Evaluation of a Sepsis Alert in the Pediatric Acute Care Setting

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Abstract

Background Severe sepsis can cause significant morbidity and mortality in pediatric patients. Early recognition and treatment are vital to improving patient outcomes.

Objective The study aimed to evaluate the impact of a best practice alert in improving recognition of sepsis and timely treatment to improve mortality in the pediatric acute care setting.

Methods A multidisciplinary team adapted a sepsis alert from the emergency room setting to facilitate identification of sepsis in acute care pediatric inpatient areas. The sepsis alert included clinical decision support to aid in timely treatment, prompting the use of intravenous fluid boluses, and antibiotic administration. We compared sepsis-attributable mortality, time to fluid and antibiotic administration, proportion of patients who required transfer to a higher level of care, and antibiotic days for the year prior to the sepsis alert (2017) to the postimplementation phase (2019).

Results We had 79 cases of severe sepsis in 2017 and 154 cases in 2019. Of these, we found an absolute reduction in both 3-day sepsis-attributable mortality (2.53 vs. 0%) and 30-day mortality (3.8 vs. 1.3%) when comparing the pre- and postintervention groups. Though our analysis was underpowered due to small sample size, we also identified reductions in median time to fluid and antibiotic administration, proportion of patients who were transferred to the intensive care unit, and no observable increase in antibiotic days.

Conclusion Electronic sepsis alerts may assist in improving recognition of sepsis and support timely antibiotic and fluid administration in pediatric acute care settings.

Keywords
- pediatric sepsis
- acute care
- quality improvement

Background and Significance

Sepsis-related morbidity and mortality can be dramatically improved with early identification and intervention.[1–3] Clinical decision support is one tool that has been used to help bring situational awareness to clinicians. Sepsis alerts helped identify patients at-risk for sepsis in our pediatric emergency department and performed well in practical use.[4] Other pediatric emergency departments have implemented similar electronic sepsis alerts and found similar results. Lloyd et al[5] compared an automated tool to a manual review and

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found that the automated tool reduced the time needed to identify sepsis. Balamuth et al[6] and Fesnak et al[7] evaluated the impact of a sepsis alert paired with a huddle or bedside assessment in the pediatric emergency department and found it helped identify cases of sepsis. Vidrine et al[8] implemented a sepsis alert in the pediatric intensive care unit (ICU) and found a sepsis alert in this context improved time between physiologic indicators of sepsis and clinical action. Dewan et al[9] also implemented a sepsis prediction tool and clinical decision support in the pediatric intensive care setting and found that the alert had adequate sensitivity and specificity to identify severe sepsis. Other estimates of embedded sepsis alerts have demonstrated adequate predictive values as a tool to identify cases of severe sepsis.[10] In acute care settings, only two studies to date have evaluated the use of a sepsis identification pathway or clinical decision support.[11,12] Bradshaw et al[11] looked at a manual paper scoring tool rather than an electronic tool and Stinson[12] used a sepsis alert to prompt a form of rapid response team with a designated nurse. Acute care provider teams are often spread across the hospital, with discontinuous coverage, making timely recognition of deteriorating patients more challenging.

The use of a sepsis alert for early warning of sepsis in the pediatric acute care setting has not been reported previously. Therefore, we sought to evaluate the effect of a sepsis alert to improve recognition of sepsis in pediatric patients admitted to acute care.

Objective

The goal of this quality improvement project (QI) was to evaluate the impact of a sepsis alert on sepsis-related mortality in the pediatric acute care setting. We evaluated this by comparing mortality and clinical outcomes in the preintervention year to the postintervention year. We hypothesized that the sepsis alert helped improve early recognition through screening for sepsis; served as an impetus to initiate team huddles to establish a plan and increase situational awareness; and to implement a care bundle of laboratories, fluid resuscitation, and intravenous antibiotics within the first hour of identification.

Methods

Population

This QI project took place at a freestanding 724 bed pediatric and women's hospital with more than 157,000 pediatric emergency visits, 22,000 inpatient admissions, and 35,000 inpatient and outpatient surgeries annually. Our institution previously implemented a sepsis alert through Epic exclusively in the pediatric emergency center setting and partnered with the organization of the Children's Hospital Association (CHA) Improving Pediatric Sepsis Outcomes (IPSO) collaborative to improve sepsis recognition and treatment across our institution. Severe sepsis data have been reported to the IPSO collaborative to facilitate national/local QI activities and to accelerate learning among collaborating organizations. Acute care was defined as non-ICU inpatient wards including the hematology/oncology floors.

To effectively recognize and rapidly treat sepsis in acute care areas, the clinical care team must efficiently work together to identify concerns and establish next steps, given that sepsis outcomes worsen without timely intervention. To achieve this, a sepsis QI team (comprised of multidisciplinary members) focused on the following processes: screening for sepsis, a multidisciplinary huddle to facilitate communication between healthcare providers, and the creation and use of a sepsis order set in the acute care setting. The sepsis QI team reviewed clinical data and facilitated Plan-Do-Study-Act (PDSA) cycles focused on several key drivers to achieve the aim of reducing sepsis-related mortality.

Intervention

Clinical Decision Support

The intervention incorporated a sepsis scoring tool that triggers a sepsis alert, evidence-based order sets, and the use of multidisciplinary huddles to facilitate communication between health care providers. In contrast to adult sepsis tools, the parameters for the sepsis alert had to be tailored for 14 different age groups. Existing pediatric sepsis screening tools were identified via literature review, Epic User Web, and the CHA IPSO Collaborative website. Our institution's emergency department sepsis screening tool was initially selected as the basis for developing inpatient tools, largely maintaining the same criteria, and scoring weights.[4] The sepsis score was calculated by using vital sign parameters pulling from the flowsheet data documented by nurses and patient care assistants such as heart rate; blood pressure; respiratory rate; and temperature, skin perfusion characteristics, capillary refill, pulse quality, neurologic assessment, and history or presence of high-risk conditions (►Fig. 1). High-risk conditions were defined as malignancy, asplenia, bone marrow transplant, indwelling lines or catheters, solid organ transplant, severe developmental delay, immunocompromised or immune suppression, or technology dependence such as the presence of a tracheostomy, gastrostomy, or ventriculoperitoneal shunt. Each characteristic has a weighted numerical score assigned to it, with the sepsis alert triggering once a score of 8 or higher is met. The sepsis alert fires for the patient care assistant (►Fig. 2), the nurse (►Fig. 3), and any provider (►Fig. 4) upon filing vital signs, entering physical assessment data, or upon chart opening. These alerts worked independently of one another. In our emergency department, the sepsis alert showed 81% sensitivity in identifying patients with septic shock.[4] To adapt this alert to acute care, we made a few minor modifications including decreasing weight of high-risk condition, adding history of bolus given in last 12 hours, and adjusting cutoff for the respiratory rate for children older than 16 years of age. This sepsis alert was initially assessed in the background for a trial period of several months to ensure its proper functioning and evaluate triggering frequency. The sepsis scoring tool calculates in real-time, visible to providers via a sepsis flowsheet as well as via a patient list column, increasing situational awareness.

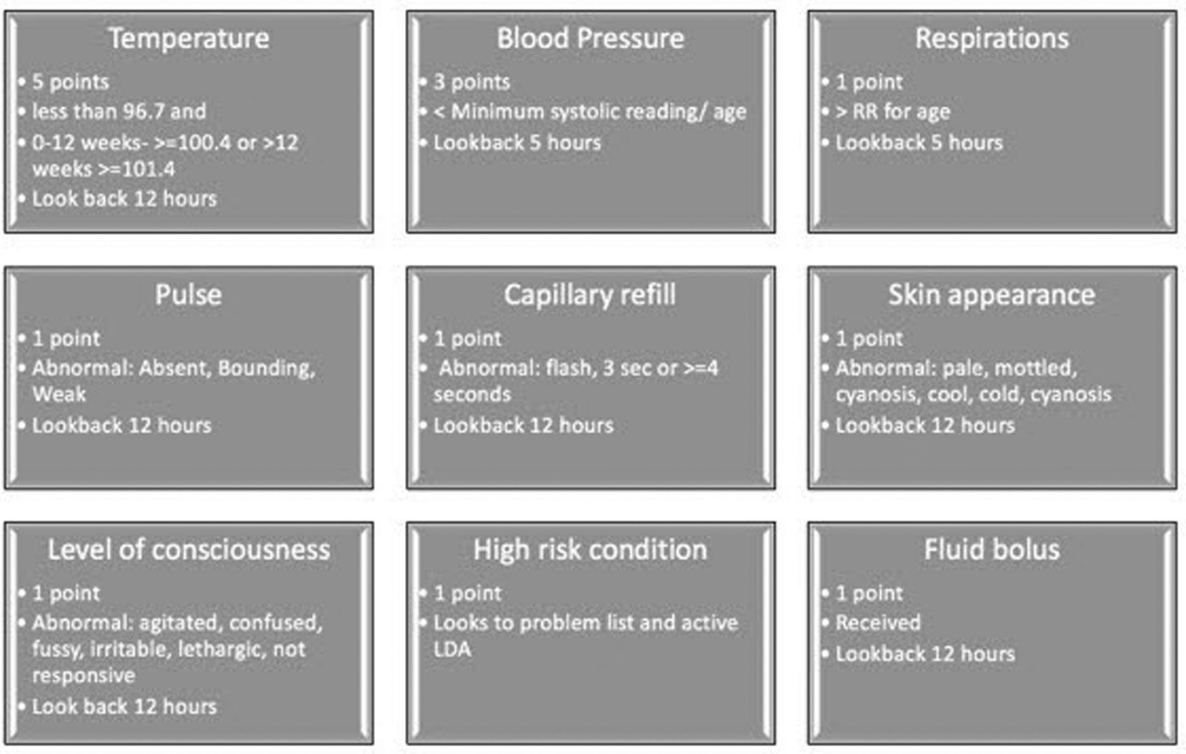


Fig. 1 Sepsis scoring. LDA, lines, drains, and airways documentation to indicate presence of a central line.

The sepsis alert, at each Epic user level, incorporates different acknowledgment reasons with varying associated lockout times that were suggested by the clinical teams. Some acknowledgment reasons have no lockout time to ensure that it will be reviewed by clinicians regularly, whereas some acknowledgments have prolonged lockouts to reduce alert fatigue such as the reason of "comfort care" (lockout time of 48 hours). Additionally, the PCA is instructed to communicate directly with the nurse, as the nurse may not consistently be in the chart at the time vital signs are filed. When the nurse sees the sepsis alert, he or she is expected to notify the physician but then has several options for consideration, including but not limited to notifying the provider, comfort care, rapid response team (RRT)/code team called, or

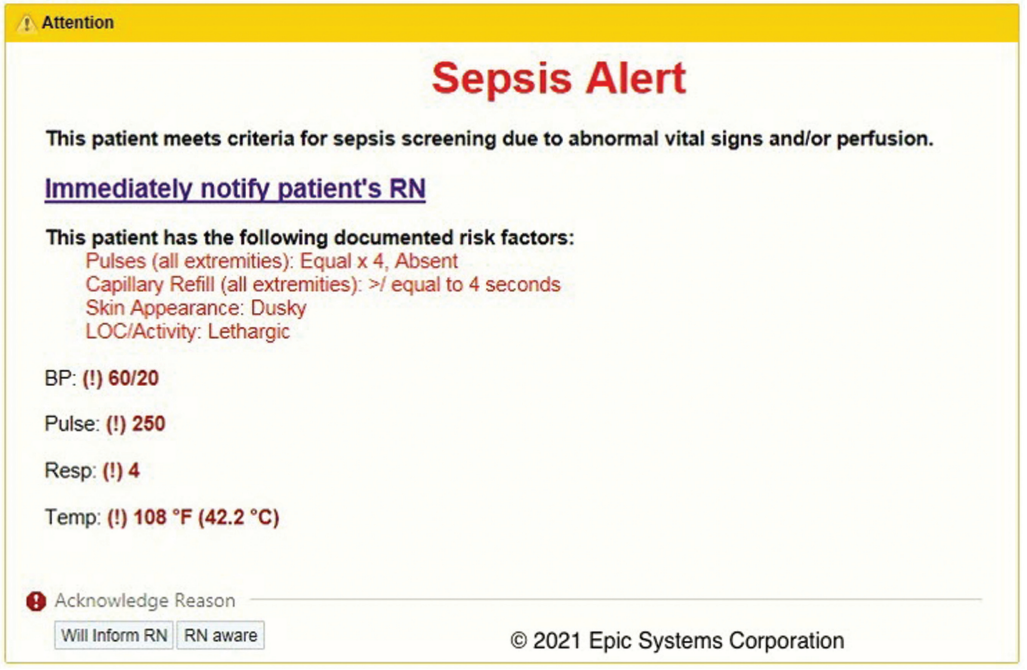


Fig. 2 Sepsis alert for patient care assistants.

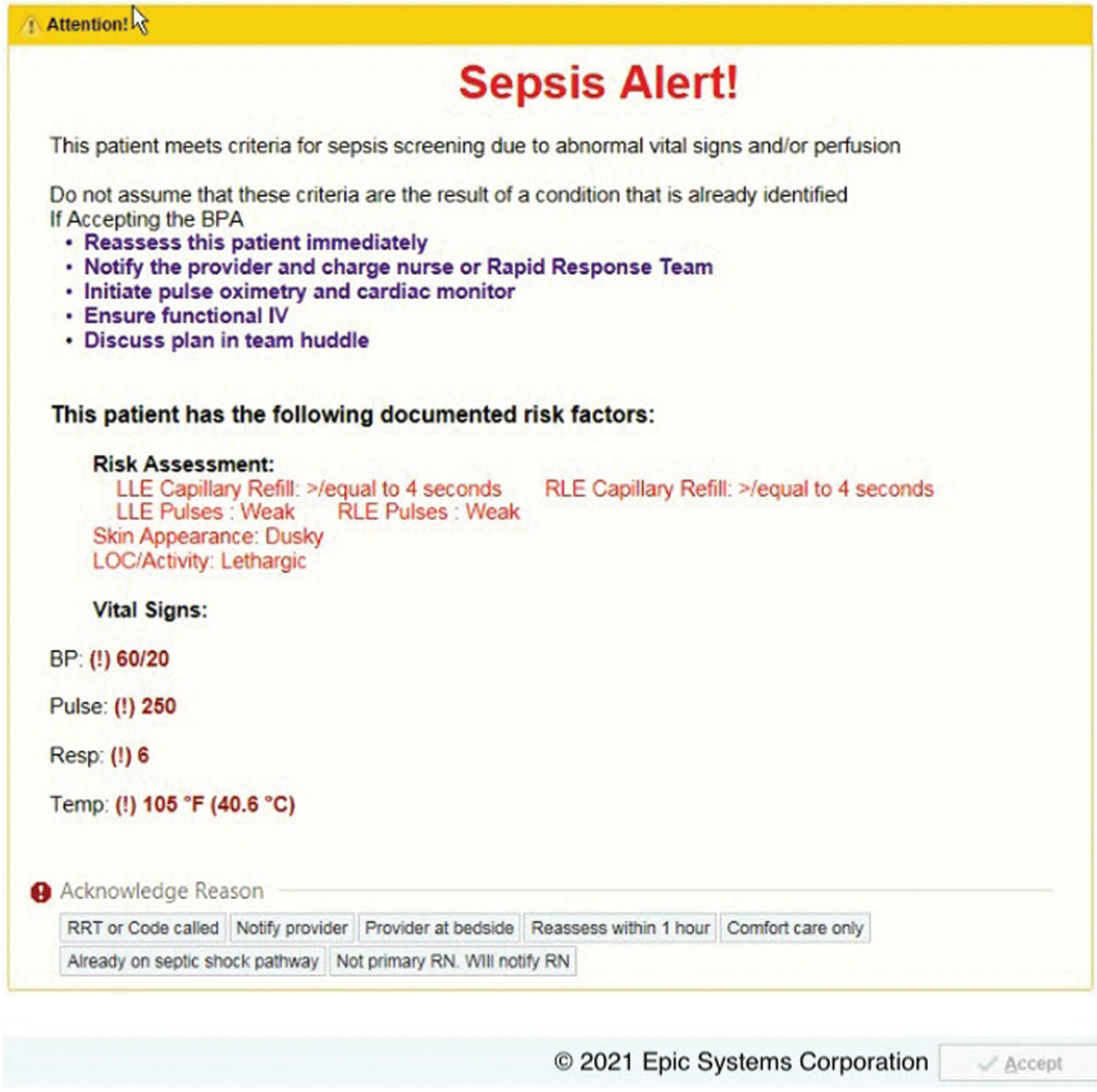


Fig. 3 Sepsis alert for nurses.

already on sepsis pathway. The physician also has multiple options, including remaining on the sepsis pathway algorithm, comfort care, RRT/code called as well as time to assess/reassess. Several incorporated evidence-based order sets assist providers in entering orders directly from the sepsis alert. These order sets were crafted by our institution's Evidence-Based Outcomes Center as a part of our Recognition and Initial Management of Septic Shock Evidence-Based Guideline work.[13] This guideline was based on a literature review in addition to national guidelines and available data for pediatric sepsis care. The order sets include suggested nursing orders for increased monitoring, laboratory tests, and antibiotic administration depending on patients' risk factors. These order sets were developed/coordinated with our pharmacists to ensure that first-dose administration antibiotics were prioritized for preparation and immediate delivery to the bedside. The sepsis alert went into production in August 2018.

Sepsis Huddle and Team Communication

Within 30 minutes of the sepsis alert firing or if a health care provider has a concern for sepsis, a care team huddle is implemented that includes but is not limited to the bedside nurse, primary provider (physician or advanced practice practitioner), charge nurse, patient care assistant, and patient/family. Key components of the huddle include the bedside nurse's presentation of the patient's current condition in the SBAR format (situation/background/assessment/recommendations), the provider's assessment of the patient, and the huddle team's consensus on a plan of care. If the patient is determined to be septic or is experiencing severe sepsis, the team will implement the next course of action, using a sepsis-specific evidence-based order set, which can be customized to an individual patient's needs: additional monitoring, oxygen, fluid resuscitation, antibiotics, and/or diagnostic imaging or laboratory testing to identify a potential infectious source.

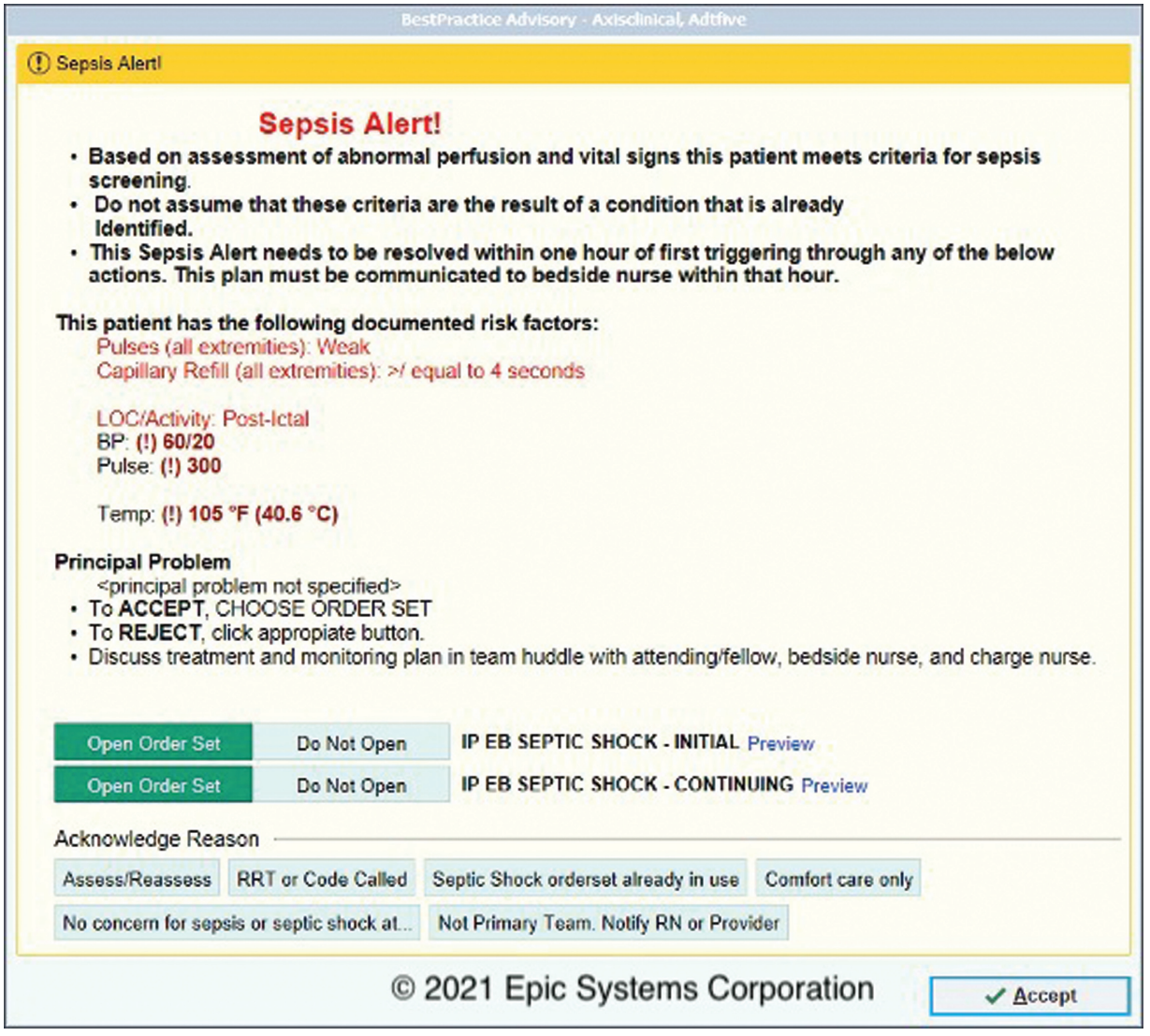


Fig. 4 Sepsis alert for physicians and advanced practice providers.

The patient assessment and response to interventions may determine that the patient may require a higher level of care. If the patient is determined to be stable enough to remain in the acute care unit, the team will decide the reassessment intervals (e.g., 30 minutes and 1, 2, or 4 hours), and placement of the patient on the Watcher's list (an Epic list of patients that provides heightened institutional awareness that a patient may require transfer to a higher level of care and requires closer monitoring). Patients who are placed on the Watcher's list will have a focused assessment and vital signs performed by a registered nurse at least every 3 hours plus a provider assessment performed at least every 6 hours. To facilitate the conversation for the huddles, a laminated reference guide was created and links to the huddle script were placed within the sepsis alert and on the institution's intranet.

If the team decides that the patient is at risk for sepsis and requires antibiotics, the provider specifies on the order that sepsis is the indication for the antibiotics. This indication alerts both the pharmacy and the bedside nurse that the antibiotics were ordered for suspected sepsis. As part of the indication (i.e., sepsis), the provider is reminded at the time of order entry to ensure the first dose for administration is entered as "STAT." Once the antibiotics have been prepared, the pharmacist texts the charge nurse through the Voalte communication system that the antibiotics are ready and are being delivered via the pneumatic tube system to the patient's acute care unit. This communication process facilitates delivery efficiencies by mitigating delays and ensuring first-dose antibiotics that are administered to the patient within 60 minutes of sepsis identification.

At our institution, a Qlikview application was used prospectively to collect sepsis cases through an electronic data warehouse integrated with the electronic health record (Epic). This application was built to aggregate key care processes both at the microsystem and mesosystem levels for review by the Sepsis QI team. Severe sepsis cases were reported to the IPSO collaborative for shared learning.

To evaluate the impact of the sepsis alerts, multidisciplinary huddles, and streamlined processes for the administration of antibiotics, we analyzed outcomes for patients with severe sepsis before and after our QI work. In working with

the IPSO collaborative, the team identified processes, outcomes, and balancing measures to be monitored throughout the intervention period.

Outcomes

The primary outcome measures in this study included in-hospital sepsis-attributable mortality (those whose death was determined on chart review to be likely caused by sepsis) within 3 and 30 days after the identification of sepsis for all pediatric patients admitted to the acute care settings at the time sepsis risk was identified.[14] Secondary outcome measures included hospital length of stay, ICU length of stay, and the rate at which patients were transferred to a higher level of care for patients during the presepsis alert period as compared with the postintervention implementation maintenance phase. Chart reviews were completed by a team of sepsis implementation physician and nurse leaders prior to submission of data to the IPSO collaborative. Process measures included antibiotic timeliness and the time to first bolus in minutes. Our balancing measure included median total antibiotic days, given the concern that increased identification and treatment to prevent septic shock would increase our antibiotic use and potentially contribute to antimicrobial resistance. All outcomes in this evaluation were selected prior to analysis.

Data Collection

The IPSO database was queried for all cases of severe sepsis in the pre- and postintervention period at our institution. The IPSO collaborative has several potential definitions for severe sepsis (later renamed to critical sepsis) including most commonly patient has a positive sepsis alert plus treatment with antibiotics, plus either two fluid boluses or one fluid bolus and a vasopressor within 6 hours. Other potential triggers for addition to the severe sepsis cohort include a positive sepsis huddle or sepsis order set use occurring independently of a sepsis alert. Finally, treatment with antibiotics, blood cultures, and either two fluid boluses or one fluid bolus and a vasopressor administered with either an ICU admission, lactate ordered, or vasopressor administered were considered severe sepsis.[14] The majority of our patients met the first definition (listed above). This operational definition of severe sepsis is consistent with the Weiss et al[15] definitions of severe sepsis in pediatric patients, the IPSO collaborative defines "time zero" as either the time of the sepsis screening alert, the time of the first sepsis order set used, the time of the positive sepsis huddle (if it occurred first), or either the time at which the first fluid bolus or antibiotic was administered, whichever occurred first. Each patient identified as having severe sepsis had baseline information extracted including dates of admission, discharge, and overall length of stay (time at which the huddle occurred, time at which the sepsis alert fired, sepsis order set utilization, time of antibiotic ordered and administered, time of fluid bolus ordered and administered); weight and bolus volumes; vasopressor administration; organ dysfunction; blood culture and lactate orders/results; patient transfer to a higher level of care; and in-hospital mortality. We excluded all patient cases in which "time zero" was in any patient care area outside the acute care units of our institution.

Statistical Analysis

Descriptive statistics were used to describe the patient characteristics between groups during the pre- and post-intervention periods. To evaluate the impact of the QI workaround sepsis in our institution, we compared patient outcomes from the preintervention period in 2017 against the postintervention period in 2019. For primary outcomes, Fisher's exact test was used to determine differences in sepsis-related mortality within 3 and 30 days, the proportion of subsequent ICU transfers between the two groups and sepsis order set utilization. For secondary outcomes, we used the Mann–Whitney U test to see if there were differences between groups to the median time-to-antibiotic or median time-to-fluid administration and antibiotic length of therapy days. We excluded the sepsis episodes with missing data elements during the analyses. We set our α for statistical significance at 0.05.

Results

From January 1, 2017 to December 31, 2017, we had a total of 79 cases of severe sepsis identified in the acute care setting and 154 cases of severe sepsis identified from January 1, 2019 to December 31, 2019. ►Table 1 provides details of the cohorts in the pre- and postintervention groups. Percentage of patients with high-risk conditions were similar between 2017 and 2019, which IPSO defines as malignancy, asplenia, bone marrow transplant, indwelling lines or catheters, solid organ transplant, severe developmental delay, immunocompromised or immune suppression, or technology dependence such as the presence of a tracheostomy, gastrostomy, or ventriculoperitoneal shunt. For our 2019 cohort, the sepsis alert fired in 75.3% of underlying high-risk condition patients with severe sepsis. A total of 83.1% of the 2019 severe sepsis cohort had the sepsis alert fire, demonstrating an adequate sensitivity of the sepsis alert and similar results as the emergency department alert.

Outcomes for pediatric patients in acute care with severe sepsis are presented in ►Table 2 and sepsis-attributable mortality over time is presented in ►Fig. 5. For our primary outcome, we determined an absolute reduction of sepsis-attributable mortality within both 3 days (2.5 vs. 0%, $p = 0.11$) and 30 days (3.8 vs. 1.3%, $p = 0.34$). For our process measures of timeliness from time zero to fluid bolus administration, the median was 135 minutes in 2017, which reduced to 73.5 minutes in 2019 ($p = 0.11$). Our median time from time zero to antibiotic administration was 147 minutes in 2017 compared with 103 minutes in 2019 ($p = 0.44$). The median times were not within the recommended 20 minutes for fluid bolus administration and 60 minutes for antibiotic administration for cases of severe sepsis, but an overall improvement in time-to-administration was encouraging. Newer data have shown relaxed care bundle guidelines (bolus within 60 minutes and antibiotics within 180 minutes) may be adequate to improve outcomes.[16]

Table 1 Baseline characteristics of patients in acute care with severe sepsis

	Preintervention year (2017)	Postintervention year (2019)
Number of severe sepsis episodes	79	154
Total acute care admissions	24,217	26,269
Rate of severe sepsis per 1,000 admissions	3.26	5.86
Median age at time zero (range)	5 y (23 d–22.8 y)	7.6 y (9 d–21.3 y)
Weight (median, IQR)	16.5 kg (10.2– 52.2 kg)	30.3 kg (11.8–45.4 kg)
Payor, % (*n*)		
Public (Medicaid or other related programs)	65.8% (52)	68.2% (105)
Private	30.4% (24)	24.7% (38)
Self-pay or no program	3.7% (3)	7% (11)
Time zero location on acute care floor	69.6%	65.6%
Time zero location on hematology/oncology floor	30.4%	34.4%
Severe sepsis episodes with underlying high-risk conditions[a]	70.9%	66.2%

[a]High-risk conditions included malignancy, asplenia, bone marrow transplant, indwelling lines or catheters, solid organ transplant, severe developmental delay, immunocompromised or immune suppression, or technology dependence such as presence of a tracheostomy, gastrostomy, or ventriculoperitoneal shunt.

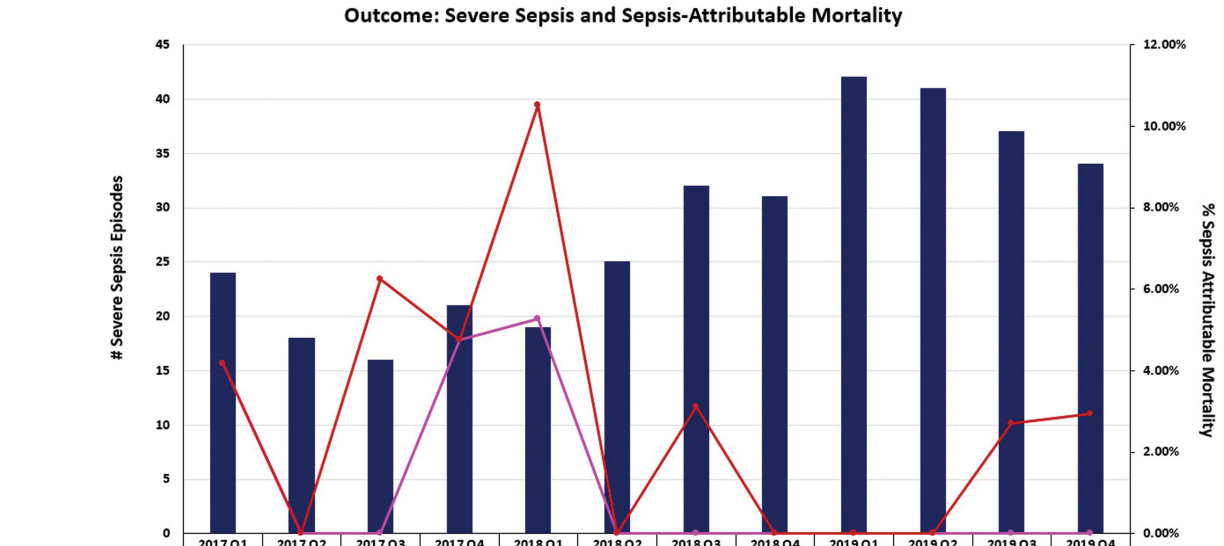
Table 2 Outcomes of patients in acute with severe sepsis

	Preintervention year (2017)	Postintervention year (2019)	Statistical significance
Sepsis-attributable mortality at 3 d, % (*n*)	2.5% (2)	0% (0)	$p = 0.11$
Sepsis-attributable mortality at 30 d, % (*n*)	3.8% (4)	1.3% (2)	$p = 0.34$
All-cause mortality, % (*n*)	6.3% (5)	1.9% (3)	$p = 0.07$
Overall length of stay (median)	20.8 d	15.2 d	$p = 0.08$
Median minutes from time zero to fluid bolus administration	135	73.5	$p = 0.11$
Median minutes from time zero to antibiotic administration	147	103	$p = 0.44$
Patients transferred to intensive care	72.2%	31%	$p < 0.01$
Median antibiotic days	19 d	9 d	$p < 0.01$
Percent of severe sepsis episodes with sepsis order set utilized	11.4%	38.1%	$p < 0.01$

Our evidence-based order set utilization increased, with the percent of patients with severe sepsis having an evidence-based order set used in their care increasing from 11.3% in 2017 to 38.3% in 2019 ($p < 0.01$). When comparing our pre- and post-intervention years, we saw fewer patients with severe sepsis who required transfer to ICU for a higher level of care. In 2017, 72.2% of patients who had severe sepsis were transferred from acute care to our ICUs compared with only 31.8% of patients ($p < 0.01$). During the study period, we found an overall decrease in antibiotic days when comparing 2017 to 2019. There was also a statistically significant reduction in median total antibiotic days in 2017 of 19 days as compared with 9 days in 2019 ($p < 0.01$).

Discussion

In this QI project, we determined that a sepsis alert complemented by other multidisciplinary initiatives, such as sepsis huddles and evidence-based order sets, did not demonstrate a statistically significant reduction in sepsis-related mortality within 3 and 30 days. The observed differences demonstrated may be explained by chance rather than our interventions. We also noted a decrease in all-cause mortality for the postimplementation cohort in addition to a reduction in sepsis-related mortality. This may indicate that the change in the sepsis-attributable mortality may be due to confounding. Notably, we demonstrated improvements both in the timeliness of administration of fluids



	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Q2	2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019 Q3	2019 Q4
# Severe Sepsis Episodes	24	18	16	21	19	25	32	31	42	41	37	34
% Sepsis Attributable Mortality at 3 days	4.17%	0.00%	0.00%	4.76%	5.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
% Sepsis Attributable Mortality at 30 days	4.17%	0.00%	6.25%	4.76%	10.53%	0.00%	3.13%	0.00%	0.00%	0.00%	2.70%	2.94%

Fig. 5 Severe sepsis and sepsis attributable mortality for pediatric patients in acute care at time zero from 2017 to 2019.

and antibiotics as primary interventions to treat severe sepsis. More patients were able to remain in acute care areas and avoid transfer to the ICU, despite reductions noted in median antibiotic days. Although we cannot assume causality from these initiatives, QI work centered around sepsis recognition could potentially translate to decreased hospital costs and decreased burden of hospitalization for the families.

Previous work in improving communication between team members or using clinical decision support (e.g., alerts based on clinical information) has demonstrated improvements in the recognition of sepsis in the pediatric emergency department[4–7] and pediatric critical care settings.[8] Other work in adult patient populations have seen mixed results. Westra et al[17] found that surveillance systems combined with other interventions to promote early recognition were helpful for reducing mortality. In other studies in the emergency room settings[18] or in adult medical and surgical inpatient acute care,[19] sepsis alerts did not demonstrate an impact on mortality. To our knowledge, this is the first instance in which a sepsis alert was implemented in the pediatric acute care setting to evaluate the impact of mortality

Although our number of hospitalizations increased between 2017 and 2019, it is notable that we still had a decrease in overall cases of sepsis per overall hospital admissions to acute care areas. Simultaneously with this work, our colleagues in the emergency department were concurrently implementing QI interventions to increase their situational awareness and intervene in cases of sepsis.

We identified further opportunities for the improvement in our measures of timeliness of antibiotic and fluid administration. For a majority of our patients in the severe sepsis cohort, we did not meet the IPSO recommended timelines, to administer antibiotics within 1 hour of recognition,[20] but we did meet the suggested goal of antimicrobial administration within 3 hours of recognition.[15] We also identified a gap in fluid bolus administration within 20 minutes of recognition of sepsis, but again demonstrated improvements in our median time from recognition to administration.

Concerning our balancing measure of antibiotic days, we recognize that our reduction of 10 antibiotic days between the two groups is not entirely attributable to our sepsis work. Antibiotic administration and management are multifactorial processes. It is important to note that our antimicrobial stewardship team implemented several concurrent interventions to optimize antimicrobial use that may have contributed to this improvement.

This QI project has some limitations. A pre- and postdesign made it difficult to ascertain the cause of differences in outcomes between groups. Even the low incidence of sepsis-related mortality in acute care settings, our small sample size may have contributed to a β (type II) error. Due to system-wide initiatives through the IPSO collaborative, the majority of our severe sepsis patients were recognized in either the emergency department or the intensive care settings. It is important to note that between pre- and postimplementation periods, our institution opened a critical care tower that expanded our capacity to care for critically ill children by both physical space as well as additional structural resources. We did not report the diagnostic accuracy of this alert in this analysis; however, we plan to report this data in future work. In addition, this sepsis alert was implemented within in a single hospital system, and therefore, this tool may not be generalizable.

Conclusion

In conclusion, this sepsis alert and complementary interventions improving shared awareness of early and severe

sepsis demonstrated absolute reductions in sepsis-attributable mortality as well as absolute reductions in time to interventions, namely fluid bolus and antibiotic administration. With this work, we achieved our overarching aim to improve the recognition of sepsis in acute care areas and reduce overall mortality.

Clinical Relevance Statement

This QI looked at the impact of a sepsis alert to improve recognition of pediatric severe sepsis in the acute care setting as well as improve patient clinical outcomes. Our work demonstrated that clinical decision support and greater situational awareness led to an absolute reduction in mortality, though our findings were not statistically significant.

Multiple Choice Questions

1. When implementing an electronic alert, the most important consideration is:
   a. The complexity of the build of the parameters
   b. The five rights: right information, right person, right format, right channel, and right time
   c. The regulatory requirements of the documentation
   d. The frequency at which the best practice alert will fire to the end user

   Correct Answer: The correct answer is option b. When considering clinical decision support, there are many considerations, but the most important to start with are determining the five rights: right information to the right person, through the right channel in the right format, and at the right time.

2. Most papers suggest that a sepsis bundle of first fluid bolus, blood culture, and antibiotics should be administered within:
   a. 15 minutes
   b. 20 minutes
   c. 1 hour
   d. 4 hours

   Correct Answer: The correct answer is option c. Within 2020 surviving sepsis campaign guidelines, they recommend starting broad spectrum antibiotics as soon as possible after recognition as delay has been shown to be associated with worsened outcome. They do concede that if the patient does not have any signs of shock the antibiotics should be administered within 3 hours.

Protection of Human and Animal Subjects

The study was performed in compliance with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and was reviewed by Baylor College of Medicine Institutional Review Board with a waiver of consent.

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None.

Conflict of Interest

None declared.

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References

1 Balamuth F, Weiss SL, Neuman MI, et al. Pediatric severe sepsis in U.S. children's hospitals. Pediatr Crit Care Med 2014;15(09): 798–805
2 Scott HF, Balamuth F, Paul RM. Sepsis bundles and mortality among pediatric patients. JAMA 2018;320(21):2271
3 Weiss SL, Fitzgerald JC, Pappachan J, et al; Sepsis Prevalence, Outcomes, and Therapies (SPROUT) Study Investigators and Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network. Global epidemiology of pediatric severe sepsis: the sepsis prevalence, outcomes, and therapies study. Am J Respir Crit Care Med 2015;191(10):1147–1157
4 Cruz AT, Williams EA, Graf JM, et al. Test characteristics of an automated age- and temperature-adjusted tachycardia alert in pediatric septic shock. Pediatr Emerg Care 2012;28(09):889–894
5 Lloyd JK, Ahrens EA, Clark D, Dachenhaus T, Nuss KE. Automating a manual sepsis screening tool in a pediatric emergency department. Appl Clin Inform 2018;9(04):803–808
6 Balamuth F, Alpern ER, Abbadessa MK, et al. Improving recognition of pediatric severe sepsis in the emergency department: contributions of a vital sign-based electronic alert and bedside clinician identification. Ann Emerg Med 2017;70(06):759–768.e2
7 Fesnak S, Abbadessa MK, Hayes K, et al. Sepsis in complex patients in the emergency department: time to recognition and therapy in pediatric patients with high-risk conditions. Pediatr Emerg Care 2020;36(02):63–65
8 Vidrine R, Zackoff M, Paff Z, et al. Improving timely recognition and treatment of sepsis in the pediatric ICU. Jt Comm J Qual Patient Saf 2020;46(05):299–307
9 Dewan M, Vidrine R, Zackoff M, et al. Design, implementation, and validation of a pediatric ICU sepsis prediction tool as clinical decision support. Appl Clin Inform 2020;11(02):218–225
10 Rolnick J, Downing NL, Shepard J, et al. Validation of test performance and clinical time zero for an electronic health record embedded severe sepsis alert. Appl Clin Inform 2016;7(02): 560–572
11 Bradshaw C, Goodman I, Rosenberg R, Bandera C, Fierman A, Rudy B. Implementation of an inpatient pediatric sepsis identification pathway. Pediatrics 2016;137(03):e20144082
12 Stinson HR, Viteri S, Koetter P, et al. Early experience with a novel strategy for assessment of sepsis risk: the shock huddle. Pediatr Qual Saf 2019;4(04):e197
13 Center TCsHE-BO. Recognition and Initial Management of Septic Shock Evidence-Based Guideline. Accessed 2017 at: https://www.ccjm.org/content/87/1/53
14 Larsen GY, Brilli R, Macias CG, et al; IMPROVING PEDIATRIC SEPSIS OUTCOMES COLLABORATIVE INVESTIGATORS. Development of a quality improvement learning collaborative to improve pediatric sepsis outcomes. Pediatrics 2021;147(01):e20201434
15 Weiss SL, Peters MJ, Alhazzani W, et al. Surviving sepsis campaign international guidelines for the management of septic shock and sepsis-associated organ dysfunction in children. Pediatr Crit Care Med 2020;21(02):52–106

16 Paul R, Brilli R, Macias C, et al. 32: Improving pediatric sepsis outcomes for all children together (IPSO FACTO): interim results. Crit Care Med 2021;49(01):17
17 Westra BL, Landman S, Yadav P, Steinbach M. Secondary analysis of an electronic surveillance system combined with multi-focal interventions for early detection of sepsis. Appl Clin Inform 2017; 8(01):47–66
18 Berger T, Birnbaum A, Bijur P, Kuperman G, Gennis P. A computerized alert screening for severe sepsis in emergency department patients increases lactate testing but does not improve inpatient mortality. Appl Clin Inform 2010;1(04):394–407
19 Downing NL, Rolnick J, Poole SF, et al. Electronic health record-based clinical decision support alert for severe sepsis: a randomised evaluation. BMJ Qual Saf 2019;28(09): 762–768
20 Evans IVR, Phillips GS, Alpern ER, et al. Association between the new york sepsis care mandate and in-hospital mortality for pediatric sepsis. JAMA 2018;320(04):358–367