Racial Differences in Sepsis Recognition in the Emergency Department

Jenny Raman, BS,[a,b] Tiffani J. Johnson, MD, MSc,[a] Katie Hayes, BS,[a] Fran Balamuth, MD, PhD[a]

abstract

OBJECTIVES: We assessed racial differences in sepsis recognition in a pediatric emergency department (ED) with an established electronic sepsis alert system.

METHODS: Quality-improvement data from June 1, 2016 to May 31, 2017 was used in this retrospective cohort study. All ED visits were included for non-Hispanic black (NHB) and non-Hispanic white (NHW) patients. The sepsis pathway was activated through the alert, 2 stages and a huddle, or outside of the alert using clinician judgment alone. We evaluated racial differences in the frequency of alerts and sepsis pathway activation within and outside of the alert. Multivariable regression adjusted for high-risk condition, sex, age, and insurance.

RESULTS: There were 97 338 ED visits: 56 863 (58.4%) and 23 008 (23.6%) from NHBs and NHWs, respectively. NHWs were more likely than NHBs to have a positive second alert (adjusted odds ratio [aOR] 2.4; 95% confidence interval [CI] 2.1–2.8). NHWs were more likely than NHBs to have the sepsis pathway activated (aOR 1.4; 95% CI 1.02–2.1). Of those treated within the alert, there was no difference in pathway activation (aOR 0.93; 95% CI 0.62–1.4). Of those recognized by clinicians when the alert did not fire, NHWs were more likely than NHBs to be treated (aOR 3.4; 95% CI 1.8–6.4).

CONCLUSIONS: NHWs were more likely than NHBs to be treated for sepsis, although this difference was specifically identified in the subset of patients treated for sepsis outside of the alert. This suggests that an electronic alert reduces racial differences compared with clinician judgment alone.

[a]*Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; and* [b]*University of Texas Southwestern Medical Center, Dallas, Texas*

Ms Raman conceptualized and designed the study, drafted the initial manuscript, conducted the initial analyses, and reviewed and revised the manuscript; Dr Johnson assisted with the study design, reviewed initial analyses, and reviewed and revised the manuscript; Ms Hayes designed the data collection instruments, conducted data extraction, and critically reviewed the manuscript for important intellectual content; Dr Balamuth conceptualized and designed the study, coordinated and supervised data collection, designed the data collection instruments, drafted the initial manuscript, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Address correspondence to Fran Balamuth, MD, PhD, Division of Emergency Medicine, Department of Pediatrics, Children's Hospital of Philadelphia, 3501 Civic Center Blvd, 2nd Floor, Philadelphia, PA 19104. E-mail: balamuthf@email.chop.edu

WHAT'S KNOWN ON THIS SUBJECT: Racial differences in care exist in pediatric emergency departments but have not been evaluated in sepsis.

WHAT THIS STUDY ADDS: In a pediatric emergency department, NHW patients were more likely than NHB patients to be treated for sepsis outside of an electronic sepsis alert but not within the alert process.

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Sepsis, an overwhelming inflammatory response to infection, is a leading cause of pediatric morbidity in the United States, with mortality ranging from 5% to 20% and >$4.8 billion in national health expenses annually.[1–3] Sepsis is challenging to detect in children. With hypotension being relatively rare in children, those with compensated septic shock can be difficult to distinguish from the vast majority of febrile children with tachycardia who do not have sepsis. Consequently, there are >95 000 annual emergency department (ED) visits in the United States resulting in evaluation for pediatric sepsis.[4]

Centers with sepsis quality improvement (QI) programs have demonstrated improved care for children, including sepsis recognition, timeliness of antibiotics and fluids, duration of organ dysfunction, and mortality.[5–10] Equity is a key component of a high-quality health care framework, according to the Institute of Medicine (now the National Academy of Medicine).[11] Equity is achieved by providing high-quality health care that does not vary with a patient's personal characteristics, such as race, ethnicity, or socioeconomic status. Despite growing attention on QI in sepsis, few organizations have specifically addressed equity as a quality metric for pediatric sepsis care. Inequities have been reported for sepsis outcomes in adult populations, with a higher risk for organ dysfunction and infection seen in adult black patients compared with in white patients.[12] However, racial differences in pediatric sepsis care and outcomes have not been studied.

The Children's Hospital of Philadelphia has had an active sepsis QI program with efforts to improve timeliness and effectiveness of sepsis care since 2012, with the addition of an electronic sepsis alert system occurring in 2014.[5] We aimed to determine if there were racial differences in the pediatric sepsis recognition process in a children's hospital ED. The sepsis alert has been described in detail elsewhere[13] but briefly involves 2 stages: the first stage screens for tachycardia and/or hypotension, and the second stage is based on nursing assessment of sepsis risk factors followed by a team decision to initiate the sepsis pathway using an order set (Table 1).

Because we did not suspect that 1 race would be more prone to infection than the other, we hypothesized that there would be no racial difference in the first alert, which is based on vital signs. Conversely, we hypothesized that racial differences would be identified in sepsis pathway activation for all ED visits, both in patients identified with and in those without the alert, because of the greater subjectivity involved in clinical assessment compared with vital sign assessment.

METHODS

Study Design and Setting

This was a retrospective cohort study in a tertiary-care, urban, academic children's hospital ED with an existing electronic health record–based sepsis alert from June 1, 2016, to May 31, 2017.

Inclusion Criteria

Subjects were included if they visited the ED and self-identified or were identified by the parent at the ED registration as either non-Hispanic white (NHW) or non-Hispanic black (NHB), the 2 most common racial groups during the study period. A more detailed subanalysis was conducted on ED patients with either a positive first sepsis alert result or those who were treated for sepsis by using the sepsis pathway and/or order set.

Description of Sepsis Recognition and Treatment Processes

Since 2014, the ED has had an electronic sepsis alert system in place designed to reduce the number of missed sepsis patients (Fig 1). The sepsis alert consists of 2 stages followed by a huddle process and has been described in detail elsewhere.[5] Briefly, the first stage of the alert has a positive result if the patient has either tachycardia or hypotension for their age. The patient must have a positive first alert result to prompt the second stage of the alert: a nursing assessment performed by the triage or bedside nurse. The second stage of the alert has a positive result if the patient has an underlying high-risk condition, an abnormal mental status, or delayed capillary refill. A high-risk condition was defined as <56 days old, asplenia, sickle cell disease, bone marrow or solid organ transplant, central line, malignancy, immunodeficiency, immunocompromise, functional technology dependence (such as need for mechanical ventilation), or significant developmental delay that affects the patient's ability to walk, talk, or eat.

A positive second alert result prompts a sepsis huddle, in which the ED team assesses the patient at the bedside and determines the need for sepsis treatment using bundled care

TABLE 1 Stages of Electronic Sepsis Alert Defined

Stage	Definition
Positive first alert result	Tachycardia or hypotension for age
Positive second alert result	High-risk condition, abnormal mental status, or delayed capillary refill
Sepsis pathway activation through the alert system	Sepsis order set after positive second alert result and bedside huddle
Sepsis pathway activation outside the alert system	Sepsis order set without positive second alert result

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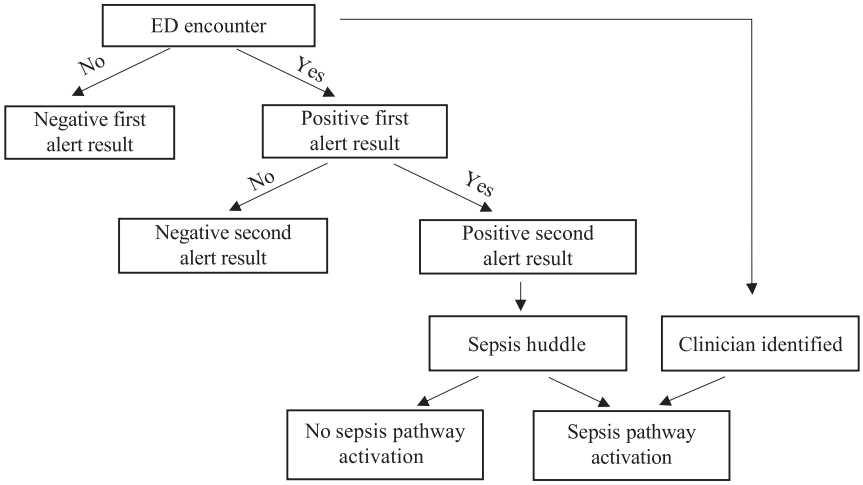

FIGURE 1
Flowchart of electronic sepsis alert stages.

in the sepsis pathway. Sepsis pathway activation is defined as using an associated order set in the electronic health record. The sepsis pathway can also be activated by clinicians, on the basis of their bedside judgment, for patients who did not trigger the sepsis alert. In this study, we aimed to evaluate each phase of the sepsis alert for racial differences.

Data Source

We used an existing QI data set extracted from the electronic health record. Data elements included race, ethnicity, sex, age, payer, first alert result, second alert result, reason for positive second alert result, sepsis pathway activation, and ICU admission within 24 hours of the ED visit.

Analysis

We compared the frequency of positive first alert results, positive second alert results, second alert components, and sepsis pathway activation between NHB and NHW patients. Frequencies, percentages, and odds ratios (ORs) were reported for descriptive elements. Unadjusted comparisons were made by using χ^2 testing. Multivariable logistic regression was performed by using predictors of sepsis pathway activation, including race (primary predictor), sepsis alert components (comorbidities, decreased capillary refill, and altered mental status), sex, age, and payer.

We evaluated independent predictors of sepsis pathway activation, including race (primary predictor), sepsis alert components, sex, age, and payer, using multivariable logistic regression. We tracked ICU admission frequency as an outcome measure. All analyses were performed with NHB as the reference group. Analyses were conducted by using Stata 15.0 (Stata Corp, College Station, TX).

Human Subjects: This study was determined to be exempt from review by the Children's Hospital of Philadelphia Institutional Review Board.

RESULTS

During the study period, there were 97 338 ED visits, of which 56 883 (58.4%) were by NHB patients and 23 008 (23.6%) were by NHW patients (Table 2). There were 12 650 (13.0%) positive first alert results, defined as tachycardia or hypotension for age (Table 3). There were 1298 (1.3%) positive second alert results, defined as an underlying high- risk condition, a change in mental status, or delayed capillary refill. A total of 242 patients had a sepsis pathway activation when using the alert system (0.25% of all visits, 1.9% of patients with a positive first alert result, and 18.6% of patients with a positive second alert result). An additional 84 patients (0.086%) had a sepsis pathway activation outside of the alert system based on clinical judgment.

TABLE 2 Demographic Characteristics of All ED Patients by Electronic Sepsis Alert Stage

	Total ED Census (*N* = 97 338)		Alert Identified (*n* = 12 650)		Clinician Identified (*n* = 84)	
	NHB (*n* = 56 863; 58.4%)	NHW (*n* = 23 008; 23.6%)	NHB (*n* = 6397; 50.6%)	NHW (*n* = 3044; 24.1%)	NHB (*n* = 23; 27.4%)	NHW (*n* = 35; 41.7%)
Female sex, *n* (%)	27 469 (48.3)	10 988 (47.8)	3249 (50.8)	1550 (50.9)	10 (44)	14 (40)
Age, y, *n* (%)						
0–1	15 849 (27.9)	2431 (10.6)	2617 (40.9)	1096 (36.0)	2 (9)	5 (14)
2–5	15 451 (27.2)	2501 (10.9)	2213 (34.6)	870 (28.6)	6 (26)	5 (14)
6–12	15 216 (26.8)	2984 (13.0)	1124 (17.6)	625 (20.6)	8 (35)	8 (23)
13–17	8690 (15.3)	2481 (10.8)	360 (5.6)	336 (11.0)	7 (30)	12 (35)
18+	1657 (2.9)	591 (2.6)	83 (1.3)	117 (3.8)	0 (0)	5 (14)
Government payer, *n* (%)	45 530 (80.1)	6737 (29.3)	5204 (81.4)	934 (30.7)	19 (83)	12 (34)

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Subsequent analysis was limited to patients who had a positive first alert result (Table 4). Demographic characteristics of this subset are listed in Table 2. We next compared the frequency of each stage of the sepsis alert between NHB and NHW patients, using both unadjusted and adjusted analyses (Table 4). NHW patients were slightly more likely than NHB patients to have a positive first alert result (OR 1.1; 95% confidence interval [CI] 1.1–1.2), a difference that disappeared after adjusting for payer, age, and sex (adjusted odds ratio [aOR] 0.66; 95% CI 0.024–18.7). NHW patients were more likely than NHB patients to have a positive second alert result (OR 3.0; 95% CI 2.5–3.3), a difference that was attenuated but persisted after adjusting for payer, age, and sex (aOR 2.4; 95% CI 2.1–2.8). The odds of sepsis pathway activation were increased in NHW patients compared with NHB patients (aOR 1.4; 95% CI 1.02–2.1). Stepwise multivariable regression was also performed with high-risk condition as the biggest contributor to the racial difference in sepsis pathway activation, followed by age, delayed capillary refill, abnormal mental status, and payer (Table 5).

We then examined racial differences in sepsis pathway activation in the subset of patients treated through the alert and/or huddle process and in the subset of patients treated outside of that process on the basis of clinician judgment, as listed in Table 3. There was no difference in sepsis pathway activation between NHW and NHB patients treated through the alert and/or huddle process (OR 1.2 [95% CI 0.9–1.7] and aOR 0.93 [95% CI 0.62–1.4], respectively). However, for patients treated outside of the alert process by using clinical judgment alone, NHB patients were more likely to be have sepsis pathway activation (OR 3.6 [95% CI 2.2–6.1] versus aOR 3.4 [95% CI 1.8–6.4]).

We went on to analyze the 3 components of the second alert: high-risk condition, abnormal mental status, and delayed capillary refill. There was no difference between NHW and NHB children in the presence of a high-risk condition (OR 1.2; 95% CI 0.90–1.6) or abnormal mental status (OR 0.86; 95% CI 0.66–1.1). Comorbidities seen in NHW and NHB children are shown in Table 7. Of note, only 1 high-risk condition can be selected through the existing electronic sepsis alert. Consequently, it is possible for a patient to have multiple comorbidities, but the data set would only reflect the single condition selected by the triage nurse. NHW patients were more likely than NHB patients to have delayed capillary refill time recorded by the provider (OR 1.8; 95% CI 1.2–2.6). There was no racial difference in ICU admission frequency among the patients treated for sepsis (aOR 1.3; 95% CI 0.68–2.5).

The median time from ED triage to initial antibiotic treatment for all patients treated on the sepsis pathway was 78 minutes (interquartile range [IQR] 44–172) for NHB patients and 64 minutes (IQR 50–119) for NHW patients, although this difference was not statistically significant (Table 6). For patients treated on the sepsis pathway through the alert system, the median time to antibiotics was 77 minutes (IQR 47–160) for NHB patients and 61 minutes (IQR 49–102) for NHW patients. For patients treated on the sepsis pathway outside of the alert system, the median time to antibiotics was 106 minutes (IQR 37–246) for NHB patients and 74 minutes (IQR 53–200) for NHW patients. Neither subset of patients had racial differences in antibiotic administration times that were statistically significant.

TABLE 3 Stages of Electronic Sepsis Alert for All ED Patients

	Total (N = 97 338)	NHB (n = 56 863; 58.4%)	NHW (n = 23 008; 23.6%)
	n (%)	n (%)	n (%)
Positive first alert result	12 650 (13)	6396 (11.2)	3043 (13.2)
Positive second alert result	1298 (1.3)	435 (0.77)	527 (2.3)
Sepsis pathway activation when using alert	242 (0.25)	74 (0.13)	104 (0.45)
Sepsis pathway activation without alert	84 (0.086)	23 (0.040)	35 (0.15)

DISCUSSION

We demonstrated that in a large, academic, pediatric ED with an established electronic sepsis alert, NHW patients were slightly more likely to be treated with the institutional sepsis pathway than NHB patients. Although there were no differences in sepsis pathway activation for patients identified through the alert, NHW patients were more likely than NHB patients to be identified and treated for sepsis outside the alert. These differences persisted after adjusting for high-risk condition, sex, age, and insurance status. These findings suggest that sepsis treatment when using an electronic alert, compared with clinician judgment alone, may reduce racial differences in care.

A previous study found that black adults were at an increased risk of sepsis and associated the increased risk with having chronic comorbidities that compromise immune function.[14] Our research supports the finding that chronic comorbidities are associated with increased risk of sepsis, with high-risk condition being the highest contributor to the unadjusted racial difference in sepsis treatment. Another study reported a higher incidence of and mortality from sepsis in adult black patients

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TABLE 4 Stages of Electronic Sepsis Alert for Patients With Positive First Alert Results

	NHB (n = 6396)	NHW (n = 3043)	Total (N = 12 652)			
	n (%)	n (%)	n (%)	OR (95% CI)	aOR (95% CI)	ARR (95% CI)
Positive second alert result	435 (6.8)	527 (17.3)	1298 (10.3)	3.0 (2.5–3.3)[a]	2.4 (2.1–2.8)[a]	0.11 (0.09–0.12)
Sepsis pathway activation when using alert	74 (1.2)	104 (3.4)	242 (1.9)	1.2 (0.9–1.7)	0.93 (0.62–1.4)	0.02 (0.02–0.03)
Sepsis pathway activation without alert	23 (0.36)	35 (1.2)	84 (0.66)	3.6 (2.2–6.1)[a]	3.4 (1.8–6.4)[a]	0.01 (0.004–0.01)
Total sepsis pathway activation	97 (1.5)	139 (4.6)	326 (2.6)	3.1 (2.4–4.0)[a]	1.4 (1.02–2.1)	0.03 (0.02–0.04)

ARR, absolute risk reduction.

[a] Statistically significant difference in frequency between NHB and NHW patients.

compared with Hispanic patients and white patients after adjusting for socioeconomic status.[15]

The implementation of an electronic sepsis alert introduces objective elements, aiming to reduce variability across practitioners by implementing a standardized process.[13] Sepsis detection also has subjective components because the decision to initiate sepsis treatment ultimately depends on clinician judgment and signs of infection. Previous studies have identified racial disparities in pediatric EDs, especially in the context of medical decision-making that involves subjectivity and clinical uncertainty. One study identified disparities in ordering laboratory studies and imaging for pediatric ED patients with subjective conditions that lacked a standardized treatment protocol, although no disparities were identified when an established evaluation protocol was in place.[16] Pediatric EDs have shown that although there were no racial differences in cranial computed tomography order use for children at low or high risk of brain injury, racial differences were noted for those with intermediate risk of brain injury, with NHB and/or Hispanic patients being less likely than NHW patients to have computed tomography ordered.[17] A study on the management of abdominal pain, a subjective complaint, showed that NHB children were less likely to receive pain medicine in the ED compared with NHW children.[18]

There are multiple proposed explanations for the observed increased frequency in sepsis pathway activation in NHW patients treated outside the alert compared with NHB patients, although there was no racial difference in sepsis pathway activation in patients treated through the alert. One possible explanation is that the racial differences were a result of provider implicit bias. Unlike patients with the alert, which includes a screening and huddle process, patients treated outside the alert are subject to clinician judgment alone, wherein they may be more susceptible to implicit provider bias. A growing body of research shows that physicians in multiple settings, including the pediatric ED, have implicit bias favoring white patients over black patients.[19–21] The literature on the impact of bias on medical decision-making is mixed and is an important area for future research.[19]

TABLE 5 Stepwise Regression for Sepsis Pathway Activation

	aOR	95% CI
Race only (NHB as referent group)	3.1	2.4–4.0
Race, high-risk condition	2.2	1.6–2.8
Race, age	2.8	1.4–2.0
Race, capillary refill	2.5	1.9–3.2
Race, mental status	2.3	1.8–3.1
Race, payer	2.7	2.0–3.6
Race, sex	3.1	2.4–4.0
Race, all but payer	1.7	1.2–2.2
Race, all the above	1.4	1.02–2.1

The following are additional possible explanations for our findings. It is possible that it is more difficult to detect increased capillary refill time or cyanosis in darker-skinned patients, as has been shown previously for identifying limb ischemia and recognizing pressure ulcers.[22] In fact, we found a 1.8-fold increase in the odds of delayed capillary refill reported in NHW patients compared with NHB patients. It is important to note, however, that capillary refill time in the context of this alert is operationalized as a given provider's opinion of the patient's perfusion status, and less as an objective test in and of itself because capillary refill time is known to change with ambient temperature,[23] and also has poor interrater reliability.[24] A second explanation may be access to care. Geographically, the children's hospital ED in this study is near a low–socioeconomic-status community (demographically, 71.2% NHB and 17.4% NHW).[25] Patients in low–socioeconomic-status areas may frequent the ED instead of visiting the pediatrician's office in nonurgent situations, or conversely, patients with poor access to care may wait until their illness is more severe before seeking care.[26–28] Only the former could result in the observed racial difference. A third explanation

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TABLE 6 Time to Antibiotics by Race

Triage to Antibiotics	NHB, Median (IQR)	NHW, Median (IQR)	*P*
All sepsis pathways (*n* = 326), min	78 (44–172)	64 (50–119)	.36
Sepsis pathway with positive alert result (*n* = 242), min	77 (47–160)	61 (49–102)	.17
Sepsis pathway without alert (*n* = 84), min	106 (37–246)	74 (53–200)	.78

may be increased requests among white parents compared with those among black parents, resulting in a greater frequency of sepsis workup.[17] Using the electronic sepsis alert may mediate parental request by incorporating more objective components into the medical decision-making process.

This study has several limitations. First, the study was performed at a single academic center that has had sepsis QI efforts in place since 2012. Consequently, the findings may not be generalizable to other institutions, especially institutions without a standardized sepsis protocol.[16] Second, additional confounders could be considered that are not available in our current data set. For example, it is possible that white children had a greater percentage of high-acuity visits than black children. Acuity was measured by the presence of high-risk conditions, decreased capillary refill, and abnormal mental status (positive second alert result). The increased frequency of positive second alert results in NHWs compared with NHBs (OR 3.0; 95% CI 2.5–3.3) suggests that white children had higher-acuity visits than did black children. However, unlike positive second alert results, which are specific for sepsis risk factors, triage acuity is a measurement of acuity that factors in the chief complaint and the patient's stability on ED presentation. Triage acuity would be interesting to consider because it can influence clinician judgment when assessing the patient. Even if there was higher acuity in white children compared with in black children, this does not explain the absence of racial differences in the patients treated through the alert. With the subset of patients treated outside the alert, both NHWs and NHBs would likely have lower acuity because they did not trigger the sepsis alert with normal vital signs and without high-risk factors for infection. Because there may be additional unmeasured confounders, it is difficult to determine if the identified racial differences were clinically appropriate or representative of a racial disparity due to provider implicit bias, parent preferences and/or expectations, or institutional practices. An alternative explanation may be that the observed racial differences were clinically appropriate. Third, it is important to underscore that the study outcome was sepsis pathway activation (meaning, sepsis treatment), not the presence of sepsis itself. This data set did not contain organ dysfunction–based outcomes, and thus, we cannot comment on differences in sepsis prevalence between races. This challenge is magnified by the following issue: it is possible that in our cohort of treated patients, there are false-positive results (ie, patients who were treated for sepsis who were not septic). One challenge of ED-based sepsis studies is the difficulty in determining who these patients are because if they improve with treatment and never develop the organ dysfunction that defines severe sepsis, it is unclear if this is because of or despite treatment. Finally, we did not evaluate sepsis alert performance in racial groups other than black and white, nor did we evaluate patients of Hispanic ethnicity. In addition, we were not able to evaluate the impact of racial concordance of provider and patient on sepsis alert performance. These topics will be addressed in future analyses.

Future studies are needed to explore sources of the observed racial differences, which may exist at the level of the patient, parent, provider, and health care system. The data set could be expanded to collect information on triage acuity, patient socioeconomic status, and access to a primary care provider. Future research is also needed to evaluate if these racial differences in sepsis detection are associated with differences in patient outcomes, such as timeliness of antibiotics and fluids, organ dysfunction, and mortality.

TABLE 7 High-Risk Condition by Race

	NHB (*n* = 6397)	NHW (*n* = 3044)
<56 d old	36	30
Asplenia and/or sickle cell	115	1
Transplant	14	23
Central line	31	136
Malignancy	3	25
Other immunodeficiency	54	113
Significant CNS issue or functional technology dependence	41	48

CNS, central nervous system.

CONCLUSIONS

In summary, in a single-center academic ED with an electronic sepsis alert in place, we demonstrated that NHW patients treated outside of the alert were more likely than NHB patients to be identified and treated

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for sepsis. There was no difference in sepsis recognition in the subset of patients treated when using the alert. These findings may suggest that using the sepsis alert reduces racial differences in sepsis detection and treatment when compared with using clinician judgment alone, a hypothesis that will be examined in future prospective studies.

ABBREVIATIONS

aOR: adjusted odds ratio
CI: confidence interval
ED: emergency department
IQR: interquartile range
NHB: non-Hispanic black
NHW: non-Hispanic white
OR: odds ratio
QI: quality improvement

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