INTRODUCTION

Introduction: The aim of our pediatric institution’s sepsis coordinating council, regarding patients meeting the Children’s Hospital Association Improving Pediatric Sepsis Outcomes (IPSO) Collaborative’s severe sepsis criteria (for details, please see supplemental digital content 1 at http://links.lww.com/PQ9/A155), is to have first-dose antibiotic administration begin within 60 minutes of provider order entry, in >80% of patient encounters. Early data analysis showed that we were not meeting the goal. This finding led to further investigation of individual patient care areas, including the emergency center, acute care, and critical care. Based on data collected over 2 months, the Pediatric Intensive Care Unit (PICU) specifically was chosen as a focus area for this initiative.

Available Knowledge/Rationale

Sepsis is a life-threatening illness caused by the body’s response to infection, which can progress to septic shock if not treated promptly. Based on current national guidelines, administration of effective antibiotics should begin within 1 hour of sepsis or septic shock recognition. Adult studies have associated delays in antibiotic therapy with poor patient outcomes, with a clear linear increased risk of mortality for every hour that passes without effective antibiotic administration, following the onset of hypotension. Patients in critical care settings likely represent a...
higher risk population due to greater severity of illness with an increased presence of comorbidities. Before any intervention, our institution’s PICU was heavily dependent on a pneumatic tube (p-tube) system for antibiotic delivery. A group of >100 pharmacists and critical care nurses at our institution identified this tube system via a knowledge assessment survey, as one of the significant barriers preventing timely antibiotic administration. That finding, along with initial data analysis, led to the development of the intervention.

**Specific Aim**

The project aimed to improve the percentage of PICU patients with severe sepsis receiving first dose antibiotics within 60 minutes of order entry to ≥50% within the allotted 6-month quality improvement project timeline. The minimum goal of 50% was selected, considering the allotted intervention timeline and perceived feasibility when compared with baseline data. An additional aim was to determine individual time components of the overall process and ultimately decrease time related to the distribution process.

**METHODS**

**Context**

This quality improvement project conducted in the PICU at Texas Children’s Hospital, which is the largest children’s hospital PICU in the United States, has >2,600 admissions annually and over 6,000 pediatric patients admitted across all intensive care units annually. Of the 162 beds devoted to critical care patients, 84 are distributed between 4 PICU floors. One dedicated PICU satellite pharmacy is devoted to these floors. While all medication orders are verified at a central pharmacy location within the hospital, the majority of patient care areas within the hospital have dedicated satellite pharmacies, including the emergency department, neonatal intensive care unit, and cardiovascular intensive care unit.

**Intervention**

This project utilized multiple interventions implemented at various times. One of those being the creation of an interruptive best practice advisory (BPA), a real-time provider “pop-up” notification or warning,4 within the electronic medical record (EPIC, Epic Systems Corporation, Verona, Wisc.). This BPA was in place before the start of this quality improvement initiative. A component of this BPA, presented at order entry included a question relating to the indication of sepsis for 5 essential antibiotics (vancomycin, piperacillin/tazobactam, cefepime, gentamicin, ceftriaxone) recommended by institutional specific septic shock guidelines (For details, please see supplemental digital content 2 at http://links.lww.com/PQ9/A155). Upon review of any one of these antibiotics, the BPA would fire prompting the verification pharmacist to accept the advisory and contact the satellite pharmacy to prioritize medication preparation (For details, please see supplemental digital content 3 at http://links.lww.com/PQ9/A155).

An inpatient institutional communication tool (VOALTE, Voalte Inc., Sarasota, Fla.) was used to communicate between pharmacy and nursing staff that a first dose antibiotic was ready for pick up. An “antibiotic champion” role was created to identify which nursing representative would be responsible for retrieving each PICU’s first dose antibiotics during each shift. It was determined by nursing leadership that the institutional “team lead” nurse was the best fit due to role flexibility along with daily responsibilities consisting of more administrative tasks when compared with direct patient care. When antibiotic preparation was complete, a notification was sent by pharmacy staff to the antibiotic champion, and the pharmacist then documented a message timestamp in a logbook. Upon message receipt, the antibiotic champion would physically retrieve the antibiotic from the pharmacy and document the time of pick up within the same logbook. The antibiotic champion was directed to immediately deliver the antibiotic, by hand, to the bedside nurse for administration (Fig. 1).

We completed the project in collaboration with our institution’s sepsis coordinating council and to fulfill the requirements of an institutional specific, longitudinal, advanced quality improvement course. Therefore, it was deemed quality improvement research and not human subjects research. Review and approval by the institutional review board were not required. Relevant data were collected from the pharmacy workflow manager software (DoseEdge; Baxter Pharmacy Workflow, Deerfield, Ill.), the electronic medical record, and the inpatient communication tool.

**Pilot**

We conducted a week-long pilot in August 2018, utilizing the antibiotic champion role. Pharmacy and PICU nursing staff received education on the new process before go-live, and a logbook placed in the satellite pharmacy allowed for documentation of key time points by both pharmacy and nursing.

**Measures for Improved Workflow**

The primary goal was to increase the percentage of sepsis patients in the PICU receiving first dose antibiotics within 60 minutes of provider order entry. Key process measures included the following time points: provider order entry to order verification, order verification to dose ready for delivery, and dose ready for delivery to administration. A run chart and stacked bar graph were used to compare time points between baseline and pilot data.

**Analysis**

The authors conducted data analysis. Baseline data included patients over 2 months (May 2018–June 2018)
who met IPSO severe sepsis criteria and were admitted to the PICU with a first dose antibiotic ordered in the PICU. These patients were identified retrospectively using a web-based platform that allowed for efficient data filtering by patient location and/or key IPSO processes. Inclusion of PICU patients in the week-long pilot (August 7–14, 2018) occurred if 1 of 5 key antibiotics triggered the previously mentioned BPA. The final analysis included any patient who met the above criteria during the pre-specified periods. The Wilcoxon rank test compared all time points from provider order to administration, while Fisher's Exact test compared the percentages of patients with antibiotic administration started within the 60-minute timeframe. A P-value of <0.05 was considered statistically significant. We developed this article following the Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) guidelines.9

**RESULTS**

Data from baseline and pilot studies highlighted the actual time for each step within the process of administering first dose antibiotics in presumed sepsis patients (Table 1). Baseline data analysis included 14 patients, while the pilot included 16 patients. Baseline data revealed 29% of PICU patients achieved the organizational goal, with a median time of 84 minutes to antibiotic administration. The new process significantly reduced the median time in minutes from dose ready for delivery to administration [Baseline: 61.5 (range 44–89.5) versus Pilot: 32.5 (range 15–45), P value: 0.0041]. The median time from provider order to administration decreased by 36.5 minutes [Baseline: 84.5 (range 58.8–117) versus Pilot: 48 (range 32–65), P-value: 0.0017]. The percentage of patients receiving antibiotics within 60 minutes of order entry significantly increased from 29% to 75% (P-value: 

| Process Steps | Baseline (n = 14) | Pilot (n = 16) | P  |
|---------------|-----------------|---------------|----|
| Provider order to pharmacy verification | 5.5 (3.5–9.3) | 4 (3–7) | 0.31 |
| Pharmacy verification to dose ready for delivery | 12 (9.6–18.8) | 9.5 (8.3–13.5) | 0.16 |
| Dose ready for delivery to administration | 61.5 (44–89.5) | 32.5 (15–45) | 0.0041 |
| Provider order to administration | 84.5 (58.8–117) | 48 (32–65) | 0.0017 |
| Patients receiving antibiotic within 60-minute timeframe | 4/14 = 29% | 12/16 = 75% | 0.026 |
| Provider order to administration time** | — | 41 (32–51) | |
| Patients receiving antibiotic within 60-minute timeframe** | — | 10/10 = 100% | |

*IQR = interquartile range (25–75%).
** Patients in whom complete antibiotic champion process was followed from start to finish.
Improving First Dose Antibiotic Pedic Quality and Safety

0.026). Of note, out of the cohort of 16 pilot patients, only 10 followed the new process to completion. Six of 16 patients (37.5%) had antibiotics delivered by pharmacy staff.

The run chart (Fig. 2) demonstrates the new antibiotic champion process had a significant impact on first dose antibiotic timeliness in patients treated for sepsis or septic shock. Baseline data showed individual process time points that were outside of the 60-minute goal, and variation existed inferring that a consistent process was non-compliant. Pilot data showed significant improvement in the overall percentage of patients meeting the goal (Fig. 3), median times, and process standardization. The hospital-wide goal for antibiotic timeliness for all patients was met for the first time during the pilot month (for details, please see supplemental digital content 4 at http://links.lww.com/PQ9/A155).

DISCUSSION

Following the implementation of the antibiotic champion pilot, 75% of evaluated patients met the institutional goal with a 36.5-minute decrease in median time between baseline and pilot data. As previously mentioned, the PICU depended largely on a p-tube system for drug delivery, and both nursing and pharmacy staff expressed concern that this was the main factor contributing to delays. Baseline data supported this concern where a single step in the process, “dose ready for delivery to administration,” indicated a median time >60 minutes. Therefore, it was decided to implement a new intervention targeted at decreasing time to get the medication to the patient’s bedside nurse. Interestingly, by removing the p-tube system from the workflow and placing a greater emphasis on interdisciplinary communication and team-work, the new process was a success.

One of the considerable strengths of this project is its relevance to other adult and pediatric hospitals working to implement appropriate strategies to administer first dose antibiotics to patients treated for sepsis or septic shock. This antibiotic champion process can be easily reproduced with only modest changes to account for differences in workflow or technology. While the project was patient-centered and timely, it also impacted other Institute of Medicine domains: safety, efficacy, and efficiency. The creation of the antibiotic champion role...
faced by difficulty in retrospectively determining exact “time the intervention was made to align the project with organiza-
the new process and not clinical outcomes. Lastly, the
of this quality improvement initiative was to evaluate
However, this is not a major drawback as the purpose
who meet the severe sepsis criteria prospectively.
need for a more accurate method to identify patients
subject to selection errors. We readily acknowledge the
process is likely more efficient because it allows for nurses to
spend more time at the bedside rather than going back
and forth to the p-tube station, and for pharmacy staff
to spend less time searching for missing antibiotics or
re-making lost doses.
A significant barrier to this project was data collection. Manual review of pharmacy preparation data and electronic medical record data was required to conduct the pilot. These time-intensive steps limited the project scope as far as the number of patients included. During the pilot, process inconsistencies led to pharmacy staff hand-delivering antibiotics. Hand delivery occurred for 6 out of 16 patients (37.5%). Interestingly, when consistently following the process to completion (the antibi-
totic champion picked up and delivered the antibiotic),
10 out of 10 patients (100%) had administration begin
within 60 minutes of provider order entry. When the
pharmacy staff hand-delivered the antibiotic, only 2 out
of 6 patients (33.3%) had administration begin within 60
minutes. This outcome may be related to workflow and
communication.
There are numerous limitations to this project. We completed this work as part of an institutional advanced quality improvement course with an intervention timeline spanning ~3 months. For this reason, the total sample size was limited to thirty patients, and the intervention was only piloted for 1 week to deter-
mine the potential effectiveness of the new process. Despite these limitations, we believe this process offers a valuable framework for other institutions looking to improve antibiotic administration times. Baseline data
patients were identified retrospectively and included based on meeting the IPSO severe sepsis definition and also receiving a first dose antibiotic in the PICU. During the pilot, it was not possible to ensure that the included patients met both criteria. The reason for this difference is due to the previously mentioned BPA triggering the start of the antibiotic champion process, which is based on provider selections at order entry and is, therefore, subject to selection errors. We readily acknowledge the need for a more accurate method to identify patients who meet the severe sepsis criteria prospectively. However, this is not a major drawback as the purpose of this quality improvement initiative was to evaluate the new process and not clinical outcomes. Lastly, the
decision was made to align the project with organiza-
tional goals rather than international guidelines due to difficulty in retrospectively determining exact “time zero.” Interim organizational goals focused on the time
from provider order entry, which is a time point that
is much easier to determine retrospectively and consist-
tently via the medical record.
After the review of pilot data, hospital leaders decided to implement the antibiotic champion process full-time for all PICU patients. We met the organizational goal of having first dose antibiotic administration begin within 60 minutes of provider order entry in >80% of all patient encounters for the first time in the month that the antibi-
otic champion was piloted. The improvement in antibiotic administration times for PICU patients likely contributed to this goal being met. Furthermore, the same goal was met for the next 2 months following implementation, before decreasing slightly (72%–75%) in the subsequent 3 months (for details, please see supplemental digital content 4 at http://links.lww.com/PQ9/A155). The reason for this decrease is not known but possibly due to the completion of the advanced quality improvement project timeline, as the presence of our team in the PICU and overall attention being devoted to the project subsided. In an attempt to continuously improve first-dose antibiotic administration times for patients with sepsis, the antibi-
otic champion process is currently being implemented
hospital-wide.
CONCLUSION
The need for communication and collaboration among
members of the patient care team has become increas-
ingly important due to the rise in the complexity of care
and regulatory oversight of hospitalized patients. Lack
of communication and breakdowns in processes con-
tribute to delays in care, which may cause harm. This
article describes the successful implementation of a new
process focused on administering first dose antibiotics to
severe sepsis patients within the recommended 60-min-
ute timeframe. Results showed a substantial increase
in the percentage of PICU patients receiving first dose antibiotics post-implementation of the antibiotic cham-
pon process. The intersection of people, process, and
technology is likely where this project was ultimately
successful.
ACKNOWLEDGMENTS
The authors would like to acknowledge Terri Brown,
MSN, RN, CPN, as a key contributor for her assistance
with data availability and article review.
The authors would like to acknowledge Wei Zhang,
Ph.D., for her assistance with statistical analysis of data
and write up of the “analysis” section of this article.
DISCLOSURE
The authors have no financial interest to declare in rela-
tion to the content of this article.
REFERENCES

1. Goldstein B, Giroir B, Randolph A; International Consensus Conference on Pediatric Sepsis. International pediatric sepsis consensus conference: definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med*. 2005;6:2–8.

2. Rhodes A, Evans LE, Alhazzani W, et al. Surviving sepsis campaign: international guidelines for management of sepsis and septic shock: 2016. *Intensive Care Med*. 2017;43:304–377.

3. Gaieski DF, Mikkelsen ME, Band RA, et al. Impact of time to antibiotics on survival in patients with severe sepsis or septic shock in whom early goal-directed therapy was initiated in the emergency department. *Crit Care Med*. 2010;38:1045–1053.

4. Ferrer R, Martín-Loeches I, Phillips G, et al. Empiric antibiotic treatment reduces mortality in severe sepsis and septic shock from the first hour: results from a guideline-based performance improvement program. *Crit Care Med*. 2014;42:1749–1755.

5. Whiles BB, Deis AS, Simpson SQ. Increased time to initial antimicrobial administration is associated with progression to septic shock in severe sepsis patients. *Crit Care Med*. 2017;45:623–629.

6. Kumar A, Roberts D, Wood KE, et al. Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care Med*. 2006;34:1589–1596.

7. Amaral AC, Fowler RA, Pinto R, et al.; Cooperative Antimicrobial Therapy of Septic Shock Database Research Group. Patient and organizational factors associated with delays in antimicrobial therapy for septic shock. *Crit Care Med*. 2016;44:2145–2153.

8. Bejjanki H, Mramba LK, Beal SG, et al. The role of a best practice alert in the electronic medical record in reducing repetitive lab tests. *Clinicoecon Outcomes Res*. 2018;10:611–618.

9. Ogrinc G, Davies L, Goodman D, et al. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. *J Nurs Care Qual*. 2016;31:1–8.