

Early Experience with a Novel Strategy for Assessment of Sepsis Risk: The Shock Huddle

Hannah R. Stinson, MD*; Shirley Viteri, MD*; Paige Koetter, BS†; Erica Stevens, BSN‡; Kristin Remillard, MSN§; Rebecca Parlow, BSN§; Jennifer Setlik, MD¶; and Meg Frizzola, DO*

Abstract

Introduction: Severe sepsis/septic shock (SS), a leading cause of death in children, is a complex clinical syndrome that can be challenging to diagnose. To assist with the early and accurate diagnosis of this illness, we instituted an electronic scoring tool and developed a novel strategy for the assessment of currently hospitalized children at risk for SS. **Methods:** The Shock Tool was created to alert providers to children at risk for SS. Above a threshold score of 45, patients were evaluated by a team from the pediatric intensive care unit (PICU), led by the Shock Nurse (RN), a specially trained PICU nurse, to assess their need for further therapies. Data related to this evaluation, termed a Shock Huddle, were collected and reviewed with the intensivist fellow on service. **Results:** Over 1 year, 9,241 hospitalized patients were screened using the Shock Score. There were 206 Shock Huddles on 109 unique patients. Nearly 40% of Shock Huddles included a diagnostic or therapeutic intervention at the time of patient assessment, with the most frequent intervention being a fluid bolus. Shock Huddles resulted in a patient transfer to the PICU 10% of the time. **Conclusion:** Implementation of an electronic medical record-based sepsis recognition tool paired with a novel strategy for rapid assessment of at-risk patients by a Shock RN is feasible and offers an alternative strategy to a traditional medical emergency team for the delivery of sepsis-related care. Further study is needed to describe the impact of this process on patient outcomes. (*Pediatr Qual Saf* 2019;4:e197; doi: 10.1097/pq9.000000000000197; Published online July 22, 2019.)

INTRODUCTION

Severe sepsis/septic shock (SS) is a complex clinical syndrome characterized by the host's systemic inflammatory response syndrome to an infectious trigger. SS is a leading cause of death in hospitalized children, accounting for 7,000 deaths in

the United States each year.^{1,2} Those who survive may face significant morbidity and health-care costs.³

Evidence-based guidelines for the management of SS focus on time-sensitive interventions such as fluid resuscitation and antibiotic administration.^{4,5} A key aspect of the successful treatment of SS is an early and accurate diagnosis, based on the presence of the inflammatory triad of fever, tachycardia, and malperfusion paired with clinical signs of inadequate tissue perfusion. Sepsis recognition is often a difficult task in the pediatric patient, however, due to many factors. First, children may present for medical care with fever and systemic inflammatory response syndrome due to a variety of causes, not all of which require intensive therapy for SS.⁵ Second, children often present in the early stages of the disease where signs and symptoms of inadequate perfusion may be subtle and nonspecific, with hypotension representing a late finding.^{6,7} Finally, chronically ill children are overrepresented in both the incidence of SS and in mortality rates due to SS but may have baseline vital signs that are outside normative values for age, making an early diagnosis especially difficult. These medically complex children represent an especially fragile population as regards SS.^{8,9}

Previous work on both the identification of children with sepsis and the effects of adherence to the American College of Critical Care Medicine/Pediatric Advanced Life Support guidelines for sepsis resuscitation has mainly focused on the first hour of treatment provided in an



From the *Division of Pediatric Critical Care, Department of Pediatrics, Nemours/Alfred I. duPont Hospital for Children, Wilmington, Del.; †Penn State College of Medicine, Hershey, Pa.; ‡Department of Quality and Safety, Nemours/Alfred I. duPont Hospital for Children, Wilmington, Del.; §Department of Nursing, Nemours/Alfred I. duPont Hospital for Children, Wilmington, Del.; and ¶Division of Pediatric Emergency Medicine, Department of Pediatrics, Nemours Children's Hospital, Orlando, Fla.

Presented preliminary data at the Children's Hospital Association Improving Pediatric Sepsis Outcomes Workshop (Dallas, TX December 2017).

*Corresponding author. Address: Hannah R. Stinson, MD, Department of Pediatrics, Sidney Kimmel Medical College at Thomas Jefferson University, Nemours/Alfred I. duPont Hospital for Children, 1600 Rockland Road, Wilmington, DE 19803
PH: 302-803-2328; Fax: 302-651-4092
Email: hrstinson@gmail.com

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To cite: Stinson HR, Viteri S, Koetter P, Stevens E, Remillard K, Parlow R, Setlik J, Frizzola M. Early Experience with a Novel Strategy for Assessing Hospitalized Patients at Risk for Sepsis: The Shock Huddle. *Pediatr Qual Saf* 2019;4:e197.

Received for publication October 16, 2018; Accepted June 19, 2019.

Published online July 22, 2019.

DOI: 10.1097/pq9.000000000000197

Table 1. Shock Tool

Parameter	Point Value
High-risk condition*	5
Hypotension†	35
Temperature abnormality†	10
Tachycardia†	10
Tachypnea†	10
Delayed capillary refill (≥ 3 seconds)	10
Altered mental status	10
Pulse abnormality (absent, weak, and bounding)	10
Skin abnormality (mottled, erythematous, flushed, cool, petechiae, and purpura)	10

*Includes diagnoses related to neoplasm, asplenia and splenic sequestration, solid organ transplant, bone marrow transplant, intellectual disability, cerebral palsy, and immunodeficiency and/or the presence of central venous access.

†Age-based thresholds may be found in Table 2.

emergency department setting.⁹⁻¹⁶ However, clinical deterioration related to SS can happen at any time during a hospitalization. Adult epidemiologic studies suggest that hospital-onset sepsis occurs in 10%–20% of all sepsis cases and is associated with a 2-fold higher odds of death compared with community-onset sepsis.¹⁷ Recent pediatric data demonstrate that a significant percentage of mortality due to SS occurred in patients initially admitted to a general ward¹ and highlights the need for improved surveillance in the hospitalized patient. To assist with the early and accurate recognition of patients with sepsis, we implemented an electronic medical record (EMR)-based, age-specific, sepsis recognition scoring system that assigns each patient a Shock Score. We designed a novel process for the rapid assessment of these at-risk patients outside the typical rapid response/medical emergency team (MET) called the Shock Huddle. The purpose of this study is to describe the Shock Huddle process, the characteristics of patients with an elevated Shock Score who underwent assessment, and the interventions performed during the Shock Huddle.

METHODS

With support from hospital leadership, Nemours/Alfred I. duPont Hospital for Children (N/AIDHC), a 200-bed, tertiary care, freestanding children’s hospital, created a multidisciplinary team for institutional quality improvement as a participant in the Children’s Hospital Association’s

Improving Pediatric Sepsis Outcomes (IPSO) collaborative in June, 2016. IPSO is a multihospital multiyear quality improvement collaborative which provided central support and guidance; here, we describe local implementation and innovation to enhance diagnosis of pediatric sepsis in the inpatient setting. The institutional review board at N/AIDHC determined that the current study was not human subject research.

We performed a retrospective cohort study to determine the effects of a quality improvement-based process for evaluating patients at risk for SS, the Shock Huddle. All eligible inpatients from April 13, 2017 to April 13, 2018 were included in the analysis. We used a historical cohort of all inpatients from the prior year for comparison.

As part of our participation in IPSO, an electronic screening tool was developed to alert providers to children at risk for sepsis and septic shock, based on the American Academy of Pediatrics trigger tool for early septic shock recognition.⁵ The Shock Tool incorporates age-based vital sign limits, clinical parameters, and exam findings of inadequate tissue perfusion to create a Shock Score (Tables 1 and 2) for patients receiving care on inpatient units. We excluded the intensive care units and cardiology inpatient care area with a plan for later Shock Tool implementation. Shock Score values ranged from 0 to 110. Before clinical implementation, we calculated Shock Scores for all hospitalized patients within the EMR. Values were hidden from the care team but were available to the investigative team. Based on the daily review of scores in patients with and without SS, a threshold score of 45 was selected. Shock Scores were updated continuously with any new nursing assessment; prior assessments were utilized in the tool calculation within a look-back period of 14 hours if they were not replaced with more recent data. Missing data points (eg, if capillary refill had not been assessed within the look-back period) did not contribute to the score. A series of EMR-based alerts (best practice advisories or best practice alerts, the clinical decision support alerting system of Epic [Epic Systems, Verona, Wis.]) were created to guide the bedside response to an elevated score (Fig. 1).

To improve the care provided to patients at risk for SS, hospital leadership approved the creation of a new nursing position called the “Shock RN” within the unit’s budgeted 20 hours per patient day. The Shock Team,

Table 2. Age-based Vital Sign Thresholds of the Shock Tool

Age	Heart Rate	Respiratory Rate	Systolic Blood Pressure
0 days to 30 days	>185	>60	<60
31 days to 90 days	>185	>60	<70
older than 90 days to 1 year	>185	>60	<70
older than 1 year to 2 years	>185	>40	<72
older than 2 years to 4 years	>140	>40	2 years < 74
older than 4 years to 6 years	>140	>34	3 years < 76
older than 6 years to 10 years	>140	>30	4 years < 78
older than 10 years to 13 years	>100	>30	5 years < 80
older than 13 years	>100	>24	6 years < 82
			7 years < 84
			8 years < 86
			9 years < 88
			<90
			<90

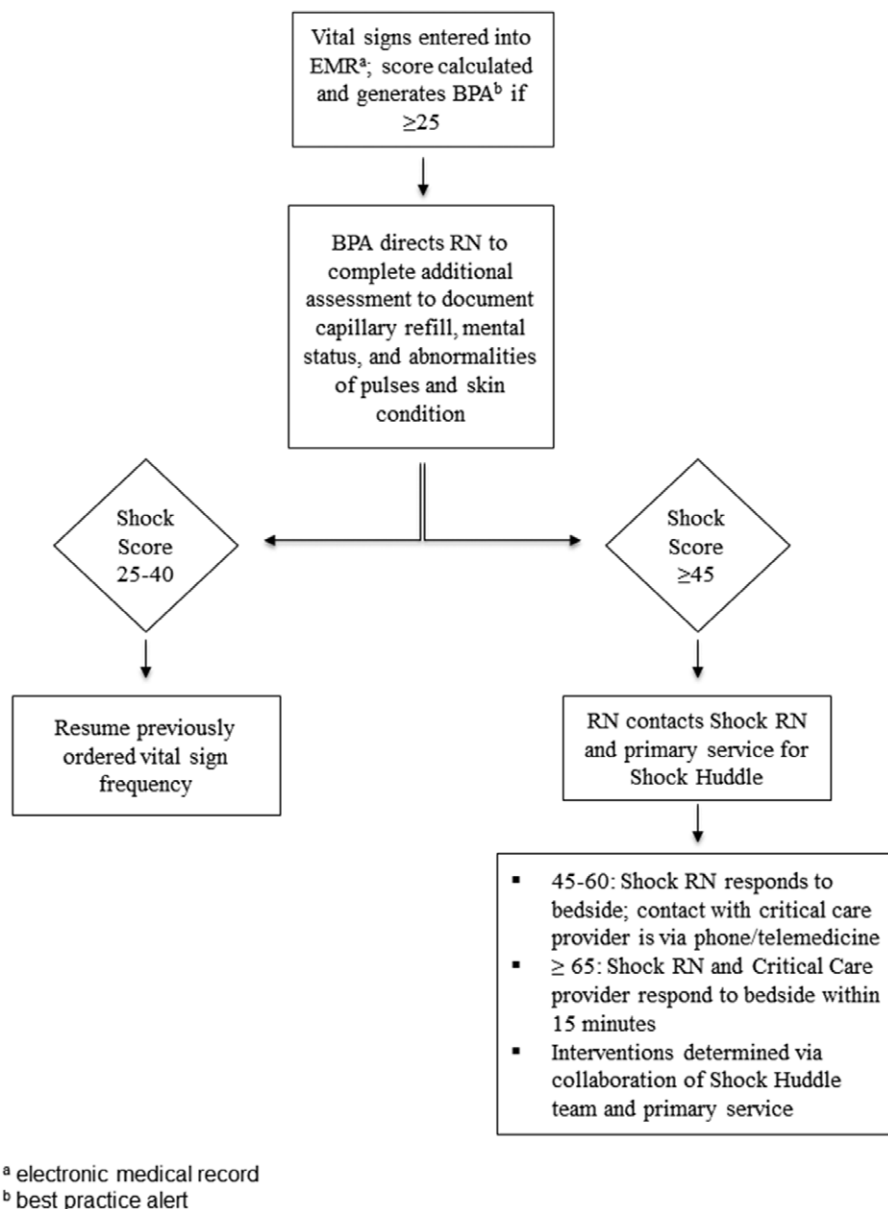


Fig. 1. Shock Huddle process. BPA: best practice alert.

composed of the Shock RN nurse and an ICU provider, evaluated all patients with a score of 45 or greater. The Shock RN was also responsible for serving as the ICU resource nurse and responding to MET activations. Minimum requirements included 2 years of critical care experience and/or the American Association for Critical Care Nurses' nursing certification for pediatric critical care. We conducted a formalized mandatory education course for all nurses interested in fulfilling the Shock RN role several months into the process. This 6-part series, run by the nurse leads of our sepsis team, was an hour-long interactive training session. The scope of the course was broad, included a review of the pathophysiology of sepsis, and discussed the importance of real-time documentation and data collection as it is related to the Shock Tool. The course highlighted the importance of the rapid

deployment of treatments such as fluid resuscitation and antibiotic administration and critically appraised the institution's compliance with order set usage and treatment goals. We provide any nurse completing the course with a resource binder including seminal articles related to pediatric sepsis, national treatment guidelines and our local goals, a copy of the Shock RN policy active at Nemours, and a "cheat sheet" regarding the Shock Huddle process to help eliminate confusion.

Once a patient's Shock Score reached 45, a best practice alert within the EMR alerted the bedside nurse to an elevated score. The bedside nurse communicated with the Shock RN via text to arrange for a Shock Huddle. In the event an increased Shock Score was missed by the bedside nurse, the Shock RN was also responsible for an hourly house-wide review of Shock Scores. Within 15 minutes

of the elevated score, members of the patient's primary team (bedside nurse, resident physician, and attending physician if in-house at the time of the Shock Huddle) gathered at the bedside of the patient with the Shock RN. Importantly, the Shock RN was given autonomy to perform an initial evaluation as long as the patient's Shock Score was below 65. If the Shock Score was 65 or greater, an ICU provider (fellow, advanced practice nurse, or attending physician) joined the Shock RN. The addition of an ICU provider at a score of 65 was decided during initial score selection upon reviewing scores of children who required transfer to the ICU with urgent intervention. During the shock huddle, the primary team gave a brief report of the patient's history and clinical condition before the Shock RN performed an independent assessment of the patient. The reasons for an increased Shock Score (ie, tachycardia, high-risk condition, etc.) were reviewed with the team. The Shock RN communicated the Shock Huddle findings with the pediatric intensive care unit (PICU) attending via a phone call or telemedicine consult (if not already present) and, together, they provided recommendations to the primary team. If there was a concern for sepsis, the huddle team prompted providers toward standardized interventions according to the Sepsis Pathway, which included the use of a sepsis order set with embedded decision support. As an additional layer of surveillance, the Shock RN reviewed the EMR of all hospitalized patients hourly to track those patients with an elevated Shock Score. Inpatient teams continued to have the option of calling the MET via the typical activation system.

There was a staggered rollout of the Shock Tool and Shock Huddle process from April to June 2017. The local IPSO collaborative team conducted an extensive educational program before and during the rollout, including mass emails to all staff, an introduction to the Shock Tool by a member of the sepsis team at departmental meetings, house-wide web-based training for all physicians and nursing staff, and noon conference lectures to the residency program on sepsis screening and septic shock. Clinical nurse specialists and nurse managers were educated and encouraged to review the process with their teams. Early in the quality improvement cycle of the Shock Huddle process, we noted that there were a large number of chronically ill patients who had persistently elevated Shock Scores due to vital sign abnormalities that represented their baseline physiologic state. As a countermeasure, Shock Huddles were limited to occur no more than once every 12 hours unless there was a new clinical concern.

Data related to Shock Huddles performed on hospitalized patients on acute care floors were collected using a paper Shock Huddle Form initially, and then transitioned to an electronic "shock assessment flow sheet" within the EMR. A retrospective chart review was performed to complete and verify data. We compared the total number of admissions, hospital length of stay, PICU length of stay,

and total inpatient mortalities from the study period to data from the prior year. We used Microsoft Excel from Microsoft Office Professional Plus 2016 for data analysis.

RESULTS

Over 1 year, 9,241 eligible inpatient admissions were screened using the Shock Score. Of these admissions, Shock Scores were elevated necessitating a Shock Huddle in 206 cases (2.23% of the total population) involving 109 unique patients. Of available data, the Shock Huddles lasted for 25.4 minutes (SD: 19.7 minute; minimum time: 5 minutes; maximum time: 120 minutes, based on 115 Shock Huddles). Additional demographic information can be found in Table 3.

Nearly 40% of Shock Huddles included a diagnostic or therapeutic intervention at the time of patient assessment, with the most frequent intervention being a fluid bolus (Table 4). Shock Huddles resulted in a patient transfer to the PICU 10% of the time (20/206). Just under one-third of the patients transferred to the ICU required vasoactive support (6/20). Forty percent necessitated significant respiratory support, with 4 patients undergoing endotracheal intubation, 2 patients requiring noninvasive

Table 3. Demographic Information

Characteristic	n (%)
Age (years)	Total 109
0-1	1 (1)
1-2	2 (2)
2-4	3 (3)
4-6	4 (4)
6-10	16 (15)
10-13	36 (33)
>13	47 (43)
Patient service	Total 206
Adolescent medicine	4 (2)
Consultative pediatrics (medically complex and admitted for surgery)	19 (9)
Diagnostic referral service (medically complex and liver transplant)	14 (7)
Gastroenterology	7 (3)
Hematology/oncology/bone marrow	50 (25)
Inpatient pediatrics	50 (24)
Orthopedics	29 (14)
Pulmonology	16 (8)
Rehabilitation medicine	2 (1)
Surgery	8 (4)
Urology	3 (1)
Shock Score parameters contributing to elevated Shock Score	
High risk condition*	140 (68)
Hypotension	153 (74)
Temperature abnormality	74 (36)
Tachycardia	136 (66)
Tachypnea	57 (28)
Delayed capillary refill	28 (14)
Altered mental status	12 (6)
Pulse abnormality	16 (8)
Skin abnormality	59 (29)
Hospital utilization measures	
Hospital length of stay, median (IQR), days	14 (5, 36.5)
In-hospital mortality	2 (1%)

*Includes diagnoses related to neoplasm, asplenia and splenic sequestration, solid organ transplant, bone marrow transplant, intellectual disability, cerebral palsy, and immunodeficiency, and/or the presence of central venous access.

Table 4. Interventions Performed at Shock Huddles (n = 206)

Intervention Type	n (%)
Any diagnostic or therapeutic intervention performed	122 (59)
Fluid bolus	
First	66 (32)
Second	20 (10)
Third	10 (5)
Blood culture	
Obtained as a result of Shock Huddle	30 (15)
Obtained within 24 hours before Shock Huddle	60 (29)
Antibiotics	
New antibiotic ordered	30 (15)
Pre-existing antibiotics	118 (57)
Vasopressor	6 (3)
Transfer to the pediatric intensive care unit	20 (10)

mechanical ventilation, and 2 patients with chronic respiratory failure requiring an increase in the level of their support. There were 2 deaths in this group of patients, 1 within 60 days of the Shock Huddle and 1 within 122 days of the Shock Huddle. We identified a bacterial source of infection in 9 cases (Table 5).

We compared the total number of admissions (10,465 vs 9,955), hospital length of stay (5.4 vs 5.8 days), ICU length of stay (4.4 vs 4.6), and mortalities (54 vs 54) from the study period to historical data from the prior year. There were no significant differences between any of the above parameters.

DISCUSSION

This study demonstrates that implementation of an EMR-based sepsis recognition tool paired with a novel strategy for rapid assessment of at-risk patients by a Shock Team led by a Shock RN is feasible. Near house-wide screening over a 1-year study period resulted in 206 clinical assessments (Shock Huddles); notably, almost 40% of these assessments resulted in a diagnostic or therapeutic intervention.

Table 5. Characteristics of Patients Transferred to the Pediatric Intensive Care Unit after a Shock Huddle

Characteristic	n (%)
Bacterial source	
Blood	4 (20)
Urine	3 (15)
Bronchoalveolar lavage	1 (10)
Stool	1 (10)
Intensive care unit level intervention within 24 hours of transfer	
Vasoactive use	6 (30)
Endotracheal intubation	4 (20)
Initiation of noninvasive mechanical ventilation	2 (10)
Increase of ventilator settings, chronic respiratory failure	2 (10)
Fluid resuscitation > 60 mL/kg	4 (20)
Mortality	2 (10)
Hospital utilization measures, days	Median (IQR)
Intensive care unit length of stay	4 (1,5)
Hospital length of stay	26 (8, 35)

To our knowledge, this is the first time a pediatric critical care nurse has been the driving force behind sepsis surveillance as part of a hospital outreach team. Previous studies have demonstrated the essential role that bedside nurses play in improving the care delivered to patients with sepsis, both regarding recognition of the diagnosis and in adherence to nurse-driven protocols.¹⁸⁻²¹ Bringing the expertise of a critical care nurse to the bedside of patients outside of the ICU is a logical next step.

This novel structure of an alternate rapid response team has been explored in the previous literature. Prior data on MET activations have shown that critical care type interventions occur much less frequently than assessments or ward-level interventions. In a study of 3,647 MET events from 151 hospitals in the United States, 72% of events had only an assessment performed. The most common ward-level interventions performed included the application of supplemental oxygen via mask or nasal cannula and insertion of a peripheral intravenous cannula followed by administration of a fluid bolus.²² Our data are consistent with this, as critical care-level interventions (in this case, the administration of a second or third fluid bolus or the initiation of a vasopressor) occurred relatively rarely (8%) (Table 4). These data suggest that a critical care nurse may serve safely as a leading member of the MET in some instances with appropriate supports in place. We provided a tiered structure in which a Pediatric Critical Care Medicine fellow, advanced practice nurse, or attending physician were mandated to be present for the initial evaluation if the Shock Score was greater than or equal to 65. They were able to offer expertise via a phone call or telemedicine consult for scores less than that to minimize the number of times a critical care physician was required to leave the PICU. Additionally, the use of a nurse as opposed to a critical care fellow or attending physician might provide an additional cost-benefit to hospitals in their utilization of METs, which represents a costly endeavor.²³

There were several noteworthy findings regarding the score breakdown of patients who underwent a Shock Huddle. First, 73% of patients had a high-risk condition (ie, neoplastic diagnosis, asplenia and splenic sequestration, solid organ transplant, bone marrow transplant, intellectual disability, cerebral palsy, immunodeficiency, and/or the presence of central venous access) as part of their elevated score. This observation is consistent with known risk factors for SS.^{2,3} More than two-thirds of patients were hypotensive at the time of their Shock Huddle, even though hypotension is thought to be a late finding in SS. We have used this information to continue to modify our screening tool to enhance its sensitivity and specificity (unpublished data).

The interventions performed at the Shock Huddles are consistent with a report describing the implementation of a pediatric sepsis identification pathway in a single medical/surgical, pediatric unit. Bradshaw et al.²⁴ reported on a paper-based vital sign screen, which triggered a

standardized physician evaluation by a resident member of the primary team. In our process, we opted to utilize a care provider that was not part of the primary team to offer an independent assessment to avoid the potential diagnostic bias of “explaining away” abnormal findings. In the study by Bradshaw et al.,²⁴ 33% of physician evaluations were associated with a plan for a diagnostic or therapeutic intervention, similar to our finding of 37%.²⁵ However, it is interesting to note that the types of interventions varied: our group administered more fluid boluses (28% vs. 12%), and fewer new antibiotic orders were placed (8% vs. 15%). It is likely that these differences are representative of case-mix differences between the two units, though it is difficult to confirm this without additional information. In our cohort, nearly one-quarter of our patients had a blood culture performed in the preceding 24 hours, and 62% were on antibiotics at the time of the Shock Huddle, both of which will impact the results.

It is also unknown whether the patients who had Shock Huddles would have had an ICU assessment via the traditional MET and whether or not this would have occurred later in the patient’s clinical course. A recent study might suggest that these patients were evaluated earlier due to the vital-sign-based trigger of the Shock Tool than with MET activation alone. That study used a large national registry to determine whether METs are appropriately activated when patients who ultimately had a cardiac arrest demonstrated abnormal vital signs. Of 215 patients requiring cardiopulmonary resuscitation, 48 (22.3%) had a MET evaluation within the preceding 24 hours, despite the fact that 36.9% of patients with available vital sign data had abnormal vital signs at least 1 hour before cardiopulmonary resuscitation, suggesting a missed opportunity for MET evaluation and potential intervention.²⁴ Pairing MET evaluation with an EMR-based recognition tool may represent a strategy for increasing evaluation predeterioration.

We did not see a statically significant change in hospital length of stay, PICU length of stay, or inpatient mortalities. Although it is feasible that the early recognition of an elevated Shock Score, delivery of fluid resuscitation, and administration of antibiotics prevented progression from sepsis to SS in a group of patients, we cannot state this definitively, nor was this study designed to examine the potential negative effects of these therapies. However, ongoing quality improvement work at our institution has demonstrated improved adherence to national guidelines regarding the treatment of pediatric septic shock with the utilization of the Shock Huddle. This improved adherence has resulted in a statistically significant decrease in the amount of prevasoactive fluid resuscitation from 88 to 55 mL/kg (abstract in press), and we hope that with further evaluation we will demonstrate improved patient outcomes. Of course, it is additionally important for future studies to examine the potential negative effects of increased screening for sepsis. These might occur at the

patient level, such as fluid overload due to unnecessary fluid resuscitation and antibiotic resistant due to increased use of antimicrobial agents, or at the provider level, such as alarm fatigue caused by the use of automated screening tools and the additional time spent assessing patients who trigger the tool. The generalizability of this study is limited as it was performed at a single, freestanding, academic children’s hospital. Further efforts by our group will focus on continued testing via quality improvement methodology and the validation of the Shock Tool to predict SS.

CONCLUSIONS:

Implementation of an EMR-based sepsis recognition tool paired with a novel strategy for rapid assessment of at-risk patients by a Shock RN is feasible and offers an alternative strategy for delivery of sepsis-related care. Nearly 40% of these assessments resulted in a patient-level intervention, and 10% of assessments ended in a transfer to the PICU. Further study is needed to describe the impact of this process on patient outcomes.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Children’s Hospital Association’s Improving Pediatric Sepsis Outcomes collaborative, a multihospital multiyear collaborative which supported this quality improvement work. This report is an independent work product not produced or endorsed by the Children’s Hospital Association.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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