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Decreasing ICU and Hospital Length of Stay through a Standardized Respiratory Therapist-driven Electronic Clinical Care Pathway for Status Asthmaticus

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Introduction: Status asthmaticus (SA) is a cause of many pediatric hospitalizations. This study sought to evaluate how a standardized asthma care pathway (ACP) in the electronic medical record impacted the length of stay (LOS). **Methods:** An interdisciplinary team internally validated a standardized respiratory score for patients admitted with SA to a 25-bed pediatric intensive care unit (PICU) at a tertiary children's hospital. The respiratory score determined weaning schedules for albuterol and steroid therapies. In addition, pharmacy and information technology staff developed an electronic ACP within our electronic medical record system using best practice alerts. These best practice alerts informed staff to initiate the pathway, wean/escalate treatment, transition to oral steroids, transfer level of care, and complete discharge education. The PICU, stepdown ICU (SD ICU), and acute care units implemented the clinical pathway. Pre- and postintervention metrics were assessed using process control charts and compared using Welch's *t* tests with a significance level of 0.05. **Results:** Nine hundred two consecutive patients were analyzed (598 preintervention, 304 postintervention). Order set utilization significantly increased from 68% to 97% ($P < 0.001$), PICU LOS decreased from 38.4 to 31.1 hours ($P = 0.013$), and stepdown ICU LOS decreased from 25.7 to 20.9 hours ($P = 0.01$). Hospital LOS decreased from 59.5 to 50.7 hours ($P = 0.003$), with cost savings of $1,215,088 for the patient cohort. **Conclusions:** Implementing a standardized respiratory therapist-driven ACP for children with SA led to significantly increased order set utilization and decreased ICU and hospital LOS. Leveraging information technology and standardized pathways may improve care quality, outcomes, and costs for other common diagnoses. *(Pediatr Qual Saf 2023;8:e697; doi: 10.1097/pq9.0000000000000697; Published online December 5, 2023.)*

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INTRODUCTION

Asthma is a common condition in childhood, and before the COVID-19 pandemic, asthma was the third leading cause of hospitalizations in the United States.[1,2] Intensive care units (ICUs) treat many children admitted for asthma.[3] In 2016, 68.4% of children with asthma admitted to our institution required intensive care. The overall length of stay (LOS) for all patients (2.8 d) was greater than the Children's Hospital Association national average benchmark (2.1 d), leading to this quality improvement initiative. There is evidence that high compliance with standardized care pathways for status asthmaticus (SA) is associated with decreased LOS. Still, there are concerns about sustainability effects if the pathways are not consistently adhered to.[4,5]

Standardization of treatment guidelines decreases provider variability and increases efficiency.[5,6] Several institutions have implemented objective scoring tools and a standardized approach to asthma care, including clinical pathways, electronic scoring tools, and order sets.[4–13] The electronic medical record (EMR) is a well-known tool for

standardizing care. However, there is limited literature on its use to standardize care for patients with SA beyond scoring tools and order sets. This quality improvement project includes the development of a clinical care pathway and its transformation into a decision support tool utilizing best practice alerts (BPAs) aimed at a sustainable process not dependent on individual provider preference.

This study sought to evaluate whether an electronic decision support tool, called the asthma care pathway (ACP), which involves the implementation of an objective scoring tool and standardized care pathway, would lead to decreased hospital days for patients admitted with SA. The primary aim of this initiative was to decrease the LOS (2.8 d) by 20% (2.24 d) and meet or exceed national benchmarks (2.1 d) within 2 years of implementation.

MATERIALS AND METHODS

This project occurred in a 260-bed tertiary care and level 1 trauma center. There is a 25-bed pediatric ICU (PICU), a 25-bed stepdown ICU (SD ICU), and 76 acute care beds. All units utilize the EPIC electronic medical record (EPIC Systems, Verona, Wis.).

The PICU is a closed multidisciplinary medical and surgical unit where a pediatric critical care physician manages all patients with 24-hour in-house coverage. The PICU care team includes two attending physician-led teams, one critical care fellow, four to six pediatric residents, and a PICU-specialized pharmacist. From 2016 to 2019, the hospital annually averaged 218 patients with an average LOS of 2.4 days versus the national benchmark of 2.1 days. Sixty-three percent of those patients were admitted to the PICU, which annually averaged 1,724 total admissions and 137 patients with SA. The average PICU LOS was 2.2 days, whereas the national benchmark was 1.7 days. The study period occurred from January 2016 to February 2020 and included a typical patient population before the COVID-19 pandemic.

The SD ICU and acute care units are staffed by pediatric hospitalists and residents (pediatrics and family medicine), with multiple teams that may care for patients hospitalized for SA. Patients are managed by the same team when transferring from the stepdown unit to the acute care units. Similar to other institutions, there was a suspicion that LOS higher than the benchmark was affected by variation in asthma management between providers.[4] There were no established guidelines, and each provider ordered and weaned treatments based on their clinical judgment.

Before implementing the ACP and decision support tool, providers utilized their discretion on patient admission criteria, treatment regimen weaning methods, criteria to transfer level of care, and discharge criteria (**see Figure 1, Supplemental Digital Content 1**, which describes process map and key driver diagram with primary and secondary leverage points, ***http://links.lww.com/PQ9/A520***). An existing order set allowed efficient ordering of albuterol but did not provide recommendations for initial dosing and weaning. Nurses and respiratory therapists (RTs) often initiated weaning based on their assessment of perceived wheezing without using a validated RS. Physicians de-escalated treatment when available to assess patient progress or when bedside staff (nurses and RTs) informed them that the patient(s) appeared to improve. As a result, there was significant variability between providers and bedside staff on the initial dosing and aggressiveness of weaning asthma treatments, which anecdotally appeared to affect hospital LOS.

Multidisciplinary Group

A multidisciplinary group, composed of physicians, pharmacists, information technologists, nurses, RTs, and a project manager, convened weekly during the preparation and development of the RS, weaning protocol, and ACP.

Standardizing Assessment

A standardized respiratory score (RS) was adopted largely from work by Liu et al and internally validated by a multidisciplinary group including physicians, nurses, and respiratory care practitioners in February 2017.[7,8] The bedside champions trialed the adopted RS on patients and found scores were consistent across staff with the different levels of patient severity. Before implementation, there was no standardized assessment of asthma severity in our hospital. The PICU staff initiated the respiratory scoring tool, which was extended to the SD ICU and acute care units. This intervention was the first step in building a foundation for the ACP. Nurses and RT champions initially scored on paper. Information technology (IT) then implemented the RS into the EMR as a precursor to further pathway development (Fig. 1).

Standardizing Treatment

After a literature review and consultation with our pulmonology and pharmacy departments, the team adopted standardized medication (albuterol and glucocorticoid) doses and formulations. In addition, the team developed nurse and RT-driven weaning guidelines using the standardized RS (Fig. 2). PICU staff initially trialed the guidelines in March 2017, and SD ICU and acute care staff subsequently trialed them before complete implementation through the EMR. Once a patient met the criteria for a wean, the bedside staff would notify the provider to place an order to make the wean per the guideline.

Electronic Care Path Development Methodology

Pharmacy and IT staff implemented the ACP within our EMR. Once a provider entered a diagnosis of asthma exacerbation or SA into the patient's electronic problem list, providers received interruptive BPAs to initiate the ACP. This order is placed via EMR by physicians upon admission to the hospital and drives the rest of the ACP. These BPAs serve as clinical decision support tools within the EMR that promote efficiency, enhance quality, and

Variable	0 points	1 point	2 points	3 points	Total
Respiratory rate (breaths/min) by age:	*Count respiratory rate for one full minute while patient is awake*				
<2 mo		≤60	61–69	≥70	
2–12 mo		≤50	51–59	≥60	
1–2 y		≤40	41–44	≥45	
2–3 y		≤34	35–39	≥40	
4–5 y		≤30	31–35	≥36	
6–12 y		≤26	27–30	≥31	
>12 y		≤23	24–27	≥28	
Retractions	None	Subcostal or Intercostal	2 of the following: • Subcostal • Intercostal • Nasal flaring in infants	3 of the following: • Subcostal • Intercostal • Substernal • Suprasternal • Supraclavicular • Nasal flaring OR head bobbing in infants	
Dyspnea by age:	*Definition: Difficult or labored breathing; shortness of breath*				
0–2 y	Normal feeding, vocalizations, and activity	1 of the following: • Difficulty feeding • Decreased vocalization • Agitation	2 of the following: • Difficulty feeding • Decreased vocalization • Agitation	Stops feeding, no vocalizations, OR drowsy/confused	
2–4 y	Normal feeding, vocalizations, and play	1 of the following: • Decreased appetite • Increased coughing after play • Hyperactivity	2 of the following: • Decreased appetite • Increased coughing after play • Hyperactivity	Stops eating or drinking, stops playing, OR drowsy/confused	
≥5 y	Counts to ≥10 in one breath	Counts to 7–9 in one breath	Counts to 4–6 in one breath	Counts to ≤3 in one breath	
Auscultation (as it relates to wheezing)	Normal breathing; no wheezing present	End-expiratory wheeze only	Expiratory wheeze only (greater than end-expiratory wheeze)	Inspiratory and expiratory wheeze AND/OR diminished breath sounds	
				TOTAL	

Figure 1. RS and components for calculation. Possible scores range from 1 to 12.

improve clinician recognition of specific diagnoses and tasks, such as this pathway.[14] When physicians start the pathway, the BPAs prompt bedside staff to record the RS and wean therapies based on the RS every four hours. The team established this time frame as a safety limit in case patients were weaned too quickly. The ACP orders could be modified if providers and staff agreed that a patient could be weaned earlier than 4 hours. Additional BPAs encourage ACP tasks promoting decreased LOS, such as transitioning from intravenous to oral glucocorticoids, transferring the patient out of the ICU, and completing asthma education with the family. In addition, medication orders for continuous and intermittent doses of nebulizer treatments and metered-dose inhalers are available for RTs to select within the ACP to encourage weaning based on the RS as an order set. (**Figures 2 and 3, Supplemental Digital Content 2**, which describes examples of EPIC orders for intermittent and continuous albuterol with dosing range, ***http://links.lww.com/PQ9/A521***.) If a patient's RS escalates or remains above a 9, BPAs recommend re-evaluation and escalation of care with no pathway weaning (Fig. 3). References to the escalation pathway guidelines are available through hyperlinks embedded in the order sets. If providers ordered mechanical ventilation [including bi-level positive airway pressure (BIPAP)], any pathway weaning was stopped.

Full Implementation

Once our institution's EMR fully integrated the ACP, the team developed and distributed training modules and videos to all staff, including physicians, nurses, and RTs. The PICU, SD ICU, and acute care areas officially utilized the ACP starting in October 2018. Just-in-time training occurred in each unit throughout implementation. Weekly meetings with our multidisciplinary group encouraged frequent plan-do-study-act cycles to analyze different components of the pathway. Additional interactive electronic modules and videos were available for new providers and as ongoing education for established providers. Real-time feedback demonstrating our outcomes and balancing measures was available on a dashboard easily accessible by our study team. (**Figure 4, Supplemental**

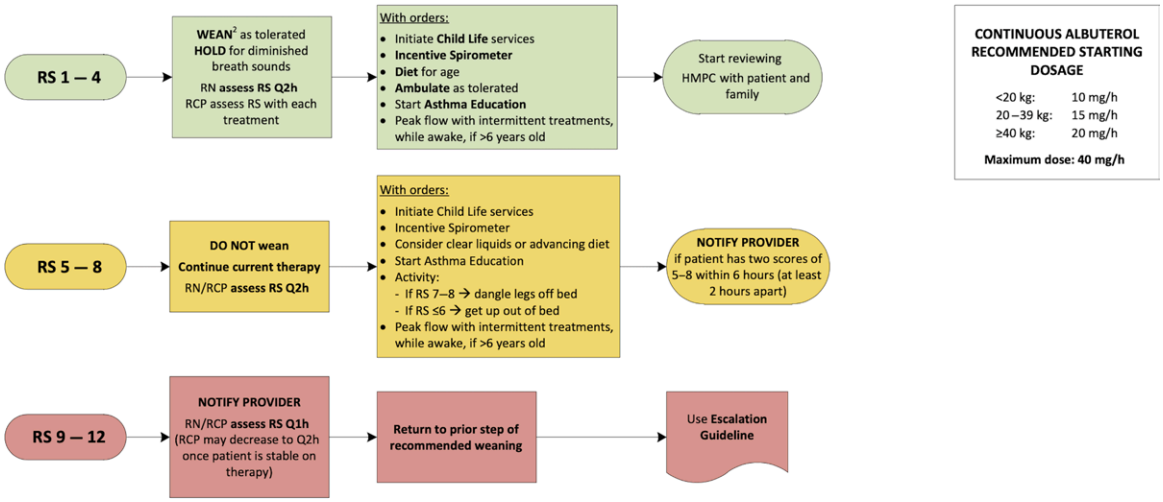

Fig. 2. Guideline for continuous albuterol weaning. Step 2: Choose one and with each scheduled reassessment of RS, assess the appropriateness of current course and change the course as needed. Notify the provider immediately if: RS worsens or has not changed after 3 scheduled scores; the patient does not tolerate wean (return to prior dose/frequency for RS 9–12); the patient falls wean twice; and the patient is noncompliant. [2]Recommended weaning: Continuous albuterol (wean Q4h): (1) if starting at 40 mg/h: 20 mg/h → 10 mg/h → Q2h; (2) if starting at 20 mg/h → 10 mg/h → Q2h; and (3) if starting at 15 mg/h → 10 mg/h → Q2h; and if starting at 10 mg/h → Q2h. Intermittent albuterol (metered-dose inhaler preferred): Wean after two treatments (wean from albuterol four puffs Q4h after one treatment): (1) do not wean patient's baseline dose; (2) if starting on continuous: wean to eight puffs Q2h; and (3) wean from eight puffs Q2h → eight puffs Q3h → four puffs Q3h → four puffs Q4h → 2 puffs Q4h (prepare to transfer the patient out of PICU once stable on intermittent albuterol). HMPC, home management plan of care.

Digital Content 3, which describes the dashboard for the ACP, including data for the LOS details, process measures, medications measures, supplemental oxygen, and readmissions, ***http://links.lww.com/PQ9/A522***.)

Dashboard Metrics

The main process measure for this project was the percent order set utilization. The primary outcome measure was LOS. The LOS at each location (PICU, SD ICU, and acute care unit) was measured separately. (**Figure 4, Supplemental Digital Content 3**, which describes the dashboard for the ACP, including data for the LOS details, process measures, medications measures, supplemental oxygen, and readmissions, ***http://links.lww.com/PQ9/A522***.) The Balancing measures were readmissions, escalation in the level of care (to SD ICU or PICU), and rate of emergency department/urgent care visits within 30 days. The percent use of supplement oxygen, including high-flow nasal cannula (HFNC), BiPAP, and invasive mechanical ventilation, was also tracked. These metrics were reviewed monthly throughout the implementation period of 1 year.

Statistical Analysis

Statistical Process Control (SPC) charts showed the progression of asthma data from preintervention to postintervention for percent order set utilization, LOS, and adjunctive support treatment with HFNC. These charts allowed the team to observe any special cause variation from the process as evidenced by any shifts or trends in the data. The team statistically compared these pre- and postintervention values using Welch's *t* tests with a significance level of 0.05 (JMP 11.2.0) (Table 1). In addition, demographics were analyzed with *t* tests (gender, race), linear regressions (age, gender), and analysis of variance (ethnicity).

RESULTS

During the study period, we analyzed 902 consecutive PICU patients with a diagnosis of SA (598 in the preintervention group and 304 in the postimplementation group). Thirty-five percent of the patients were female (319/902), whereas 65% (583/902) were male. Ages ranged from 2 to 18.7 years, with a median age of 6.9. The average age was 7.6 ± 4.1 years of age. The reported ethnicity breakdown was Asian 12.3%, Black 32.5%, Hispanic/Latino 22.7%, and White 32.5.

After implementing the electronic ACP within our institution's EMR, order set utilization significantly increased from 68% to 97% ($P < 0.001$). The SPC chart for order set utilization demonstrates special cause variation with a shift above the centerline starting 7 weeks (data points) before the intervention that continues postimplementation (Fig. 4). Hospital LOS decreased by 14.8% from 59.5 ± 13.9 to 50.7 ± 6.1 hours ($P = 0.003$) (Table 1). Pediatric ICU LOS significantly decreased by 19% from 38.4 ± 13.7 to 31.1 ± 6 hours ($P = 0.013$), and SD ICU LOS decreased by 18.7% from 25.7 ± 8.9 to 20.9 ± 4 hours ($P = 0.01$) (Table 1). In the SPC chart for overall hospital LOS, special cause variation was noted by a shift starting 3 weeks before interventions that continued postimplementation (Fig. 5). The SPC chart of

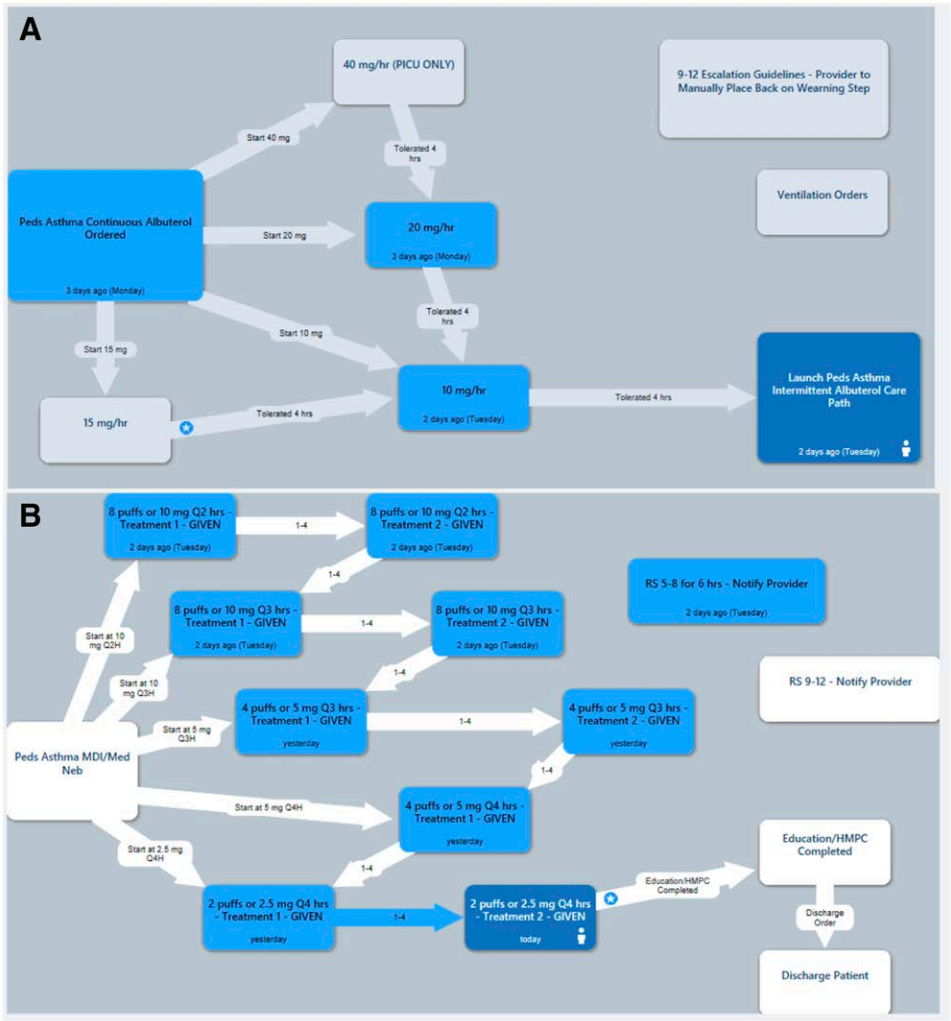

Fig. 3. Asthma care pathway progression maps. Progression map for the continuous albuterol (A) and intermittent albuterol ACP (B). © 2023 Epic Systems Corporation.

Table 1. Effect of ACP on LOS

	Preimplementation (h)	Postimplementation (h)	Percent Change	*P*
Overall hospital LOS	59.5 ± 13.9	50.7 ± 6.1	14.8	0.003
PICU LOS	38.4 ± 13.7	31.1 ± 6	19	0.013
SD ICU LOS	25.7 ± 8.9	20.9 ± 4	18.7	0.01
Acute care LOS	23.3 ± 5.9	21.1 ± 4.6	9	0.165

PICU LOS demonstrates the start of a shift below the centerline 6 weeks (data points) before interventions that continued postimplementation (Fig. 5). There were no special cause variations for HFNC. There were no significant changes in acute care LOS. It was notable that all metrics demonstrated a decrease in the amount of variation. The run charts from the project dashboard also demonstrated the overall decreased LOS and decreased variation. (**Figure 5, Supplemental Digital Content 4,** which describes the run chart of the overall LOS from ACP dashboard, ***http://links.lww.com/PQ9/A523***.) The LOS reduction resulted in overall hospital cost savings of $1,215,088 for the patient cohort. The cost savings were calculated using our internal hospital cohort subjects of SA. The average cost savings were calculated using the average utilization cost for inpatient SA diagnoses. These average charges were generated from internal hospital data, Children's Hospital Association internal communications, KidsData.org, and Health Plan internal communications.

The initial readmission rate was 2%, and postintervention was 1.7%. Rates of HFNC (23%), BiPAP (1.3%), and mechanical ventilation (0.5%) were steady during the study period. The mortality rate was 0.1% (the one death in 2016 was before any interventions). Emergency department/urgent care visits within 30 days of discharge were 3.7% preintervention and 6.9% postintervention. There were no significant differences in the readmission rate, mode of respiratory support, mechanical ventilation, or mortality rate between the preintervention and postintervention groups. There were no significant outcome differences due to gender, age, ethnicity, or race.

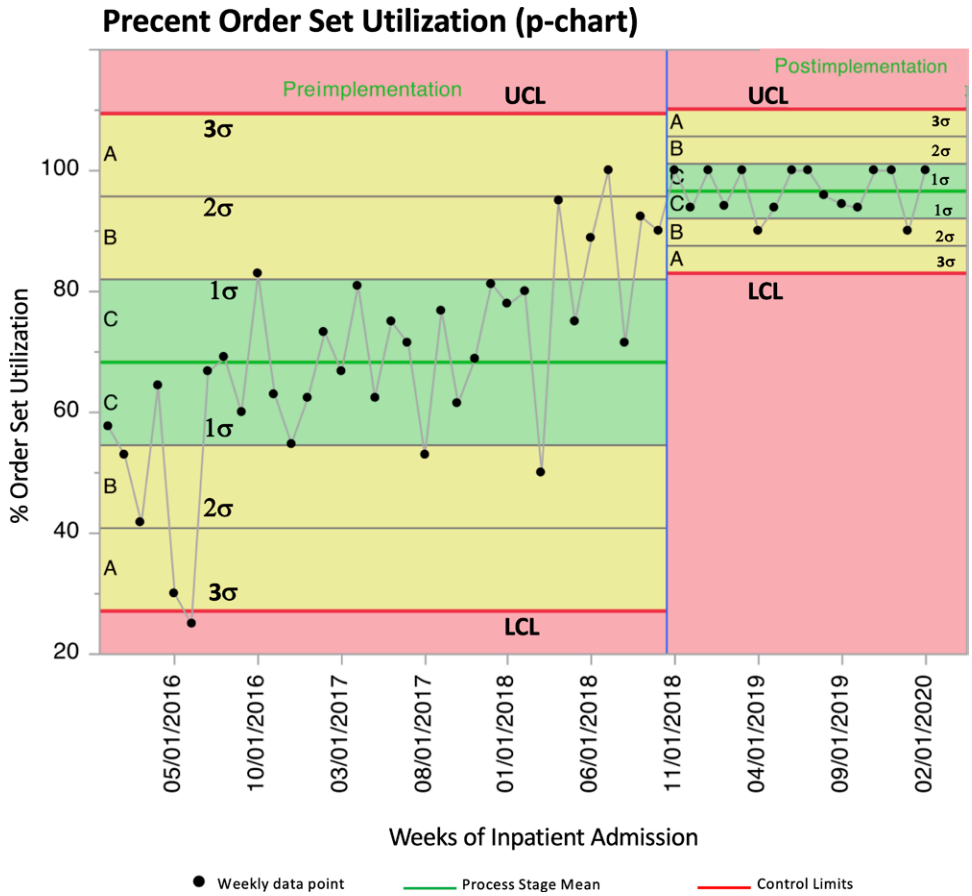

Fig. 4. Control chart for percent of order set utilization. Zone A is within 3 s from the mean value, zone B is within 2 s from the mean value, and zone C is within 2 s from the mean value. LCL, lower control limit; s, standard deviation; UCL, upper control limit.

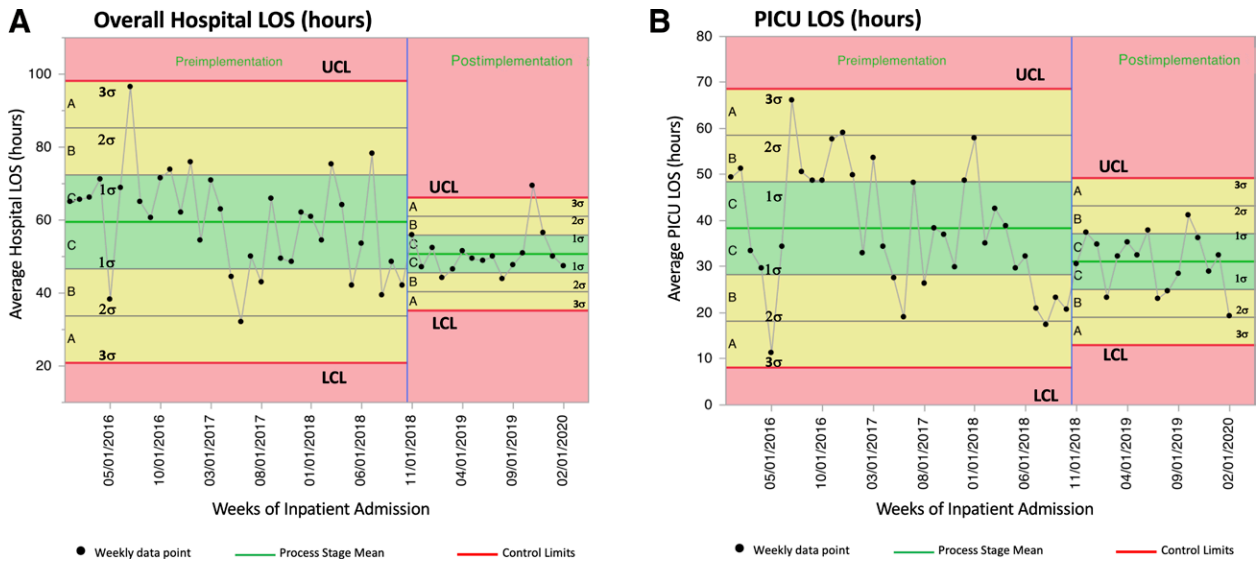

Fig. 5. Control charts for LOS. Control chart for the average LOS for the overall hospital (A), PICU (B). Zone A is within 3 s from the mean value, zone B is within 2 s from the mean value, and zone C is within 2 s from the mean value. LCL, lower control limit; s, standard deviation; UCL, upper control limit.

DISCUSSION

Implementing a standardized RT-driven ACP for children with SA led to significantly increased order set utilization with decreased ICU and overall hospital LOS without increasing readmission rates. This project demonstrates that leveraging EMR technology with effective clinical

decision tools and standardized pathways for common diagnoses can improve the quality of care, outcomes, and cost savings.

Previous studies have established that guideline development can result in standardization, improvements in care, and, at times, decreased LOS.[11–13,15,16] Electronic clinical pathways have multiple standard functions and decision support for providers.[17] Different levels of decision support to providers impact patient care delivery, including customized order sets, best practice alerts (BPAs), reporting of variance, and tracking nursing, respiratory therapist, and pharmacist engagement.[18,19] Implementing electronic clinical pathways well can directly impact the clinical care provided by improving medication administration, encouraging appropriate evaluation for diagnosis or treatment, avoiding low-value care, decreasing the LOS, decreasing the need to transfer to a higher level of care, and improving overall health outcomes.[20,21]

The ACP led to obvious decreases in the variation between providers in the various patient care settings. Standardization of care through pathways decreases PICU LOS, overall hospital LOS, duration of receiving albuterol, and time to transition from continuous to an intermittent inhaled bronchodilator.[4,8–10] Additionally, an RT-driven asthma pathway has been shown to decrease hospital LOS in the PICU.[9]

The ACP involved using an order set critical to standardizing care. The foundations of this order set included standardized assessments with the RS and standardized treatment algorithms. Our institution had an asthma order set in place for 5 years, but it did not involve standardized assessments, treatment algorithms, and prompts for clinicians to initiate use. As a result, there was significant variation among providers in its use. This variability led to the development of the current ACP, which allows RTs to drive the weaning process. Nursing and RT-driven weaning decrease hospital LOS in other studies.[5,12,22] Although order sets have impacted care delivery, our project would likely not have been successful if it solely relied on the order sets.[18]

The SPC charts noted shifts in the weeks before the study interventions. For the percent order set utilization (Fig. 4), there were seven data points above the centerline before the implementation date. Each data point represented 1 week, so the shifts appeared seven weeks before the go-live date. During this period, providers and staff from the PICU, SD ICU, and acute care were being educated about the guidelines and the process in anticipation of the start of the ACP. RTs followed the guidelines and requested physicians to put orders to facilitate the weaning process. The SPC chart of PICU LOS (Fig. 5) demonstrated the start of a shift six weeks before the go-live date, and the SPC chart of the overall hospital LOS showed a shift three weeks before that time. It is possible that since the process started in the PICU, the effects of standardization (even without the EMR changes) would have been seen as the staff was utilizing the guidelines and order sets.

BPAs were the next important piece for the success of the ACP. Individual BPAs targeted physicians, nurses, or RTs to assist with each step of the clinical delivery. Upon admission, if providers entered a diagnosis of asthma or SA into the EMR problem list, a BPA prompted them to consider using the ACP and asthma order set. BPAs prompted providers to wean albuterol based on the RS, wean to oral glucocorticoid therapy when the patient tolerated intermittent bronchodilator therapy, and transition care between the PICU, SD ICU, acute care units, or discharge. (**Figures 6 and 7, Supplemental Digital Content 5**, which describes BPA for transitioning from continuous albuterol to intermittent and discharge, ***http://links.lww.com/PQ9/A524***.) Combined with a standardized RS, BPAs have allowed children with asthma to move safely along the pathway toward discharge. They have ensured successful treatment weaning without physicians having to enter an order each time. BPAs have demonstrated efficacy in multiple facets of care, including maintaining compliance with evidence-based recommendations, decreasing the provision of low-value care, improving antibiotic stewardship, and likely decreasing the time to start antibiotics for sepsis.[19,23,24] BPAs certainly have limitations, and for patients with ACP orders, if providers entered any albuterol orders outside of the ACP or wanted to modify the existing orders, there would be BPAs asking to discontinue duplicate orders. Initially, providers would discontinue the ACP orders as closing the BPA was the easiest choice. The IT team clarified the BPAs to make it easier to continue the ACP, and the team educated providers not to use albuterol orders outside of the ACP if patients met inclusion criteria. The project team did not review the percentage of BPAs that were ignored through the implementation process; however, the significant increase in order set utilization suggests that acceptance of the BPA offset any alert fatigue that may have occurred.

Limitations

This study was a single-center project that looked retrospectively at the specific impact of the ACP. It excluded Pandemic-era data due to the effect of COVID-19 on our hospitalizations. As noted nationwide, with social distancing and masking, there was a sharp decline in admissions from a typical viral illness and almost no asthma admissions. There was no analysis of the effects of demographics such as race, age, weight, asthma severity, or other comorbidities on LOS. The study did not analyze the financial impact of decreased albuterol usage from a pharmacy and purchasing standpoint or capacity management/patient flow metrics. Although there was a decrease in readmission rates, there were no control charts or follow-up analyses on those statistics. There was also no statistical analysis or charts done on emergency department/urgent care visit rates within 30 days. The increase noted did not include investigations on how many were unique patient encounters. With the decreased overall LOS, it

could be considered that patients were being discharged too early, leading to increased emergency department visits; however, the rate of readmission was lower postintervention. Therefore the discharges appeared appropriate. There were no ethical considerations for this project. The quality improvement project did not go through a formal Institutional Review Board review.

Future Directions

Future directions should include investigating the use of HFNC and continuous albuterol, including the impact of respiratory care-driven protocols and the effectiveness of HFNC as a delivery method. Further investigations should evaluate if increased rates of emergency department/urgent care visits postdischarge without increased readmissions could be due to increased education and awareness of symptoms leading to families seeking provider evaluations at a higher rate. In addition, future work should study the impact of a standardized escalation protocol that includes inhaled anesthetics.

CONCLUDING SUMMARY

Implementing a standardized RT-driven electronic pathway for children with SA led to significantly increased order set utilization and decreased ICU and hospital LOS. Leveraging IT and standardized pathways for common diagnoses in which there is existing variability in care can lead to improved quality of care, outcomes, and cost savings. There are additional areas within our system to further standardize, including HFNC use, escalation pathways, and standards for inhaled anesthetics in treating severe, refractory SA. However, there is limited evidence about best practices for these care methods.

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DISCLOSURE

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

REFERENCES

1. Leyenaar JK, Ralston SL, Shieh M-S, et al. Epidemiology of pediatric hospitalizations at general hospitals and freestanding children's hospitals in the United States. *J Hosp Med*. 2016;11:743–749.
2. Bloom B, Cohen RA, Freeman G. Summary health statistics for U.S. children: national health interview survey, 2011. *Vital Health Stat*. 2012;10:1–88.
3. Al-Eyadhy AA, Temsah M-H, Alhaboob AAN, et al. Asthma changes at a pediatric intensive care unit after 10 years: observational study. *Ann Thorac Med*. 2015;10:243–248.
4. Brennan S, Lowrie L, Wooldridge J. Effects of a PICU status asthmaticus de-escalation pathway on length of stay and albuterol use. *Pediatr Crit Care Med*. 2018;19:658–664.
5. Miksa M, Kaushik S, Antovert G, et al. Implementation of a critical care asthma pathway in the PICU. *Crit Care Explor* 2021;3:e0334.
6. Bekmezian A, Fee C, Weber E. Clinical pathway improves pediatrics asthma management in the emergency department and reduces admissions. *J Asthma*. 2015;52:806–814.
7. Liu LL, Gallaher MM, Davis RL, et al. Use of a respiratory clinical score among different providers. *Pediatr Pulmonol*. 2004;37:243–248.
8. Rutman L, Atkins RC, Migita R, et al. Modification of an established pediatric asthma pathway improves evidence-based, efficient care. *Pediatrics*. 2016;138:e20161248.
9. Miller AG, Haynes KE, Gates RM, et al. A respiratory therapist-driven asthma pathway reduced hospital length of stay in the pediatric intensive care unit. *Respir Care*. 2019;64:1325–1332.
10. Phillips M, Fahrenbach J, Khanolkar M, et al. The effect of a pediatric intensive care severity-tiered pathway for status asthmaticus on quality measures and outcomes. *Pediatr Allergy Immunol Pulmonol*. 2017;30:246–251.
11. Magruder TG, Narayanan S, Walley S, et al. Improving inpatient asthma management: the implementation and evaluation of a pediatric asthma clinical pathway. *Pediatr Qual Saf* 2017;2:e041.
12. Flaherty MR, Whalen K, Lee J, et al. Implementation of a nurse-driven asthma pathway in the pediatric intensive care unit. *Pediatr Qual Saf* 2021;6:e503.
13. Desai M, Caldwell K, Gupta N, et al. Effectiveness of pediatric asthma pathways in community hospitals: a multisite quality improvement study. *Pediatr Qual Saf* 2020;5:e355.
14. Fry C. Development and evaluation of best practice alerts: methods to optimize care quality and clinician communication. *AACN Adv Crit Care*. 2021;32:468–472.
15. Zemek R, Plint A, Osmond MH, et al. Triage nurse initiation of corticosteroids in pediatric asthma is associated with improved emergency department efficiency. *Pediatrics*. 2012;129:671–680.
16. Gupta M, Greene N, Kilpatrick SJ. Timely treatment of severe maternal hypertension and reduction in severe maternal morbidity. *Pregnancy Hypertens*. 2018;14:55–58.
17. Wakamiya S, Yamauchi K. What are the standard functions of electronic clinical pathways? *Int J Med Inform*. 2009;78:543–550.
18. Fay EE, Hitti JE, Delgado CM, et al. An enhanced recovery after surgery pathway for cesarean delivery decreases hospital stay and cost. *Am J Obstet Gynecol*. 2019;221:349.e1–349.e9.
19. Fleddermann A, Jones S, James S, et al. Implementation of best practice alert in an electronic medical record to limit lower-value inpatient echocardiograms. *Am J Cardiol*. 2018;122:1574–1577.
20. Martin C, Pappas J, Johns K, et al. Semiautonomous treatment algorithm for the management of severe hypertension in pregnancy. *Obstet Gynecol*. 2021;137:211–217.
21. Smith A, Banville D, Gruver EJ, et al. A clinical pathway for the care of critically ill patients with asthma in the community hospital setting. *Hosp Pediatr* 2019;9:179–185.
22. Pound CM, Gelt V, Akiki S, et al. Nurse-driven clinical pathway for inpatient asthma: a randomized controlled trial. *Hosp Pediatr* 2017;7:204–213.
23. Schulz L, Osterby K, Fox B. The use of best practice alerts with the development of an antimicrobial stewardship navigator to promote antibiotic de-escalation in the electronic medical record. *Infect Control Hosp Epidemiol*. 2013;34:1259–1265.
24. Chanas T, Volles D, Sawyer R, et al. Analysis of a new best-practice advisory on time to initiation of antibiotics in surgical intensive care unit patients with septic shock. *J Intensive Care Soc*. 2019;20:34–39.