High Reliability Pediatric Septic Shock Quality Improvement Initiative and Decreasing Mortality

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abstract

BACKGROUND AND OBJECTIVE: Septic shock impacts mortality, morbidity, and health care costs. A quality improvement (QI) initiative was launched to improve early recognition and timely treatment of patients with septic shock in a pediatric emergency department (PED). Our primary aim was to describe the longitudinal effectiveness of the program, iterative changes in clinical practice, and associated outcomes.

METHODS: We implemented multiple interventions during our QI initiative (February 2007 to December 2014). Analysis of compliance and outcomes focused on a bundle consisting of: (1) timely antibiotics, (2) intravenous fluids (IVF) for rapid reversal of perfusion abnormalities and/or hypotension. Logistic regression was used to obtain adjusted odds ratios (ORs) for death and pediatric ICU (PICU) admission.

RESULTS: A total of 1380 patients were treated for septic shock; 93% met screening criteria at triage. Implementation of the various processes improved timely interventions. One example included implementation of a sepsis order set, after which the mean proportion of patients receiving timely antibiotics increased to its highest rate. The odds of death were 5 times as high for children who did not receive bundle-compliant care (OR, 5.0 [95% Confidence Interval 1.9, 14.3]) compared with those who did (OR, 0.20 [95% Confidence Interval 0.07, 0.53]). Among PICU admitted patients, the odds of mortality were greater for children who presented with abnormal mental status and a higher pediatric index of mortality 2 score.

CONCLUSIONS: QI methodology improved septic shock program goal adherence and decreased mortality without increasing PICU admissions or PED length of stay over the 8-year period, supporting continued emphasis on early recognition, timely IVF resuscitation, and antibiotic administration.

Sepsis, severe sepsis, and septic shock significantly contribute to pediatric mortality, morbidity, and health care costs.[1–7] Rapidly restoring perfusion and/or correcting hypotension are paramount to improving outcomes.[8–12] Clinical guidelines for pediatric and neonatal septic shock[13,14] are endorsed by the American College of Critical Care Medicine and incorporated into the Pediatric Advanced Life Support (PALS) treatment guidelines.[15–17] Improved outcomes associated with PALS-directed management of children have been described in a variety of clinical settings.[8,10,11,14,18–20] Septic shock quality improvement (QI) initiatives in pediatric emergency departments (PED) have identified compliance barriers and demonstrated improved outcomes with adherence to the

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American College of Critical Care Medicine/PALS guidelines.[19–22]

Before February 2007, we did not have a standardized process for identifying or managing PED patients with septic shock. An analysis revealed inconsistency among providers regarding fluid administration strategies, antibiotic selection and timing, and laboratory evaluation. Compliance with and awareness of pediatric septic shock national guidelines and recommendations were low among PED personnel.

We report our experience of implementing and sustaining a longitudinal iterative QI program, describe the effect on outcomes, including mortality, hospital length of stay (LOS), pediatric ICU (PICU) admission, and PICU LOS and cost, and address barriers to achieving high levels of compliance with program goals.

METHODS

Setting and Context

Primary Children's Hospital (PCH) is a 289-bed, freestanding, university-affiliated, tertiary pediatric hospital with ~41 000 PED visits annually, 13 000 general admissions, and 2600 PICU admissions. PCH serves as a referral children's hospital for Utah and surrounding regions, including portions of Nevada, Idaho, Montana, and Wyoming.

The PED uses an electronic health record that is incapable of computerized physician order entry, nursing documentation, and electronic alerts, but provides access to laboratory results, images, and clinical notes. All order sets, general orders, treatment guidelines, and charting are paper based.

Interventions

In 2006, we established a multidisciplinary team consisting of a PED physician and nurse practitioner, a PICU physician, and system improvement staff to address the need for a PED septic shock recognition and management program. After reviewing national pediatric septic shock treatment recommendations, the team identified areas for improvement and developed a recognition and treatment guideline, which was implemented in 2007.

For septic shock patients, the guideline stipulates placing the patient on cardio-respiratory monitors and oxygen, rapid establishment of intravenous or indwelling catheter access, criteria for intraosseous access, rapid intravenous fluid (IVF) delivery (unless contraindicated, ie, due to heart or kidney failure), timely antibiotic delivery, basic laboratory evaluation, and vasoactive medications for fluid-refractory shock. Basic laboratory requirements include complete blood count with differential, blood culture, lactate, blood gas (capillary or venous), and select electrolytes; point-of-care testing at the bedside assesses the latter 3. Source-specific evaluation is based on history and physical examination.

To standardize our approach and facilitate early identification, the guideline includes a screening tool/algorithm (Supplemental Fig 3). All PED patients undergo screening at triage and are assessed throughout their stay. If a patient screens positive: (1) an alert is broadcast to all PED personal communication badges, the patient is moved to a treatment room, and the attending physician notified; (2) bedside handoff and team huddle (attending, resident or licensed independent practitioner, nurse, technician, and respiratory therapist) are performed to assess for signs of septic shock; and (3) if hypotension and/or perfusion abnormalities are identified, the septic shock pathway is initiated. When the pathway is initiated (not limited to triage), a "code sepsis" alert is broadcast to all PED personnel and intravenous team. A pharmacist responds to facilitate antibiotic ordering and delivery, and a trauma charge nurse responds to assist with procedures, intravenous access, and IVF delivery.

Patients with septic shock constitute <0.5% of the annual PED census. To heighten awareness, an educational campaign was extended to all PED personnel and took place in the form of presentations during divisional meetings, nursing education modules, and dissemination (E-mail and paper) of the guideline. The guideline was made readily available in the PED. Nursing instruction was provided regarding rapid IVF administration techniques (push–pull, rapid infuser, and pressure bag).

Study of the Interventions

To evaluate the impact of the program, we used a quantitative time-series study design. Time 0 was the time at which a patient met screening criteria after a complete nursing assessment. The majority of patients screened positive at triage, but could screen positive at any time. For patients not meeting criteria at triage, vital signs and physical findings were reviewed to determine time 0. Time 0 and times to interventions were extracted from the medical record and the patient tracking system. Annotated run-charts and p-charts were used monthly to depict the proportion of patients with compliant care for antibiotic and IVF goals. To monitor order set compliance and the screening tool false positive rate, monthly run charts were used. Special cause variations were investigated.[23] Subsequent iterative efforts were informed by Pareto analyses.

Cohort Identification

Patients were identified through a series of electronic screens, followed

TABLE 1 Select Patient Characteristics, Clinical Findings, and Bundle Receipt

	Received Bundle			
	No (*N* = 261)	Yes (*N* = 1119)	Overall (*N* = 1380)	*P*
Sex: male, (%)	131 (50.2)	518 (46.3)	649 (47.0)	.256[a]
Age category, (%)				.863[a]
≤3 mo	24 (9.2)	116 (10.4)	140 (10.1)	
4–23 mo	55 (21.1)	256 (22.9)	311 (22.5)	
2–5 y	71 (27.2)	310 (27.7)	381 (27.6)	
6–11 y	44 (16.9)	169 (15.1)	213 (15.4)	
≥12 y	67 (25.7)	268 (23.9)	335 (24.3)	
Race/ethnicity (Hispanic/Latino and white), (%)	219 (83.9)	939 (83.9)	1158 (83.9)	.424[a]
Patient discharged with at least 1 CCC diagnosis code, (%)	103 (39.5)	480 (42.9)	583 (42.2)	.312[a]
Malignancy[b], (%)	12 (4.6)	107 (9.6)	119 (8.6)	.010[a]
Met sepsis criteria, (%)				.980[a]
At triage	242 (92.7)	1036 (92.6)	1278 (92.6)	
Later in ED stay	17 (6.5)	73 (6.5)	90 (6.5)	
Not met (provider concern for sepsis)	2 (0.8)	10 (0.9)	12 (0.9)	
ED disposition, (%)				.573[a]
Floor	167 (64.0)	695 (62.1)	862 (62.5)	
ICU	94 (36.0)	424 (37.9)	518 (37.5)	
Selected vital signs and clinical features[c], (%)				
Abnormal temperature[d]	212 (81.2)	901 (80.5)	1113 (80.7)	.882[a]
Hypotension[d]	32 (12.3)	122 (10.9)	154 (11.2)	.762[a]
Tachycardia	225 (86.2)	923 (82.5)	1148 (83.2)	.148[a]
Tachypnea[d]	191 (73.2)	814 (72.7)	1005 (72.8)	.788[a]
Abnormal capillary refill time[d,b]	97 (37.2)	509 (45.5)	606 (43.9)	.009[a]
Abnormal mental status[d]	50 (19.2)	213 (19.0)	263 (19.1)	.740[a]
Pulse abnormality[d,b]	34 (13.0)	244 (21.8)	278 (20.1)	.006[a]
Skin Appearance[d]	182 (69.7)	813 (72.7)	995 (72.1)	.161[a]
PIM2 risk, median (Q1, Q3)[e]	1.0 (0.4,1.6)	1.1 (0.4,1.8)	1.0 (0.4,1.8)	.293[f]
Died during hospitalization[b], (%)	11 (4.2)	13 (1.2)	24 (1.7)	<.001[a]
Admission to PICU within 12 h of hospital admission, (%)	104 (39.8)	444 (39.7)	548 (39.7)	.960[a]
PICU LOS (d), median (Q1, Q3)[g]	1 (1, 4)	2 (1, 4)	2 (1, 4)	.380[f]
Hospital LOS (d), median (Q1, Q3)[g]	3 (1, 5)	3 (2, 6)	3 (2, 6)	.485[f]
ED cost (USD, adjusted for inflation), median (Q1, Q3)[b]	835 (738, 1006)	874 (742, 1039)	868 (740, 1030)	.030[f]
Total hospital cost (USD, adjusted for inflation), median (Q1, Q3)	8489 (3973, 20859)	9029 (4472, 21 149)	8857 (4408, 20 859)	.561[f]

Q, quartile; USD, US dollars.

[a] χ^2 test.

[b] Indicates $P < .05$.

[c] Vital sign parameters and clinical feature definitions are listed in Supplemental Fig 3.

[d] The following number of patient visits were omitted because of missing data from the percentage calculations for the following variables: abnormal temperature (*n* = 8), hypotension (*n* = 54), tachypnea (*n* = 2), abnormal capillary refill time (*n* = 58), abnormal mental status (*n* = 15), pulse abnormality (*n* = 210), and skin appearance (*n* = 18).

[e] PIM2 risk only calculated for PICU patients.

[f] Two-sided Wilcoxon rank-sum with normal approximation and continuity correction.

[g] PICU and hospital LOS analyses exclude deaths.

by a 2-stage chart review process. On a bimonthly basis, we generated a list of all admitted PED patients between the ages of 0 days and <19 years old (February 1, 2007 through December 31, 2014). Patients were excluded if they presented with anaphylaxis, diabetic ketoacidosis, submersion injury, or trauma designation. The following electronic filters were applied to identify possible cohort candidates: (1) lactate assessed in the PED (prechecked item on the order set); (2) admission to the PICU directly or within 12 hours of the PED visit; and (3) level 1 triage (highest level of acuity; all patients who screen positive are triaged level 1). Other filters were added and subsequently removed because they contributed an inconsequential number of patients (≤5 total, combined), including a PED encounter within 48 hours of an index visit and an inpatient sepsis rapid response within 12 hours of admission. Patients were flagged for possible inclusion during preliminary bimonthly review by one of the team clinicians. Identified patient records underwent extensive assessment by a designated system improvement analyst who determined patient inclusion based on established criteria. If inclusion was unclear after detailed review, the case was presented during the monthly meeting and consensus was achieved among team members. To enhance consistency of patient inclusion, a septic shock case review algorithm was created in 2012 (available by request). Formal interrater reliability testing was not performed. When necessary, clarification was obtained from the treating clinician(s).

Measures

Process measures included the proportion of patients who received goal-compliant care for IVF and antibiotic administration, analyzed individually and as a bundle. The bundle represents the primary metric for program compliance analysis (target goal 85%). We monitored the performance characteristics of the screening tool (2013 to 2014) and compliance with the physician-in-room time goal. Outcome measures included the proportion of patients who died or were admitted to the PICU and PICU and hospital LOS. Additional metrics were tracked but not reported (eg, use of oxygen, obtaining blood cultures before the initiation of antibiotics, and clinician documentation of initial perfusion and response to therapeutic interventions). For balancing measures, we examined the median LOS for all patients in the PED, PICU admission rates, and adverse events related to program interventions. Additionally, we measured hospital (costs incurred during the admission) and PED costs.

Statistical Analysis

Patient characteristics were summarized by using counts and percentages for categorical data and median, first, and third quartiles for continuous data. Missing values were excluded from summary calculations. Univariate associations of bundle compliance with outcome were assessed using the χ^2 test for PICU admission within 12 hours and the Wilcoxon rank-sum test for PICU and hospital LOS. Costs were adjusted for inflation using the Consumer Price Index obtained from the Bureau of Labor Statistics (http://www.bls.gov/cpi/). Bundle compliance rates were calculated by calendar month and summarized graphically using p-charts. Control limits were set to 3 SDs from the mean. Outcomes were compared between patients who

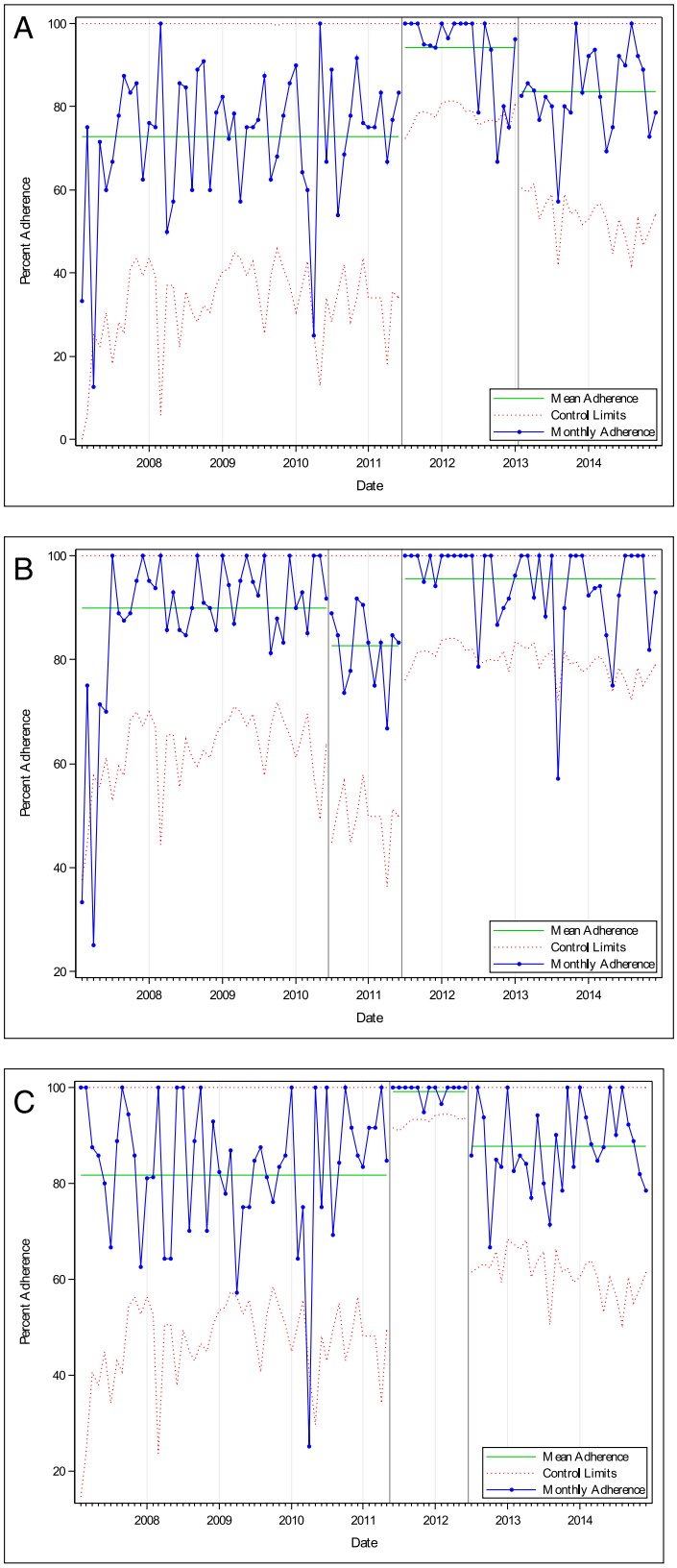

FIGURE 1
Statistical process control charts for process measure compliance. A, Bundle compliance. B, IVF compliance. C, Antibiotic compliance. Key interventions: January 2011 order set implemented and October 2012 antibiotic administration timing change (from 3 hours to 1 hour).

received bundle-compliant care and those that did not.

In-hospital mortality for patients treated for septic shock in the PED was illustrated with a g-chart. Logistic regression was used to obtain the adjusted odds ratios (ORs) of death and PICU admission. γ Regression with a log link function was used to analyze the total emergency department (ED) and hospital costs, as well as the PICU LOS. Negative binomial models were used to analyze ED and hospital LOS. To remedy the overdispersion of the LOS data, we fixed the dispersion parameter at a value of 1 in the estimation procedure so the estimated SEs are adjusted to achieve models that are optimally dispersed. To construct these final models, backward stepwise selection was used. Candidate covariates with significant association (significance level $\alpha = 0.15$) with the outcome were kept in the model. We used the Akaike information criterion to compare models. Goodness of fit for logistic regression models was assessed with the Hosmer–Lemeshow test. Mortality is reported as both deaths within 7 days of ED admission and during the total hospital stay. The Cochran–Armitage test was used to evaluate the trend in physician-in-room-time.

Analyses of individual care elements included percentage compliance with each element of the guideline during the ED visit. Complex chronic conditions (CCCs) using established codes[24] were defined as having ≥1 systems involved and were used to compare outcomes. All statistical analyses were performed in SAS version 9.4 (SAS Institute, Inc, Cary, NC). Charts and graphs were created by using Excel (Microsoft, Redmond, WA), R version 3.1.1 (The R Foundation, Vienna, Austria), and SAS version 9.4.

TABLE 2 Septic Shock Screening Algorithm/Tool Test Characteristics

	2013	2014
Sensitivity % (95% CI)	97 (95–99)	100 (100–100)[a]
Specificity % (95% CI)	98 (98–98)[b]	97 (97–98)[b]
PPV % (95% CI)	24 (21–27)	15 (13–17)
NPV % (95% CI)	100 (100–100)[b]	100 (100–100)[b]

CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.
(false positive and true negative) difficult to detect.
[a] There were no false negatives in 2014.
[b] There were >30 000 true negatives, making the influence of other factors

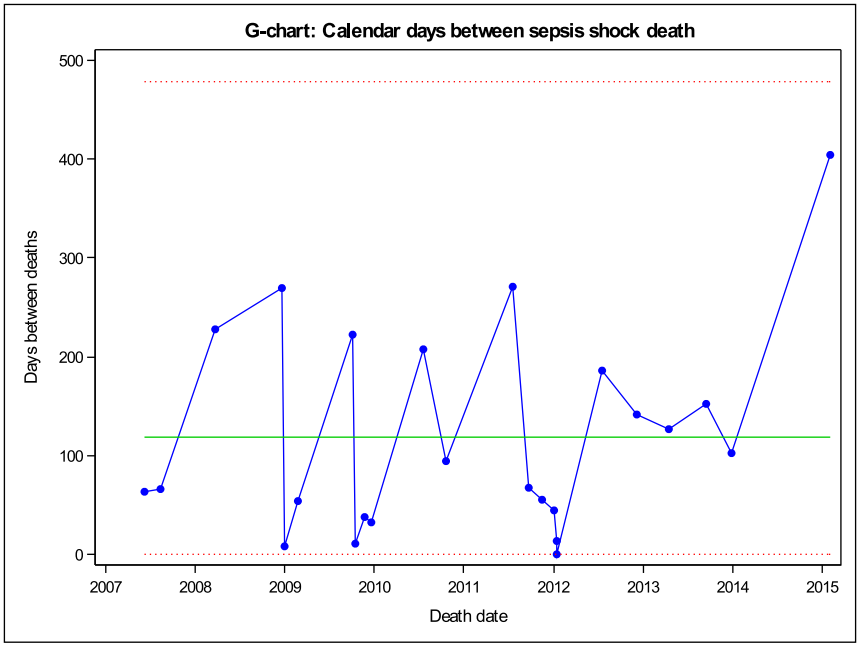

FIGURE 2
G-chart depicting days between in-hospital deaths of patients treated for septic shock in the PED (there were no deaths in 2014; the next death was included, which occurred in February 2015.

Ethical Considerations

The study was approved and a waiver of informed consent granted by the University of Utah institutional review board and the PCH privacy board. No conflicts of interest were identified.

RESULTS

Population Description

During the study period, 1380 patients were treated for septic shock in the PED, and 1278 (93%) met screening criteria at triage. Demographic and clinical features are presented in Table 1.

There were no differences in age, sex, or number of CCCs between patients whose care was compliant versus noncompliant with the bundle. The cohort had a median age of 3.8 years (range, 1.4–11.7 years), 53% (731) were female, and 42% (583) had ≥1 CCC. Hypotension was documented in 154 (11%) of patients.

Intervention Evolution

Program revisions resulted from provider feedback to improve clarity and utility, whereas others reflected iterative changes derived from p-charts and Pareto analyses. An example of the latter is decreasing the time-to-antibiotic-administration

TABLE 3 Adjusted Odds of Death (n = 1353)

Predictors	Category	Adjusted ORs (95% CI)
Age category[a]	≤3 mo	<0.01 (<0.01–>999)
Age category[a]	4–23 mo	1.20 (0.43–3.33)
Age category[a]	2–5 y	0.27 (0.06–1.24)
Age category[a]	6–11 y	<0.01 (<0.01–>999)
Sex	Male	1.41 (0.55–3.65)
Met sepsis criteria at triage	Yes	0.26 (0.07–0.96)
Patient discharged with ≥1 CCC diagnosis code	Yes	2.08 (0.70–6.16)
Abnormal mental status[b]	Yes	3.18 (1.17–8.64)
Abnormal skin appearance[b]	Yes	4.15 (0.80–21.46)
Received bundle	Yes	0.20 (0.07–0.53)
PIM2 Risk		1.04 (1.01–1.08)

[a] Age category reference is ≥12 y.
[b] Vital sign parameters and clinical feature definitions are listed in Supplemental Fig 3.

TABLE 4 Adjusted Odds of PICU Admission (n = 1100)

Predictors	Category	Adjusted ORs (95% CI)
Age category[a]	≤3 mo	1.04 (0.61–1.78)
Age category[a]	4–23 mo	0.68 (0.45–1.04)
Age category[a]	2–5 y	0.39 (0.26–0.58)
Age category[a]	6–11 y	0.66 (0.42–1.03)
Sex	Male	0.87 (0.66–1.16)
Met sepsis criteria at triage	Yes	0.42 (0.24–0.73)
Cardiovascular (CCC)	Yes	2.10 (1.29–3.40)
Gastrointestinal (CCC)	Yes	1.09 (0.41–2.92)
Neuromuscular (CCC)	Yes	2.29 (1.55–3.37)
Other congenital or genetic (CCC)	Yes	1.82 (1.20–2.77)
Hypotension[b]	Yes	3.36 (2.06–5.49)
Abnormal temperature[b]	Yes	0.35 (0.24–0.50)
Abnormal capillary refill[b]	Yes	1.33 (0.99–1.78)
Abnormal mental status[b]	Yes	3.56 (2.49–5.11)
Pulse abnormality[b]	Yes	1.73 (1.23–2.44)
Received bundle	Yes	0.87 (0.60–1.25)

[a] Age category reference is ≥12 y.
[b] Vital sign parameters and clinical feature definitions are listed in Supplemental Fig 3

from 3 hours to 1 hour in 2012. Pharmacists were instrumental in planning, implementation, and subsequent interventions. High risk conditions with risk stratification were added to the screening tool in 2012. Specific evidence-based recommendations were added to guide selection of vasoactive agents.[13] Transfusion parameters and prompts to address metabolic abnormalities were added. We received provider feedback about being too prescriptive with IVF requirements; therapeutic goals of fluid resuscitation were adapted to emphasize correcting perfusion abnormalities and/or hypotension within 1 hour.[1,13,14,17] This adjustment resulted in greater awareness and consistent detection of perfusion abnormalities among the entire PED staff. Throughout the project, a minimum of 40 mL/kg has been recommended. Although an infrequent occurrence, care was considered compliant if the provider clearly documented that perfusion abnormalities were corrected with less IVF.

To prompt screening and improve recognition, we distributed a laminated quick reference card summarizing physical findings and age-adjusted vital signs to all PED personnel for their badge clip. The screening tool algorithm was laminated and posted in strategic locations in the PED, including the triage desk.

An order set (paper) was implemented January 2011 reflecting all key aspects of care in the guideline (updated in accordance with guideline changes). Order sets are available in triage and areas of the PED with the specific slot colored bright red for easy, fast recognition. A technician responds to all positive screen alerts and brings an order set and point-of-care testing equipment to the room.

The improvement team now includes pharmacy and antibiotic stewardship personnel and a PED nurse educator. Source control has been emphasized and a site/source-specific antibiotic table was created with the antibiotic stewardship team.

Modifying clinician behavior with guideline adherence presented a significant barrier, which has been previously described.[25] Timely feedback (in-person or E-mail) to physicians, nurses, technicians, and pharmacists to discern barriers and to provide positive feedback has led to significant gains in adherence. Poor documentation was found to be a barrier to compliance analysis. Communication to providers regarding missing elements has resulted in a notable decrease in missing documentation.

To enhance education we created an American Board of Pediatrics Maintenance of Certification curriculum for PICU and PED physicians with good participation (2011 to 2014), and a septic shock module was incorporated into the PED nurses' yearly mandatory skills training.

Process Measures

Mean bundle adherence improved over the study period from 73% to 84% (Fig 1). Individual bundle element adherence is shown in Fig 1. The addition of an order set with use assessment resulted in increased compliance with process measures (Fig 1). Average monthly order set

usage rate was 79% (range, 20% to 100%).

Test characteristics of the screening tool were fairly consistent (Table 2). As intended, sensitivity and negative predictive value are high to capture a rare condition with significant potential for negative outcomes. The monthly average false positive rate was 80%, (range, 73% to 86%).

The goal for attending physician assessment of positive screen patients was within 15 minutes of room placement (changed to 10 minutes in 2015). Compliance with this measure averaged 55% in the first 2 years and 84% in the last 2 ($P < .001$, Cochran–Armitage test).

Outcome Measures

Overall cohort mortality was 1.7% (24 patients); 71% (17 patients) died within 7 days of admission (Table 1). Days between deaths increased in the last 2 years (Fig 2). Among patients who received bundle-compliant care, 1.2% (13 patients) died compared with 4.2% (11 patients) of those who did not ($P < .001$,Table 1). Bundle noncompliance and abnormal mental status were independently associated with significantly increased odds of death (Table 3).

Of the 548 (40%) patients admitted to the PICU, 513 (94%) were admitted directly from the ED. Hypotension, abnormal mental status, and pulse abnormality were significantly associated with PICU admission (Table 4). Among PICU-admitted patients, the pediatric index of mortality 2 (PIM2) score was a significant predictor for PICU LOS (data not shown) and mortality (Table 3). PICU and hospital LOS were unaffected by bundle-compliant care (data not shown).

Balancing Measures

The median LOS for the general PED population decreased during the study period (data not shown), with average admission rates of 20% to 24%; admits to the PICU averaged 1.6% to 2.4%. Adverse events were rare, including 3 cases (0.2%) of nonfatal pulmonary edema attributable to fluid resuscitation in the PED; none required renal replacement therapy. No patient developed antibiotic-related anaphylaxis. No deaths were attributed to program interventions. On average, ≤5 patients met screening criteria per day.

Cost Analysis

Hospital costs were associated with factors that led to PICU admission. Adjusted for inflation, hospital costs did not increase over time (Supplemental Table 5); PED costs increased by 4%, although recognition at triage was associated with lower costs (Supplemental Table 6).

DISCUSSION

Summary and Interpretation

We describe an iterative approach to implementing a PED QI program to improve septic shock recognition and treatment. Based on Pareto analyses, it is now a rare event that a patient with septic shock receives noncompliant care due to delayed recognition. Meeting septic shock screening criteria at triage (versus any other time during the ED visit) resulted in decreased odds of death and PICU admission and was associated with decreased PED costs. Compliance with IVF and antibiotic measures has improved; importantly, the odds of survival were 5 times as high for children who received bundle-compliant care.

In the United States the prevalence of severe sepsis among children is increasing whereas mortality is decreasing, a trend also observed in our local population.[5,26,27] Mortality is low in our cohort, and a trend of increased number of days between deaths is noted in the last 2 years (Fig 2). After implementation of a PED sepsis-targeted QI intervention, Paul et al[20] found an increase in the number of sepsis cases between each condition-related death.

In previously published work, we described a decrease in hospital LOS after program implementation, similar to the initial work by Paul et al.[19,21] Over the duration of the program, we were unable to demonstrate a significant effect on PICU or hospital LOS. Overall, our PICU and hospital LOS are lower than national benchmark data, suggesting that significant marginal improvement would be difficult to demonstrate.

We describe an 8-year, QI program with sustained improvements in septic shock recognition, timely interventions, and an associated decrease in mortality; whereas similar publications report <5 years of information.[19–22,28–31] Our study is similar to previous work demonstrating improved outcomes associated with increased adherence to program goals without compromising resources.[20,22]

Limitations

Our study has several limitations. First, changes to case identification methodology because of changes in the electronic patient tracking system in the PED may have affected our patient identification process, thereby altering outcome calculations; however, we endeavored to ensure patient selection criteria were applied consistently throughout. Second, ED LOS (balancing measure) did not change, however, we lack data to determine if the process negatively impacted other children in the PED. Third, results may not be generalizable to other institutions from this single-center

study. Fourth, the codes for CCCs may overestimate the burden of chronic disease in our patient population.[24] Fifth, a severity of illness assessment was not possible for the entire cohort, limiting the ability to assess effect on outcomes of children not admitted to the PICU. To our knowledge, there are no predictive mortality and/or morbidity scores validated for use in PEDs. Lastly, a challenge of retrospective chart review is inconsistent documentation of clinical descriptors.

CONCLUSIONS

Implementation of a QI program has resulted in improved recognition and care of patients with septic shock in the PED and associated decreased mortality without compromising resources. Sustainability is achieved through multiple key drivers including an engaged, dedicated team with consistent personnel structure, use of QI tools to monitor progress, and provision of specific, timely positive feedback and solicited concerns from front-line caregivers.

The next steps include addressing timely recognition and treatment of sepsis across the spectrum of care, particularly within intensive care, inpatient, and hematology/oncology units, as well as adult ED where children are evaluated.

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ABBREVIATIONS

CCC: complex chronic condition
ED: emergency department
IVF: intravenous fluid
LOS: length of stay
OR: odds ratio
PALS: pediatric advanced life support
PCH: primary children's hospital
PED: pediatric emergency department
PICU: pediatric ICU
PIM2: pediatric index of mortality 2
QI: quality improvement

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