Am J Emerg Med*. 1997;15(3):299–302
9. Marom R, Sakran W, Antonelli J, et al Quick identification of febrile neonates with low risk for serious bacterial infection: an observational study. *Arch Dis Child Fetal Neonatal Ed*. 2007;92(1):F15–18
10. Schwartz S, Raveh D, Toker O, Segal G, Godovitch N, Schlesinger Y. A week-by-week analysis of the low-risk criteria for serious bacterial infection in febrile neonates. *Arch Dis Child*. 2009;94(4):287–292
11. Garcia S, Mintegi S, Gomez B, et al Is 15 days an appropriate cut-off age for considering serious bacterial infection in the management of febrile infants? *Pediatr Infect Dis J*. 2012;31(5):455–458
12. Alessandrini E. Defining quality performance measures for pediatric emergency care. Available at: www.childrensnational.org/EMSC/PubRes/toolbox.aspx. Accessed May 31, 2013
13. Ferguson CC, Roosevelt G, Bajaj L. Practice patterns of pediatric emergency medicine physicians caring for young febrile infants. *Clin Pediatr*. 2010;49(4):350–354
14. Newman TB, Bernzweig JA, Takayama JI, et al Urine testing and urinary tract infections in febrile infants seen in office settings: the Pediatric Research in Office Settings' Febrile Infant Study. *Arch Pediatr Adolesc Med*. 2002;156(1):44–54
15. Young PC. The management of febrile infants by primary-care pediatricians in Utah: comparison with published practice guidelines. *Pediatrics*. 1995;95(5):623–627
16. Belfer RA, Gittelman MA, Muniz AE. Management of febrile infants and children by pediatric emergency medicine and emergency medicine: comparison with practice guidelines. *Pediatr Emerg Care*. 2001;17(2):83–87
17. Wood JN, Feudtner C, Medina SP, Luan X, Localio R, Rubin DM. Variation in occult injury screening for children with

suspected abuse in selected US children's hospitals. *Pediatrics*. 2012;130(5):853–860

18. Fletcher DM. Achieving data quality. How data from a pediatric health information system earns the trust of its users. *J AHIMA*. 2004;75(10):22–26
19. Newman TB, Bernzweig JA, Takayama JI, Finch SA, Wasserman RC, Pantell RH. Urine testing and urinary tract infections in febrile infants seen in office settings: the Pediatric Research in Office Settings' Febrile Infant Study. *Arch Pediatr Adolesc Med*. 2002;156(1):44–54
20. Pantell RH, Newman TB, Bernzweig J, et al. Management and outcomes of care of fever in early infancy. *JAMA*. 2004;291(10):1203–1212
21. Institute of Medicine. *Performance Measurement: Accelerating Improvement*. Washington, DC: The National Academies; 2005
22. Tieder JS, Hall M, Auger KA, et al. Accuracy of administrative billing codes to detect urinary tract infection hospitalizations. *Pediatrics*. 2011;128(2):323–330

(Continued from first page)

Dr Jain designed the study, interpreted the data, and drafted the initial manuscript; Dr Cheng assisted with data analysis and revised the manuscript; Drs Alpern and Alessandrini conceptualized the study, assisted in study design and data interpretation, and critically revised the manuscript; Dr Thurm conducted the data analysis and interpreted the data; Drs Schroeder, Black, Ellison, and Stone interpreted the data and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

Drs Jain and Cheng are currently affiliated with Division of Pediatric Emergency Medicine, Emory University and Children's Healthcare of Atlanta, Atlanta, Georgia; Dr Alpern's current affiliation is Division of Emergency Medicine, Ann and Robert H. Lurie Children's Hospital Center for Healthcare Studies Northwestern University, Feinberg School of Medicine Chicago, Illinois; Dr Thurm's current affiliation is Children's Hospital Association, Overland Park, Kansas; Dr Schroeder's current affiliation is Division of Emergency Medicine, Children's Mercy Hospital, The University of Missouri-Kansas City, Kansas City, Missouri; Dr Black's current affiliation is University of South Dakota School of Medicine and Sanford Children's Hospital, Sioux Falls, South Dakota; Dr Ellison's current affiliation is Division of Emergency Medicine, Children's Hospital of Philadelphia Perelman School of Medicine at The University if Pennsylvania, Philadelphia, Pennsylvania; and Dr Alessandrini's current affiliation is Anderson Center for Health Systems Excellence and Division of Emergency Medicine Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio.

www.pediatrics.org/cgi/doi/10.1542/peds.2013-1820

doi:10.1542/peds.2013-1820

Accepted for publication Nov 6, 2013

Address correspondence to Shabnam Jain, MD, MPH, Emory University, Children's Healthcare of Atlanta, Pediatric Emergency Medicine, 1645 Tullie Circle NE, Atlanta, GA 30329. E-mail: sjain@emory.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Management of Febrile Neonates in US Pediatric Emergency Departments

Shabnam Jain, John Cheng, Elizabeth R. Alpern, Cary Thurm, Lisa Schroeder, Kelly Black, Angela M. Ellison, Kimberly Stone and Evaline A. Alessandrini

Pediatrics; originally published online January 27, 2014;
DOI: 10.1542/peds.2013-1820