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Improving Situational Awareness to Decrease Emergency ICU Transfers for Hospitalized Pediatric Cardiology Patients

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ABSTRACT

Introduction: Failure to recognize and mitigate critical patient deterioration remains a source of serious preventable harm to hospitalized pediatric cardiac patients. Emergency transfers (ETs) occur 10–20 times more often than code events outside the intensive care unit (ICU) and are associated with morbidity and mortality. This quality improvement project aimed to increase days between ETs and code events on an acute care cardiology unit (ACCU) from a baseline median of 17 and 32 days to ≥70 and 90 days within 12 months. **Methods:** Institutional leaders, cardiology-trained physicians and nurses, and trainees convened, utilizing the Institution for Healthcare Improvement model to achieve the project aims. Interventions implemented focused on improving situational awareness (SA), including a "Must Call List," evening rounds, a visual management board, and daily huddles. Outcome measures included calendar days between ETs and code events in the ACCU. Process measures tracked the utilization of interventions, and cardiac ICU length of stay was a balancing measure. Statistical process control chart methodology was utilized to analyze the impact of interventions. **Results:** Within the study period, we observed a centerline shift in primary outcome measures with an increase from 17 to 56 days between ETs and 32 to 62 days between code events in the ACCU, with sustained improvement. Intervention utilization ranged from 87% to 100%, and there was no observed special cause variation in our balancing measure. **Conclusions:** Interventions focused on improving SA in a particularly vulnerable patient population led to sustained improvement with reduced ETs and code events outside the ICU. *(Pediatr Qual Saf 2023;8:e630; doi: 10.1097/pq9.0000000000000630; Published online September 28, 2023.)*

INTRODUCTION

Many hospital systems that have employed rapid response teams (RRT) coupled with risk prediction tools such as the pediatric early warning score (PEWS) have reduced in-hospital cardiac arrests and mortality rates.[1–3] Despite these improvements, failure to recognize and mitigate critical patient deterioration remains a source of serious preventable harm.[4] Emergency transfers (ETs) to the intensive care unit (ICU) are defined as a transfer in which the patient receives endotracheal intubation, greater than or equal to 3 fluid boluses, and/or the initiation of vasopressor agents in the first 60 minutes of ICU care or before arrival to the ICU.[4] Importantly, patients who are emergently transferred have a higher likelihood of in-hospital mortality compared with matched controls (22% versus 9%).[5] In one published study, ETs are estimated to occur ten times more commonly than cardiopulmonary arrests (CAs) outside of the ICU and are considered a more proximal measure for critical patient deterioration.[4,5]

Many deterioration events are preceded by objective clinical changes, such as vital sign abnormalities and subjective changes, like the "gut feelings" of a patient, family, or provider.[6] National efforts to reduce ETs in hospitalized pediatric patients have focused on interventions to improve provider situational awareness (SA), informally defined as "knowing what's going on."[4,7,8] Increased SA promotes earlier recognition of potential patient deterioration, with subsequent risk mitigation and escalation

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of care as indicated, to prevent ETs and their associated morbidity and mortality.[4]

Starting in 2009, our institution began a decade-long journey to eliminate preventable harm, including reducing ETs and code events outside the ICU.[9] Despite hospital-wide improvement after implementing multiple interventions to enhance SA, sustained improvement was not achieved. In the fall of 2018, institutional quality and safety leadership observed special cause variation with an increase in the rate of ETs per 10,000 non-ICU patient days, which prompted a deeper dive. The inpatient acute care cardiology unit (ACCU)—a general cardiology unit—had the highest number of ETs in 2018, with 11 total events. As a result, improvement efforts were pursued in January 2019 with the SMART aim (specific, measurable, attainable, relevant, and time-bound) to increase calendar days between ETs on the ACCU from a baseline median of 17 to greater than 70 days within 12 months and to sustain indefinitely. Our secondary aim was to increase calendar days between cardiopulmonary arrest events in the ACCU from a baseline median of 32 to greater than 90 days within 12 months and to sustain indefinitely, with a global goal of eliminating unrecognized clinical deterioration.

METHODS

Context

This project is a single-center quality improvement (QI) study conducted at a large, not-for-profit, quaternary care, freestanding pediatric teaching hospital located in the Midwest with more than 1.5 million annual patient visits. The Heart Center within the institution performs over 350 thoracic surgical cases annually and includes a 20-bed cardiac ICU (CTICU) and a 24-bed ACCU.

The ACCU is a non-ICU unit that admits ~1,400 neonatal to adult-aged (≥18 years with no age limit) patients annually with both acquired and congenital heart disease. The ACCU manages a wide range of patient acuity from observation encounters of less than 24 hours to medically complex patients, including tracheostomy/ventilator-dependent patients and those requiring high-flow nasal cannula, ventricular assist devices, inotrope infusions, subcutaneous and inhaled pulmonary hypertension therapies, intermittent renal replacement therapy, and interstage single ventricle patients. Approximately 40% of ACCU patients are postsurgical, with immediate postoperative care provided in the CTICU.

The ACCU medical team consists of an attending pediatric cardiologist, a pediatric cardiology fellow, two categorical pediatric residents, and an advanced practice nurse (APN), operating in-house during daytime hours, 7 days/wk. Daily management decisions are made during family-centered bedside rounds by a multidisciplinary team. Nighttime coverage includes a single in-house night float pediatric resident, in-house single APN, home-call cardiologist, and cardiology fellow.

A "Watchstander" program has existed since 2014 in all non-ICU units.[4] Every 4 hours, a nursing assessment of Watchstander criteria occurs, which includes: Monaghan's PEWS ≥ 5,[10] RRT activated within the past 24 hours, neurologic changes, escalating respiratory support, fluid input/output mismatch, gut feeling/concern of the caregiver, communication concern, sepsis risk with abnormal vital signs and/or staff unfamiliar with a high-risk diagnosis or treatment plan. Patients triggering any of these criteria automatically become "watchers." When a patient is made a watcher, the primary front-line provider (resident or APN), bedside nurse, and charge nurse huddle at the bedside to develop a mitigation and escalation plan. Active watchers populate an electronic health record (EHR) dashboard monitored by a 24/7 in-house hospitalist responsible for ensuring documentation of a mitigation and escalation plan. In addition to the Watchstander program any patient, family or staff member can call a rapid response within our institution, with ICU providers expected to respond within 15 minutes. ALthough other general med surg units escalate care to the pediatric ICU (PICU), the ACCU escalates care to the CTICU, which is geographically located on the same floor.

Preintervention

In January 2019, we assembled a multidisciplinary team of stakeholders from our institutional Watchstander program and Heart Center, including CTICU/ACCU attendings and APNs, ACCU nursing leadership, a pediatric cardiology fellow, and a chief resident. The team utilized strategies derived from the Institute of Healthcare Improvement (IHI) model for improvement, including aim statement, key driver diagram, and plan-do-study-act cycles. We analyzed baseline ACCU ET data retrospectively to identify root causes with the performance of a "5 Why" analysis. Failures were affinitized into key drivers, which informed interventions (Fig. 1).

Interventions

Based on historical patient deterioration events, we developed and implemented a "Must Call List" for front-line staff in June 2019 (Table 1). If a patient fulfills any listed clinical criteria, front-line staff are expected to escalate this information to the cardiology fellow on call as soon as detected, with further escalation and next steps at the fellow's discretion. The Must Call List aids in creating a shared mental model for front-line providers, including nurses, residents, and APNs, by defining clinical changes necessitating escalation. Our team posted this list in ACCU workrooms, resident call rooms, and nursing education boards. The list was also included in resident orientation materials and disseminated to the nursing staff via email. The list continues to evolve as new opportunities are uncovered. In addition, the team implemented secondary rounds in July 2019, a nighttime rounding

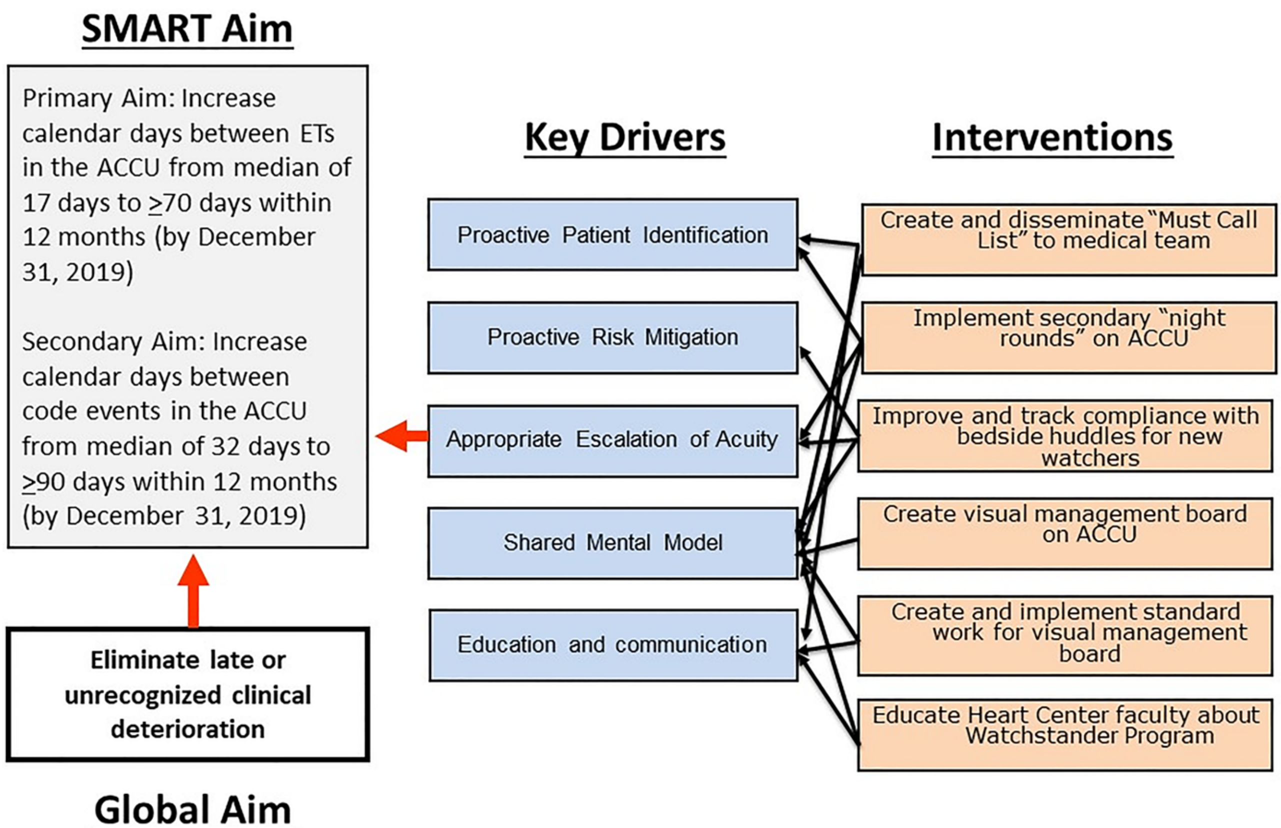

Fig. 1. Key driver diagram.

Table 1. "Must Call List" Contents

Clinical Criteria	Definition
Telemetry changes	Change in rhythm, pauses greater than 2 s, complex ventricular ectopy, nonsustained ventricular tachycardia, high grade heart block (second degree type II or greater)
Escalating respiratory support	Starting supplemental oxygen, escalating support (nasal cannula to high flow), maxed out on high-flow nasal cannula (2 L/kg)
Worsening hypoxemia	10 or more point change in oxygen saturation, any desaturation event in a patient with central shunt (eg, BTT shunt)
Pleural chest tube issues	Output abruptly stopped
Fluid balance issues	Positive or negative ≥ 1 L unless intentional goal
Fevers	In neonate (<30 d of life), in patients with central lines or immunocompromised (including transplant recipients)
Perfusion concerns	Loss of pulse in an extremity following cardiac cath procedure, and visible or occult blood in patient's stool
Early warning systems	Escalating PEWS score, patient made a "Watcher"

process seeking to promote SA among nighttime providers to address the disproportionate number of overnight ETs. Secondary rounds occur in the evening and include night shift front-line providers, charge nurses, and bedside nursing. Secondary rounds mirrored morning rounds by reviewing interval events, updated objective data, and input from the bedside nurse and patient/family. After rounds, front-line providers communicate with the on-call cardiology fellow to ensure the timely escalation of patient/family and medical team concerns.

In July 2019, we created the ACCU visual management board to promote proactive communication, problem-solving, and SA among ACCU staff. The contents of the board are updated daily by the ACCU charge nurse. They include staffing information, SA outcome metrics (including watchers, ETs, rapid response, and code events), unit acuity information, and unit-specific quality and safety metrics (including hospital-acquired conditions and employee/patient safety events). To complement the board, we developed a twice-daily huddle process (**see Supplemental Materials, Supplemental Digital Content 1,** for ACCU huddle standard work, ***http://links.lww.com/PQ9/A448***). The morning huddle occurs before medical rounds and involves the entire ACCU medical team and charge nurse. The evening huddle occurs at the nursing shift change and involves nursing staff (charge nurse and day/night bedside nursing). During the huddles, a review of patients at risk for deterioration occurs with a discussion of the current mitigation and escalation plans. Strategically related to this project, the initial quality metric chosen for the visual management board focused on improving compliance with bedside huddles on newly identified watchers (Fig. 2).

In August 2019, we provided targeted education to Heart Center faculty and fellows on the institutional Watchstander

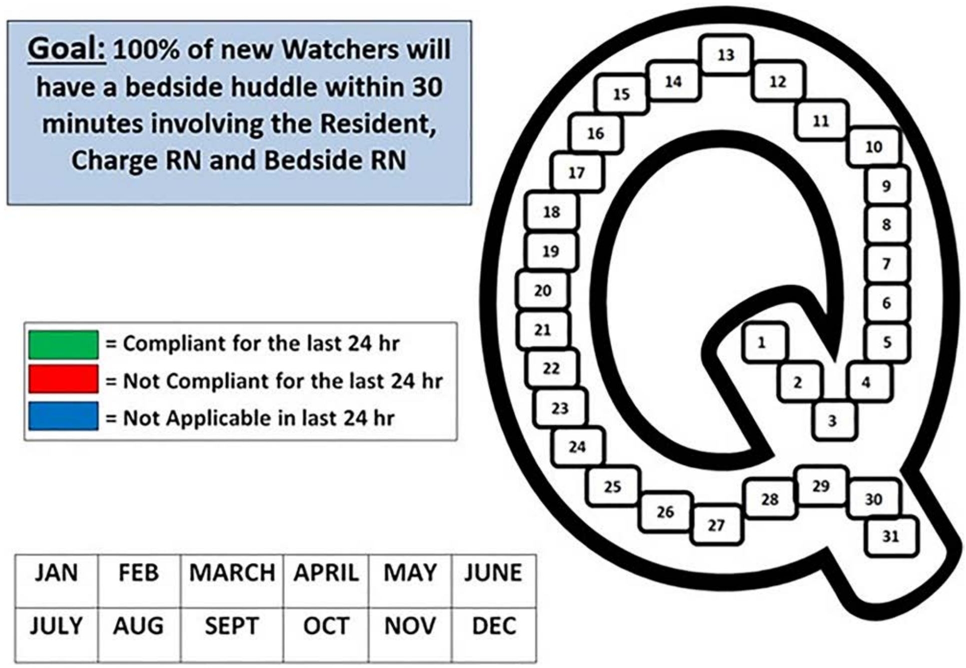

Fig. 2. Visual Management Board quality metric sheet. This tool is laminated and visually displayed on the ACCU visual management board. On the first day of each month, the charge nurse selects the appropriate month at the bottom left of the sheet. Each number within the "Q" represents a calendar date for the selected month. Completion of this sheet occurs every 24 hours by coloring each calendar date as either green (compliant), red (not compliant), or blue (not applicable for the last 24 hours) so that, visually, the team can quickly assess overall compliance with the stated goal.

program. Our improvement team felt this education was necessary as many Heart Center providers were unaware of the existing Watchstander program at project initiation. As a result, Watchstander leadership provided a single lecture during a Cardiology Division faculty meeting and disseminated Supplemental Material via email.

Study of Interventions

Baseline data were collected retrospectively from January through December 2018 for the outcome and balancing measures. The project began in January 2019 with a prospective collection of outcome, process, and balancing measures. During the study period (January through December 2019), there were no concurrent improvement efforts targeting safety culture within the ACCU. Of note, near the conclusion of the study period, a data-driven predictive model was implemented in the ACCU to promote earlier identification of clinical deterioration.[11] This algorithm went live in the ACCU in January of 2021, 2 years following project initiation and the observed improvements. While the evaluation of this tool and its implementation are out of the scope of this manuscript, sustained improvements should be considered in the context of this concurrent intervention.

Measures and Data Collection

Outcome Measures

1. Days between ACCU ETs: Given the rare nature of ETs, our primary outcome measure was the number of calendar days between ACCU ETs.
2. Days between ACCU code events: A code event occurs when a patient requires chest compressions (regardless of duration), electrical shock, and/or invasive/sustained noninvasive ventilation during an emergency response.[12]

Process Measures

1. Utilization of ACCU visual management board daily morning huddle: Assessed monthly through the performance of random audits with an updated board and a completed daily huddle required for compliance.
2. Utilization of bedside huddles for newly designated watchers within the ACCU: Assessed monthly from August 2019 to September 2020 by reviewing the metric sheet on the ACCU visual management board.

Balancing Measures

1. CTICU average length of stay (LOS): Calculated monthly for all patients admitted to the CTICU. Evaluated to ensure that efforts targeting a decrease in ETs were not inadvertently leading to delays in patient transfer from the CTICU to the ACCU as many ACCU patients begin their hospitalization in the CTICU.

Data Analysis

We obtained data for analysis from the EHR (Epic, Epic Systems, Verona, Wis.). We generated Statistical Process

Control (SPC) charts using QI Macros SPC Software Version 2020.10, an add-in to Microsoft Excel with the application of established rules for identifying special cause variation.[13] Given the rarity of events, we chose to display days between ETs and code events on g-charts. We utilized an X-bar and S-chart to display CTICU LOS.

Ethical Considerations

The institutional review board (IRB) determined this project was QI, not human subjects research. Therefore, IRB review and approval were not required per institutional policy. The authors followed the Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) Guidelines for this publication.[14]

RESULTS

The baseline median distribution of days between ETs in the ACCU was 17. There was a centerline shift on the SPC chart plotting this metric (Fig. 3) beginning in June 2019 following evidence of special cause variation (two outlier data points outside baseline control limits), coinciding with team assembly and initial interventions. As a result, the new aggregate median days between ACCU ETs increased to 59 days, sustained for over 2 years. In July 2021, there was a peak of 191 days between ETs, the longest stretch observed during the study period. Regarding the absolute number of ETs, we observed 11 total ETs in 2018, which was reduced to five events in 2019 and six in 2020. Patient volumes within the ACCU remained stable in 2018 and 2019 (6,433 non-ICU patient days versus 6,266, respectively), with a transient decrease beginning in March 2020, corresponding with the COVID-19 pandemic.

The baseline median days between code events in the ACCU was 32. There was a centerline shift on the SPC chart plotting this metric (Fig. 4) beginning in February 2019 (run of 10/11 data points above the baseline center line).[15] The new aggregate median days between code events in the ACCU increased to 63 days, sustained for over two years. In July 2021, there was a peak of 194 days between code events, the longest stretch observed during the study period.

Regarding our process measures, audits occurred daily for the first 3 months following implementing the ACCU visual management board and daily huddle process. Audits revealed 100% utilization of daily data updates for the board and performance of twice-daily huddles. In addition, our improvement team assessed compliance with bedside huddles performed on newly designated watchers monthly for 14 months. As a result, the number of compliant days per month increased from 87% (August/September 2019) to 97%–100% (May–September 2020). We discontinued formal audits for the above process measures given exceptional observed utilization. Regarding the defined balancing measure, the baseline average CTICU LOS was 5.6 days with no observed special cause variation following project implementation (Fig. 5).

DISCUSSION

Using QI methodology to increase SA, this study successfully reduced ETs and non-ICU code events in hospitalized pediatric cardiology patients with improvement sustained for over two years. We initially observed a shift on our SPC chart plotting days between ACCU code events in February 2019. We postulate that the work to promote earlier identification and risk mitigation for high-risk patients directly impacted code events. Also, team engagement, unit awareness, and communication efforts toward the QI project likely contributed to reducing these already rare events. Given the relatively low incidence of pediatric in-hospital arrests, our improvement team chose ETs as their primary outcome measure, representing a more proximal measure for significant clinical deterioration.[5] We saw a shift in our SPC chart plotting days between ETs in the ACCU in June 2019. Like the decrease in code events, we attribute initial improvements observed following team assembly to the broad multidisciplinary stakeholder buy-in, the belief that improvement was possible, the focus on patients at risk for deterioration, and the creation of a shared mental model amongst front-line staff.

Following the implementation of multiple interventions in the summer of 2019, we observed evidence of special cause variation with 129 and 170 days between ETs in the ACCU. Given the rapid adoption and high utilization of interventions and no other known changes during the study period, we felt the observed improvements were directly related to practice changes resulting from this project. Unfortunately, given the rapid implementation of multiple countermeasures and the rarity of events, it is difficult to ascertain which intervention(s) had the biggest impact on our observed improvement.

Some have proposed that the initial step necessary for proactive risk mitigation involves "recognition" of what might happen next, followed by "respond" and "learn."[16] Recognition relies on one's skill and experience, which may be lacking depending on multiple factors, including the level of training. A large proportion of front-line providers in our ACCU are categorial pediatric residents, most of whom are new to inpatient pediatric cardiology. Our team acknowledged this experience gap as an opportunity to improve the identification and escalation of at-risk patients, addressed through the implementation of the Must Call List. We postulate that the Must Call List was the most impactful intervention in this improvement work, given that it promotes shared SA among all care team members regardless of role, experience, or the level of training. Subsequent interventions, including secondary/night rounds and improved compliance with bedside huddles for new watchers, have provided new venues to escalate patient care concerns for high-risk patients, allowing providers to "respond" or take action to prepare for or change the course of events.[16]

After initial improvement, we have observed sustained improvement through 2021. As previously noted, there was a concurrent intervention with implementing a clinical

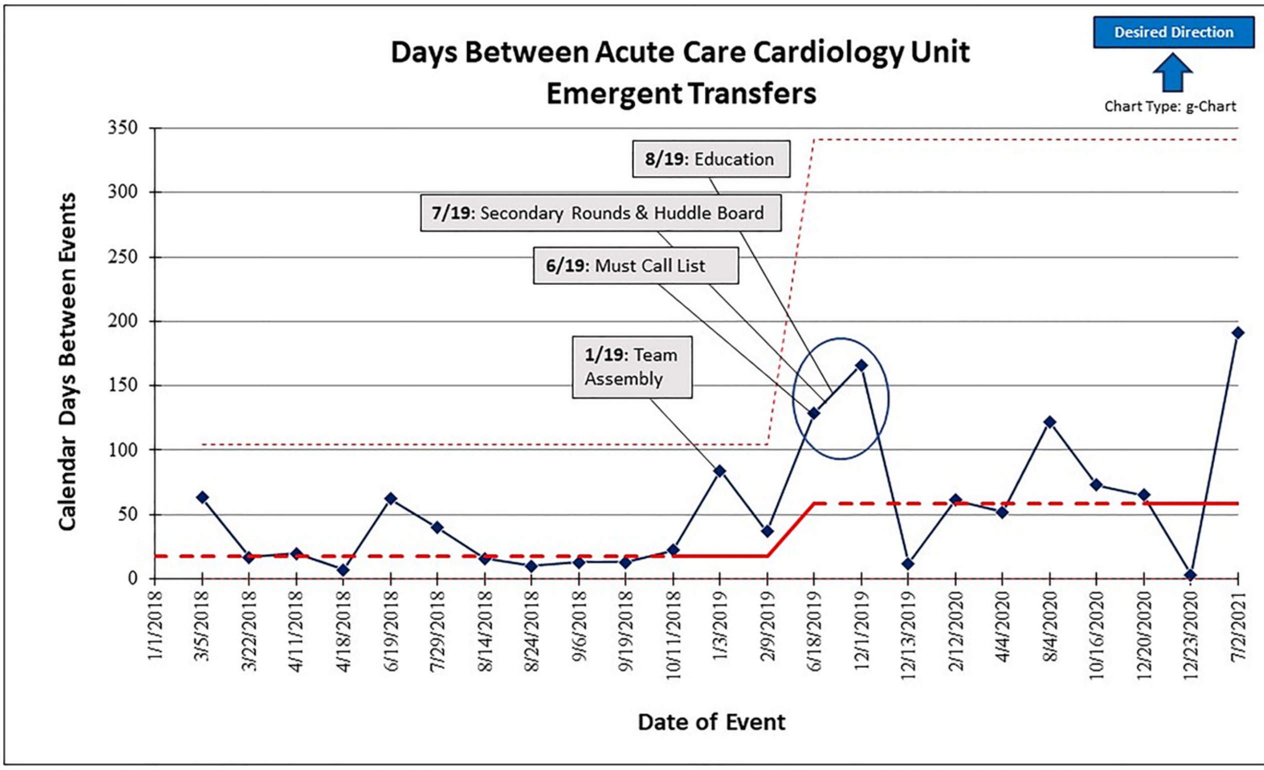

Fig. 3. Statistical process control chart with primary outcome measure: days between ACCU emergency transfers. Circled data points represent special cause variation (two outlier data points outside baseline control limits).

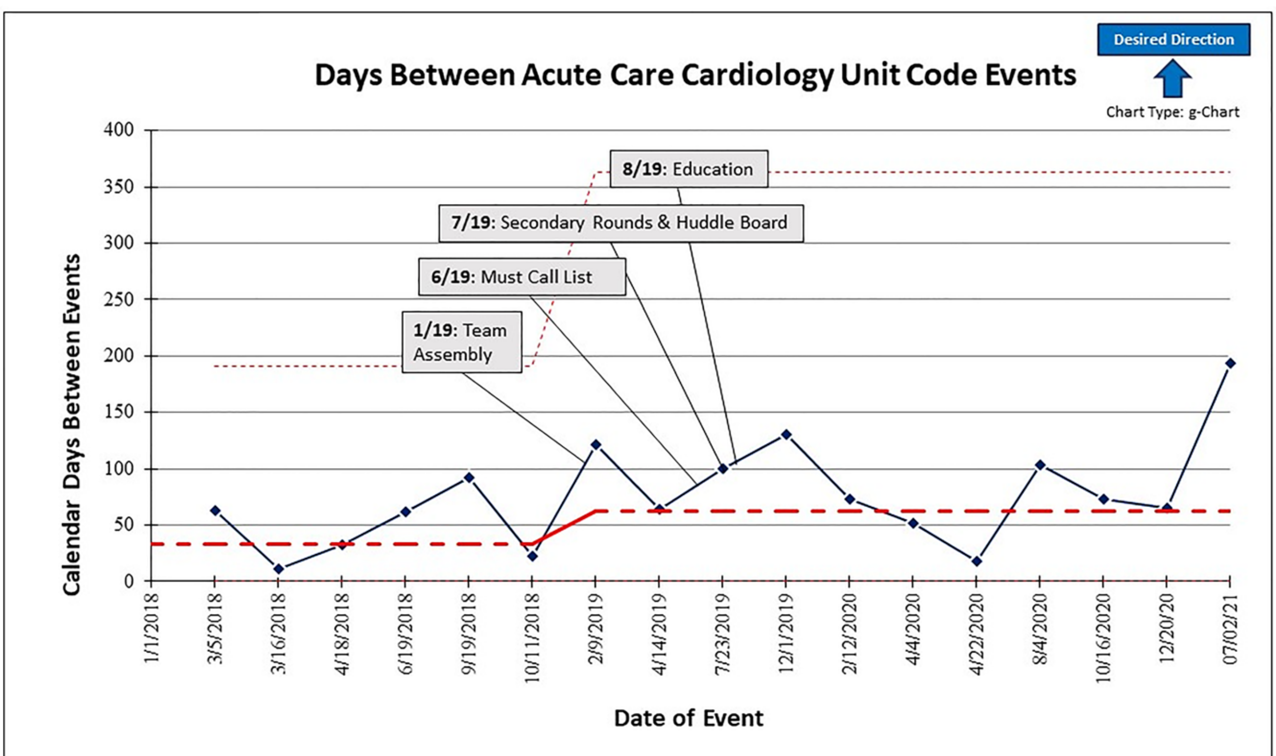

Fig. 4. Statistical process control chart with secondary outcome measure: days between ACCU code blue events. There is a center line shift beginning in February 2019 (run of 10/11 data points above the baseline center line).

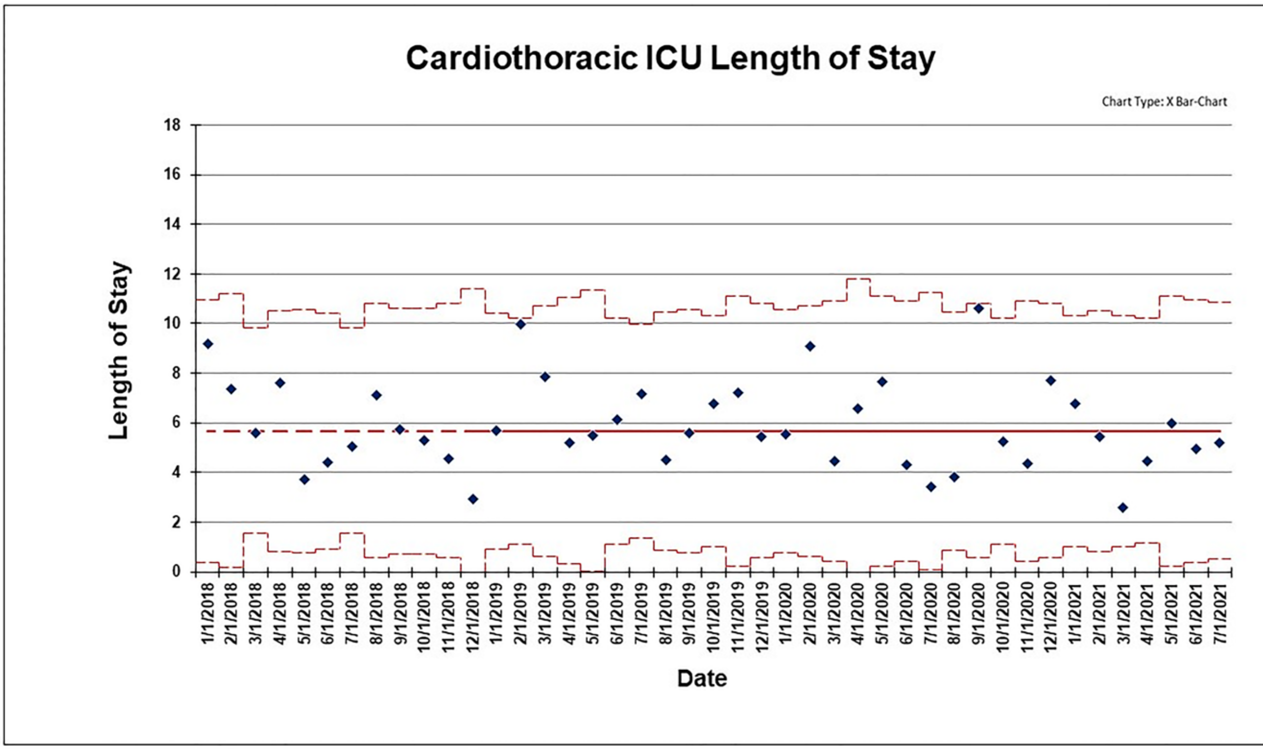

Fig. 5. Statistical process control chart with balancing measure: cardiac ICU length of stay.

deterioration algorithm on the ACCU in January 2021. In addition to the described QI project interventions, which have become standard work, we speculate that this algorithm may have contributed to sustained improvements—ongoing data collection and analysis will be necessary.

Nationally, there has been an overall reduction in pediatric in-hospital CAs following the implementation of RRTs and early warning scores.[17] Despite this improvement, the incidence of pediatric in-hospital CA remains over 15,000/y based on national registry data.[17] Children with underlying cardiac disease are at greater risk for experiencing a CA compared to children without cardiac disease, with 36% of in-hospital CA occurring in pediatric cardiac patients.[18] Despite an extensive body of literature describing early warning systems to reduce clinical deterioration in pediatrics, there has been minimal focus on this high-risk cohort.

Pediatric cardiac patients pose unique challenges regarding implementing traditional early warning systems, partly due to baseline vital sign derangements (hypoxemia/cyanosis) and higher rates of preexisting arrhythmia and congestive heart failure. For these reasons, Boston Children's Hospital developed a modified pediatric early warning tool called the Cardiac Children's Hospital Early Warning Score (C-CHEWS).[18] McLellan et al performed a retrospective cohort study to validate C-CHEWS, finding it superior to PEWS in discerning cardiac patients at risk for deterioration.[19] Our team considered implementation of C-CHEWS as part of this work; however, we could not retrospectively validate this tool given missing variables in our EHR (eg, "new onset or increase in ectopy"). Instead, our study combined the ongoing use of PEWS, defined Watchstander criteria, and newly implemented tools to enhance SA—all of which enhanced earlier identification of at-risk patients with corresponding mitigation and escalation planning.

Other studies have attempted to reduce ETs and CA through improvement efforts focused on increasing SA. A single-center observational time series by Brady et al[4] sought to reduce UNSAFE transfers, which are equivalent to ETs. They successfully reduced UNSAFE transfers from 4.4 to 2.4 per 10,000 non-ICU patient days through interventions to improve SA. Specifically, identifying five risk factors led to improved identification of high-risk patients by creating a shared mental model. Our study augments this concept by developing a Must Call List containing cardiac-specific risk factors based on previous deterioration events showing that similar principles aimed at recognition can be successfully applied to subspecialty cohorts.

A multi-institution study sponsored by the Children's Hospital Association (CHA) sought to reduce pediatric code events outside of the ICU across 20 institutions.[20] Each institution implemented intervention(s) selected from a change package focused on improved prevention, detection, and intervention for deteriorating patients. The results are mixed, with only a modest 3% reduction in the aggregate median code rate per 1,000 patient days, likely limited by the study's short duration (12 months) and lack of a consistent operational definition for "code blue." Finally, Dean et al sought to reduce non-ICU arrests by implementing the Late Rescue Collaborative, a single-center multidisciplinary committee developed to track and evaluate patient deterioration.[21] Through the implementation of 16 interventions surrounding cultural change and enhanced recognition of deteriorating patients, the collaborative saw a reduction in non-ICU arrests from 0.31 to 0.11 arrests per 1,000 non-ICU patient days sustained for 3 years. Our study differs in that our focus was on more proximal risk mitigation for those at the highest risk for deterioration—pediatric cardiac patients.

Limitations

The findings from this QI project should be interpreted within several potential limitations. Prior studies describing outcomes for ETs were based on analysis of heterogeneous populations with the impact on cardiac patients unknown. We could not track the utilization of several interventions, making it difficult to ascertain which interventions ultimately had the greatest impact on our outcomes. Additionally, this study was limited to a single center with a strong culture rooted in continuous improvement coupled with a robust QI Services department, which allocates resources for QI projects. As described earlier, additional institutional resources for the Watchstander program exist to promote SA. Institutions without these resources may have difficulty duplicating our work. In addition, this study did not assess the operational costs of the existing Watchstander program and the interventions implemented. Finally, outcome measures for this study do not consider the opportunity for an ET or code to occur; however, as stated previously, non-ICU patient days within the ACCU remained stable in 2018 and 2019, with only a brief dip corresponding with the COVID-19 pandemic in early 2020.

CONCLUSIONS

Interventions focused on improving SA, and proactive risk mitigation can effectively reduce ETs and code events in non-ICU pediatric cardiac patients. Targeted interventions to improve "recognition" and "response" for those at the highest risk for deterioration led to this sustained improvement. Future data analysis will be needed to assess the impact of our data-driven predictive analytics tool on ETs and code events.

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DISCLOSURE:

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

REFERENCES

1. Ortmann L, Prodhan P, Gossett J, et al. Outcomes after in-hospital cardiac arrest in children with cardiac disease: a report from get with the guidelines--resuscitation. *Circulation*. 2011;124:2329–2337.
2. Al-Omari A, Al Mutair A, Aljamaan F. Outcomes of rapid response team implementation in tertiary private hospitals: a prospective cohort study. *Int J Emerg Med*. 2019;12:31.
3. Mankidy B, Howard C, Morgan CK, et al. Reduction of in-hospital cardiac arrest with sequential deployment of rapid response team and medical emergency team to the emergency department and acute care wards. *PLoS One*. 2020;15:e0241816.
4. Brady PW, Muething S, Kotagal U, et al. Improving situation awareness to reduce unrecognized clinical deterioration and serious safety events. *Pediatrics*. 2013;131:e298–e308.
5. Hussain FS, Sosa T, Ambroggio L, et al. Emergency transfers: an important predictor of adverse outcomes in hospitalized children. *J Hosp Med*. 2019;14:482–485.
6. Schein RM, Hazday N, Pena M, et al. Clinical antecedents to in-hospital cardiopulmonary arrest. *Chest*. 1990;98:1388–1392.
7. Brady PW, Wheeler DS, Muething SE, et al. Situation awareness: a new model for predicting and preventing patient deterioration. *Hosp Pediatr*. 2014;4:143–146.
8. Sosa T, Sitterding M, Dewan M, et al. Optimizing situation awareness to reduce emergency transfers in hospitalized children. *Pediatrics*. 2021;148: e2020034603.
9. Brilli RJ, McClead RE, Jr, Davis T, et al. The preventable harm index: an effective motivator to facilitate the drive to zero. *J Pediatr*. 2010;157:681–683.
10. Monaghan A. Detecting and managing deterioration in children. *Paediatr Nurs*. 2005;17:32–35.
11. Gorham TJ, Rust S, Rust L, et al. The vitals risk index-retrospective performance analysis of an automated and objective pediatric early warning system. *Pediatr Qual Saf*. 2020;5:e271.
12. Sharek PJ, Parast LM, Leong K, et al. Effect of a rapid response team on hospital-wide mortality and code rates outside the ICU in a children's hospital. *JAMA*. 2007;298:2267–2274.
13. Provost LP, Murray SK. *The Health Care Data Guide: Learning From Data For Improvement*. 1st ed. Jossey-Bass; 2003.
14. Goodman D, Ogrinc G, Davies L, et al. Explanation and elaboration of the SQUIRE (Standards for Quality Improvement Reporting Excellence) guidelines, V.2.0: examples of SQUIRE elements in the healthcare improvement literature. *BMJ Qual Saf*. 2016;25:e7e7.–e7ee7.
15. Tague NR. *The Quality Toolbox*. 2nd ed. ASQ Quality Press; 2005.
16. Bartman T, Merandi J, Maa T, Cosgrove T, Brilli RJ. Safety II: a novel approach to reducing harm. In: Shah R, Godambe S, eds. *Patient Safety and Quality Improvement in Healthcare*. Vol 1. 1 ed. Springer, Cham; 2021.
17. Holmberg MJ, Ross CE, Fitzmaurice GM, et al. Annual incidence of adult and pediatric in-hospital cardiac arrest in the United States. *Circ Cardiovasc Qual Outcomes*. 2019;12:e005580.
18. McLellan MC, Connor JA. The Cardiac Children's Hospital Early Warning Score (C-CHEWS). *J Pediatr Nurs*. 2013;28:171–178.
19. McLellan MC, Gauvreau K, Connor JA. Validation of the Cardiac Children's Hospital Early Warning Score: an early warning scoring tool to prevent cardiopulmonary arrests in children with heart disease. *Congenit Heart Dis*. 2014;9:194–202.
20. Hayes LW, Dobyns EL, DiGiovine B, et al. A multicenter collaborative approach to reducing pediatric codes outside the ICU. *Pediatrics*. 2012;129:e785–e791.
21. Dean NP, Ghebremariam E, Szeles R, et al. Late rescue collaborative: reducing non-ICU arrests. *Pediatr Crit Care Med*. 2020;21:513–519.