

**Implementation of a Cardiac Arrest Prevention Bundle in the Pediatric Intensive Care Unit: A Quality  
Improvement Project**

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## Abstract

Cardiac arrest (CA) in pediatric cardiac patients remains a significant cause of morbidity and mortality, with in-hospital CA rates among this population posing considerable challenges. Despite numerous quality improvement (QI) initiatives aimed at reducing CA rates, survival improvements have plateaued, necessitating novel approaches focused on prevention and early intervention. This study aimed to reduce CA rates in high-risk pediatric cardiac patients through the implementation of a Cardiac Arrest Prevention (CAP) bundle at Oregon Health and Science University's (OHSU) Pediatric Intensive Care Unit (PICU). The CAP bundle included a structured form and twice-daily multidisciplinary huddles designed to enhance situational awareness, communication, and early intervention strategies.

A 12-month implementation of the CAP bundle occurred from March 2023 to March 2024, complemented by pre- and post-implementation nursing surveys to assess the impact on staff perspectives and practices. Outcome measures focused on changes in CA rates per 1000 patient days, while process measures evaluated nursing participation and compliance with the CAP protocols.

Results indicated an initial increase in CA rates from 4.85 to 24.9 per 1000 patient days post-implementation. Despite this, most CA incidents occurred in patients not included in the CAP bundle. However, nursing survey results revealed significant improvements in staff awareness, involvement in care planning, and preparedness to respond to patient deterioration. By the end of the study, over 95% of nurses reported better understanding of patient risk and felt more empowered to act preemptively.

While the primary aim of reducing CA rates was not achieved, the project fostered a culture of proactive care and enhanced multidisciplinary communication, suggesting that further refinement and comprehensive application of the CAP bundle could yield better outcomes. Future studies should focus on identifying critical bundle elements and ensuring broader patient inclusion to fully realize the potential benefits of CA prevention strategies.

**Disclosures**

This author is a full time Doctor of Nursing Practice student paying tuition to the institution where the pediatric CAP bundle was implemented in the PICU and works in the PICU at this institution. Otherwise, this author has no conflicts of interest or financial relationships to disclose.

**Table of Contents**

Problem Description _____	5
Available Knowledge _____	6
Rationale _____	8
Specific Aims _____	8
Context _____	9
Interventions _____	10
Study of the Interventions _____	11
Measures _____	11
Analysis _____	11
Ethical Considerations _____	12
Results _____	12
Summary _____	24
Interpretation _____	24
Limitations _____	25
Conclusions _____	26
References _____	27
Appendix A: Cause and Effect Diagram _____	29
Appendix B: Cardiac Arrest Prevention Bundle Form _____	30
Appendix C: Bundle Huddle Video Example _____	31
Appendix D: Pre/Post-implementation Nursing Survey _____	32
Appendix E: IRB Request for Determination _____	35
Appendix F: Letter of Support from Clinical Agency _____	36

## Introduction

### Problem Description

CA is a known and unfortunate complication in the pediatric cardiac population that contributes to high morbidity and mortality. There are an estimated 15,200 pediatric in-hospital patients who receive cardiopulmonary resuscitation (CPR) each year (Morgan et al, 2021; Riley et al., 2022a; Khoubian & Alten, 2022). One of the earliest studies (Rhodes et al., 1999) reported that while CA in the PICU population is relatively uncommon, it is also associated with poor outcomes. Additionally, the incidence of children requiring CPR in a PICU has been estimated to be between 1.5% and 6% (Rhodes et al., 1999). While the rates of CPR are relatively low, the survival rate for these children is only between 8.8% and 31% (Rhodes et al., 1999).

CA after congenital heart surgery is often an acute event in a child who otherwise has healthy organ systems versus a chronically ill child who may already have end stage organ failure to some degree (Rhodes et al., 1999). Several factors increase the rate of death in children who experience CA including a lower mean arterial pressure (MAP) and significant inotropic support (Rhodes et al., 1999). Additionally, pediatric patients, who are more hemodynamically unstable right before a CA event, are more likely to die (Rhodes et al., 1999).

Initially, pediatric IHCA outcomes improved in the early 2000's (Morgan et al, 2021). However, the rates of survival after pediatric IHCA have plateaued as more than half of children will not survive to hospital discharge (Morgan et al, 2021; Riley et al., 2022a; Khoubian & Alten, 2022). Furthermore, hospitalized children with cardiac disease have 10 times the risk of CA as compared to non-cardiac patients (Khoubian & Alten, 2022). While there have been many factors identified that contribute to CA in children with cardiac disease, there is no identified mechanism, standardized method, or protocol for reducing CA in children with cardiac disease.

## Available Knowledge

Despite many studies and quality improvement (QI) initiatives aimed at improving CA resuscitation, there has been little improvement in mortality rates after pediatric IHCA (Khoubian & Alten, 2022). Khoubian & Alten (2022) stated the lack of improvement in survival among these children suggests a need for a different approach to reduce CA. There is emerging evidence that shows focusing on CA prevention may improve overall outcomes (Khoubian & Alten, 2022). An important piece of this shift in focus is changing the mindset of many providers who may believe CA is unavoidable and inevitable in the pediatric cardiac patient population (Khoubian & Alten, 2022). However, new evidence revealed CA events can be prevented by focusing on prevention and the pre-arrest phase (Khoubian & Alten, 2022). To improve the rates of CA, there must be improved identification of high-risk patients and the pre-arrest phase while continuing to foster communication and situational awareness amongst the healthcare team (Khoubian & Alten, 2022).

The outcomes after cardiac surgery at children's hospitals have improved over the last several decades, but these improvements appear to be plateauing (Gaies et al., 2019). Morbidity and mortality remains high for pediatric patients who received complex operations and/or complications (Gaies et al., 2019). Additionally, there is variation in outcomes across hospitals especially for patients who received complex cardiac surgery (Gaies et al., 2019). These differences suggest there is opportunity to improve the care for patients with pediatric cardiac disease (Gaies et al., 2019). However, the most effective strategies to prevent CA and improvement outcomes remain unclear (Gaies et al., 2019). Gaies et al. (2019) demonstrated that optimizing research and QI initiatives required multidisciplinary participation as well as increased data and resource sharing between institutions.

In one recent study (Riley et al., 2022b), a pediatric CAP bundle was implemented as part of a QI project at a tertiary, academic medical center. The CAP bundle consisted of a bedside tool that emphasized a shared mental model through the implementation of collective team knowledge (Riley et

al., 2022b). The CAP bundle gave bedside providers the ability to adapt and respond appropriately to patient deterioration (Riley et al., 2022b). After implementing the CAP bundle, the CA rate decreased by 68% which was sustained for 30 months (Riley et al., 2022b). Multidisciplinary engagement and buy-in was critical to achieving the culture change that led to significant and sustained CA reduction (Riley et al., 2022b). A shared mental model paired with targeted communication allowed the team to adjust resources as well as monitoring of a patient's evolving level of risk to proactively prevent arrest (Riley et al., 2022b). In addition, establishing an interdisciplinary leadership team and QI process with stakeholder buy-in allowed for the culture change required to ultimately ensure sustainable change (Riley et al., 2022b).

One of the most robust studies (Alten & Gaies, 2018) was led by researchers at Cincinnati Children's Hospital and 14 other hospitals, who challenged the notion that IHCA is largely unavoidable. Pediatric cardiac intensive care unit (CICU) teams from the Pediatric Cardiac Critical Care Consortium (PC<sup>4</sup>) formed a collaborative network to implement the CAP bundle consistent with the Institute for Healthcare Improvement (IHI) framework (Alten et al., 2022). There were 15 hospitals from the PC<sup>4</sup> that implemented the bundle voluntarily (Alten et al., 2022). The CAP bundle was composed of five elements developed to increase situational awareness and communication among bedside staff in order to recognize and mitigate deterioration in high-risk patients (Alten et al., 2022). The 5-element bundle, created using PC<sup>4</sup> epidemiological data and resuscitation experts, was inexpensive, independent of any technology, and a bit prescriptive (Alten et al., 2022). This framework allowed each participating ICU to adapt the bundle to their individual system, resources, and workflow (Alten et al., 2022). The only mandatory bundle element was twice-daily CAP safety huddles designed to facilitate communication by creating situational awareness for high-risk patients, developing a plan to recognize early deterioration and, if necessary, rescue patients from impending CA (Alten et al., 2022). After implementation of the CAP bundle, there was a 30% relative reduction in risk adjusted IHCA incidence rate at CAP hospitals but

no change at control hospitals that chose not to adopt the bundle (Alten et al., 2022). This translated to an average decrease of 11 IHCA events per month at the CAP hospitals (Alten et al., 2022; Alten & Gaies, 2018). Results demonstrated it was possible to identify patients at high-risk for CA, and with implementation of a simple bedside CAP bundle resulted in significant reduction of CA in these children (Alten & Gaies, 2018). While implementation of a CAP bundle led to significant IHCA reduction across multiple pediatric CICU's, future studies were needed to determine which bundle elements were critical for CA prevention (Alten & Gaies, 2018).

In addition to CA prevention, nursing empowerment has become an increasing focus for many ICU's around the country. The ICU nursing model illustrates how gaining advanced knowledge and skills can expand nurses' roles, leading to better patient care and outcomes (Munro & Hope, 2020). Encouraging registered nurses to fully utilize their capabilities in collaborative care for critically ill patients is essential. Furthermore, investing in and empowering nurses can deliver substantial benefits. Most evidently, enhancing nursing practice improves patient outcomes (Munro & Hope, 2020). Critical care presents tremendous opportunities for nurses to excel, and advancements in nursing positively impact both colleagues and patients (Munro & Hope, 2020).

### **Rationale**

For decades, CA was viewed as an unavoidable complication for many children with congenital heart disease. Recently, children's hospitals around the country that implemented a CAP bundle have documented CA can be an avoided complication, thus providing evidence that the old view to be false through implementation of a CAP bundle. This QI project aimed to reduce CA rates in children with cardiac disease through the implementation of a CAP bundle. A cause-and-effect diagram (Appendix A) was utilized as a graphic tool to explore and display the causes of CA in the PICU. This tool identified many factors that contributed to CA in high-risk cardiac patients, graphically displayed these causes and their effects, and helped to identify areas for improvement (*Cause and Effect Diagram*, n.d.). This project

utilized the Institute for Healthcare Improvement Quality Improvement's Plan-Do-Study-Act (PDSA) cycle as a framework. The use of PDSA cycles allowed for testing of change with the ability to observe, analyze, and modify the CAP bundle over time (Institute for Healthcare Improvement [IHI], n.d.). Ultimately, the primary goal of implementation of the CAP bundle was to reduce CA events in high-risk pediatric cardiac patients at OHSU. The secondary goal was to measure nurses' perspective of implementation of the CAP bundle in the PICU over a 12-month period.

### **Specific Aims**

Specifically, the primary aim was to decrease CA (CA) by 25% from 4.85 CA/1000 patient days to 3.65 CA/1000 patient days between March 2023 and March 2024 in the PICU at OHSU. In addition, a secondary aim was to measure staff nurses' perception of implementing CAP bundle in the PICU.

## **Methods**

### **Context**

This quality improvement (QI) project was conducted within the PICU at OHSU Doernbecher Children's Hospital in Portland, Oregon over a 12-month period from March 2023 through March 2024. As one of the largest hospital systems and the only academic medical center in the state of Oregon, the PICU serves a large and diverse population from Oregon and the surrounding region. The patients served are critically ill children aged newborn to 21 years, presenting with a variety of conditions including congenital heart disease, respiratory failure, extracorporeal membrane oxygenation (ECMO), dialysis, and sepsis. The PICU comprises 20 single-patient rooms with an average daily census of 15 patients. At the time, the unit employed roughly 75 nurses (RNs) as well as 8 nursing support staff, which included intensive care unit techs (ICU techs) and health unit coordinators (HUC). RNs with less than two years of experience accounted for 11.4% of RNs. The combined internal and external nursing turnover rate at OHSU as an organization was 24%. Oversight of orientation for new hires, as well as ongoing education and support for existing staff, was provided by the Critical Care Specialty Practice

Leader (SPL). The RNs and support staff were managed by a nurse manager (NM) and an assistant nurse manager (ANM). All nursing QI projects were overseen by the OHSU Nursing Strategic Council, which consisted of a 5:1 ratio of clinical RNs to formal nurse leaders. The CAP QI team members included three pediatric cardiac intensivists, a pediatric cardiologist, a PICU fellow, a pediatric cardiac nurse practitioner, the cardiac SPL, two PICU registered nurses, and a Doctor of Nursing Practice student who was also a PICU bedside nurse.

### **Intervention**

The primary intervention for this QI project was the implementation of a CAP bundle form (Appendix B) and bundle huddle (Appendix C). Between March 2023 and March 2024, a CAP bundle form and bundle huddle were implemented. This CAP bundle form consisted of five elements: reasons for high risk of CA, clinical signs of decompensation/imminent CA, action plan for mitigation, additional bedside precautions, and vital sign parameters with extracorporeal membrane oxygenation (ECMO) discussion. The bundle was designed to promote situational awareness and interdisciplinary communication to recognize and mitigate deterioration in high-risk cardiac patients. These bundle elements were captured on a form kept at the patient bedside near the code sheet.

The bundle huddle was a formal, multidisciplinary bedside discussion that occurred separately from patient rounds. It was designed to create situational awareness and a shared mental model among the team for high-risk cardiac patients. The twice-daily huddle included the bedside nurse, charge nurse, CVICU attending, CVICU fellow, Cardiology attending (days), advanced practice provider (days), and a respiratory therapist. Topics included the most likely reason for an IHCA for a particular patient as well as the mitigation and rescue plan. The goal was for the entire team to recognize early deterioration and agree on plans for reversal and rescue of a patient. This part of the process allowed for conversation and discussion.

In addition to the CAP bundle form and bundle huddle, a pre/post-implementation nursing survey was utilized (Appendix D) to measure staff nurses' perspective of the CAP bundle and its effect on nursing empowerment. These surveys allowed the CAP team to measure the bedside nursing perspective in the PICU. The initial survey was conducted prior to implementation. The survey was then repeated at 3-month intervals (June, September, and January) in addition to a final survey after implementation in March 2024.

### **Study of the Intervention**

The study of this intervention included quarterly review of unit CA data compared to over 70 national centers that submit data to the PC<sup>4</sup> database (Participants, n.d.) The review improved understanding of patients at risk of CA and mitigation factors that prevent CA in this patient population.

### **Measures**

The outcome measure for this QI project was the reduction CA per 1000 patient days from March 2023 through March 2024 tracked quarterly. Process measures included percentage of PICU nurses who completed the pre-implementation survey, percentage of PICU nurses who completed post-implementation surveys, collection of completed CAP bundle forms, and a QR code survey filled out at the end of each huddle. A balancing measure for this project was increased utilization of cardiac code pack medications including epinephrine, dwindle epinephrine, calcium chloride, and occasionally rocuronium.

### **Analysis**

An analysis of outcomes included comparison of pre/post-implementation CA rate per 1000 patient days as well as pre/post-implementation nursing survey data. Nursing survey data for this QI project was collected using Qualtrics®, an online survey tool, analyzed using Microsoft Excel®, and displayed via tables, pie, and bar graphs. This data was additionally analyzed quantitatively using

independent t-tests. PICU nurse demographics were summarized using means, frequency counts, percentages for nominal variables.

### **Ethical Considerations**

A request for determination was submitted to the Institutional Review Board (IRB) and was deemed a QI project not utilizing human subject research (Appendix E). Various ethical considerations included patient confidentiality and maintaining anonymity during surveys and analysis of data. To ensure anonymity, survey participants were required to create a unique patient identifier so that subsequent surveys could be compared by individual participants while still maintaining anonymity. Some of the demographic questions including age, ethnicity, and gender did not require survey participants to respond. Data and survey responses were kept secure via OHSU encryption and two-factor authentication. The participating clinical site gave consent to the project by signing a letter of support (Appendix F).

## **Results**

### **Patient & Nursing Participants**

Patient participants were deemed eligible for inclusion based on their risk of CA, criteria for inclusion were postoperative neonatal cardiac bypass surgery, post-operative Blalock–Thomas–Taussig shunt or pulmonary artery band, admission for an active medical problem with intubation within the first four hours, severe pulmonary hypertension, or other criteria deemed eligible by the attending provider. The only explicit exclusion criterion was being a medical or surgical patient without any form of cardiac disease.

Nursing participants were eligible for survey inclusion if they were employed as nurses within the PICU. Overall, the PICU nursing staff were majority White females who were 30-39 years of age with a collective nursing experience between 6-10 years, and PICU-specific experience typically ranging from 2-5 years. Representation across day and night shifts was relatively balanced. Additionally, most nurses

possessed formal cardiac training tailored to the care of cardiac patient populations. Detailed demographic information is provided in Table 1.

**Table 1**

*Demographic Characteristic of Nurses in the PICU*

Variable	Pre-Intervention n = 44	Post-Intervention		
		3 months n = 37	6 months n = 29	12 months n = 39
<i>Age (years)</i>				
30-39	25 (56.8%)	16 (43.2%)	16 (55.2%)	16 (41%)
<i>Gender</i>				
Female	36 (81.2%)	30 (81.1%)	24 (82.8%)	34 (87.2%)
<i>Ethnicity</i>				
White	30 (68.2%)	28 (75.7%)	20 (69%)	31 (79.5%)
<i>RN Experience (years)</i>				
2-5	9 (20.5%)	8 (21.6%)	6 (20.7%)	7 (17.9%)
6-10	18 (41%)	12 (32.4%)	10 (34.5%)	17 (43.6%)
<i>PICU Experience (years)</i>				
2-5	15 (34.1%)	14 (37.8%)	8 (27.6%)	10 (25.6%)
6-10	10 (22.7%)	5 (13.5%)	8 (27.6%)	5 (12.8%)
<i>Shift</i>				
Dayshift (7a-7p)	28 (64%)	17 (45.9%)	17 (58.6%)	20 (51.3%)
Nightshift (7p-7a)	16 (36%)	20 (54.1%)	12 (41.4%)	19 (48.7%)
<i>Cardiac Trained</i>				
Yes	35 (79.5%)	33 (89.2%)	25 (86.2%)	26 (66.7%)
No	9 (20.5%)	4 (10.8%)	4 (13.8%)	13 (33.3%)

**Cardiac Arrests**

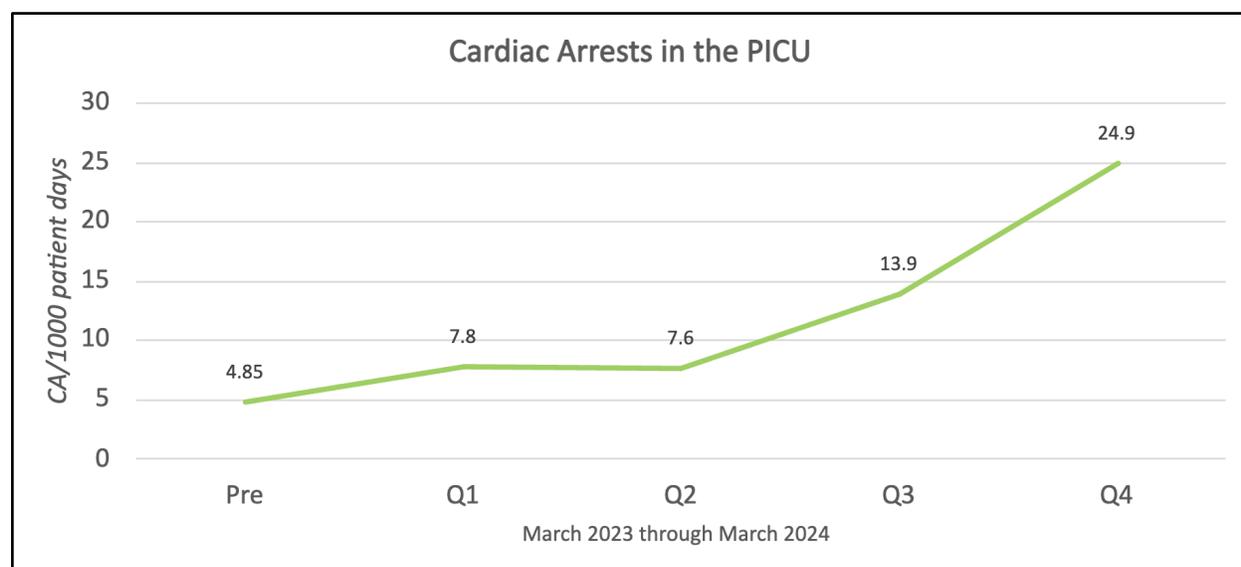
The baseline CA rate before implementation stood at 4.85 CA per 1000 patient days. After implementation of the CAP bundle and huddle, the rate experienced a modest rise to 7.8 CA per 1000 patient days, maintaining stability over two consecutive quarters, where it plateaued at 7.6 CA per 1000 patient days. However, a notable escalation in rates ensued in the subsequent two quarters, soaring to 13.9 and 24.9 CA per 1000 patient days, respectively (Figure 1).

In the first quarter after implementation (Q1), three CA events occurred, comprising two medical cases and one surgical case. Notably, only one of these patients was enrolled on the CAP bundle. Moving to the subsequent quarter (Q2), two CA events transpired, encompassing one medical

case and one surgical case. Remarkably, neither of these patients were enrolled in the CAP bundle, despite one meeting the qualifying criteria. However, in the third quarter (Q3), a notable escalation in the CA rate was observed, with five occurrences recorded, three of which were medical cases and two surgical. Intriguingly, only one patient was enrolled in the CAP bundle during this period, although the CAP bundle form had not been completed for over 24 hours, and another patient who qualified had not been included in the bundle due to recent return from the operating room. Transitioning to the fourth quarter (Q4), five CA events occurred, involving two patients. One patient had undergone post-cardiac catheterization, while the other presented with medical issues, namely arrhythmias. Neither of these patients were enrolled on the CAP bundle due to their failure to meet explicit criteria. Despite the relatively small number of patients involved, each CA event contributes significantly to the overall CA rate, leading to a rapid escalation. This phenomenon is particularly noteworthy given the institution's classification as a medium-sized center, where even minor instances of CA can exert a considerable impact on the overall CA rate.

**Figure 1**

*Cardiac Arrests from Pre-Implementation to 1-Year Post-Implementation*



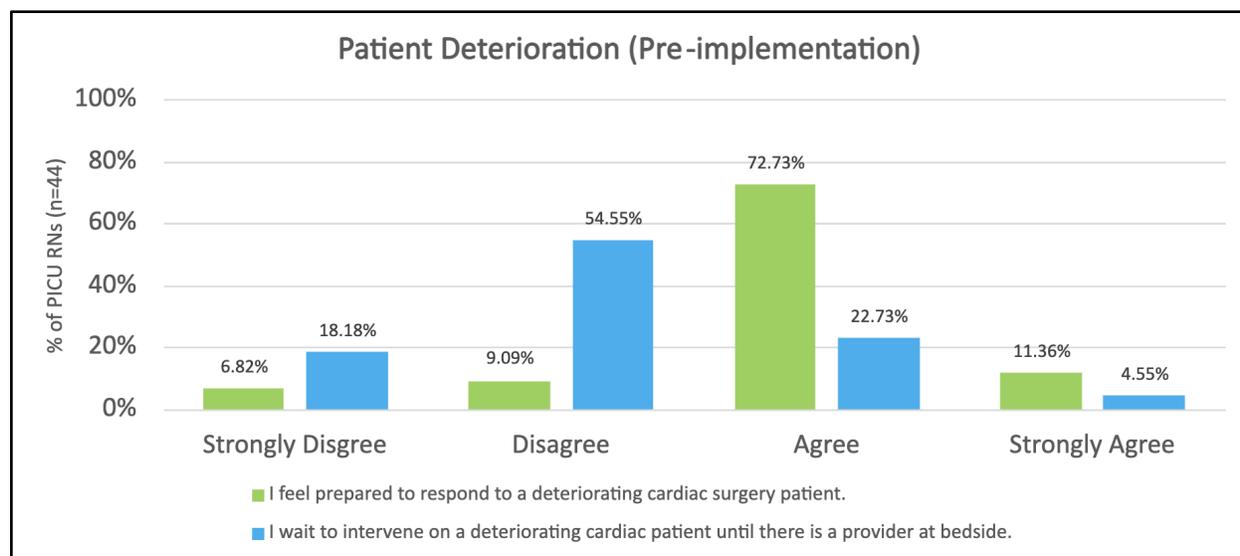
## Nursing Surveys

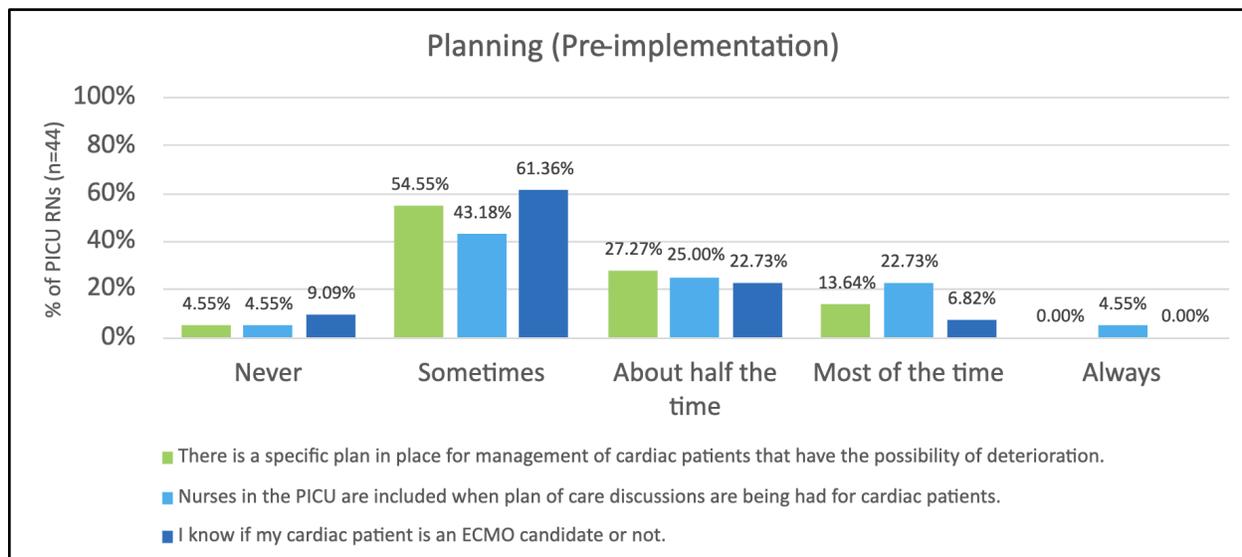
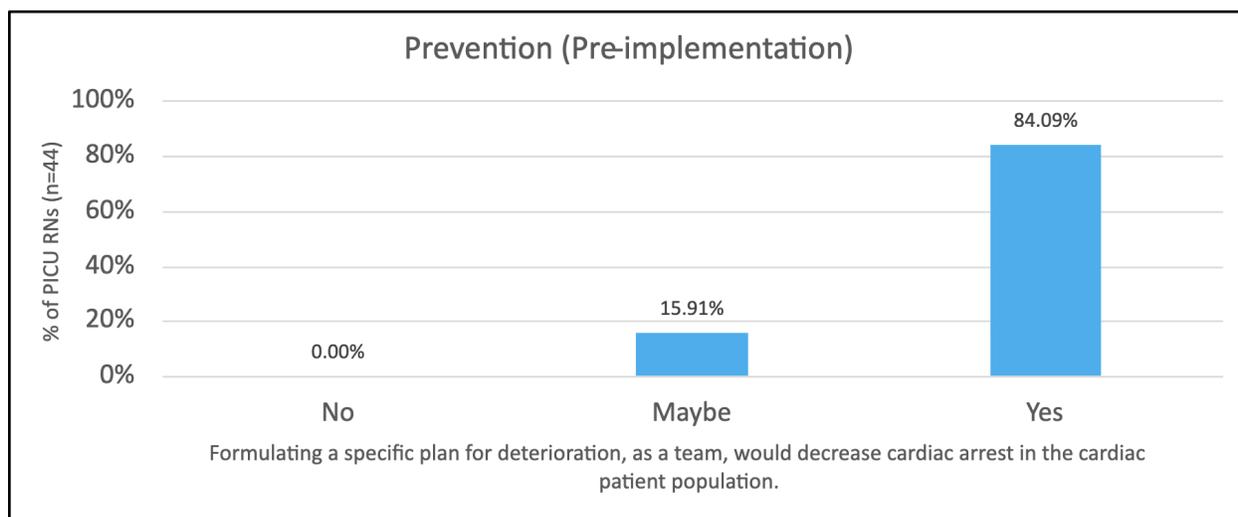
### *Pre-Implementation*

During late-February and early-March 2023, nurses ( $n=44$ ) from the PICU completed an anonymous pre-implementation nursing survey analyzing current thoughts regarding patient deterioration, planning for decompensation, and prevention of CA in cardiac patients. Most of the time or always, nurses reported they were not aware of a mitigation plan for deterioration ( $n=6$ , 13.6%) (Figure 2). This involved a lack of bedside nurses included in plan-of-care discussions ( $n=12$ , 27.3%) and not knowing if their patient was an ECMO candidate ( $n=3$ , 6.8%) (Figure 3). The majority of nurses ( $n=37$ , 84.1%) agreed that formulating a specific plan for deterioration, as a team, would decrease CA in the cardiac patient population (Figure 4).

**Figure 2**

*Nurses Perspective of Patient Deterioration, Pre-Implementation*



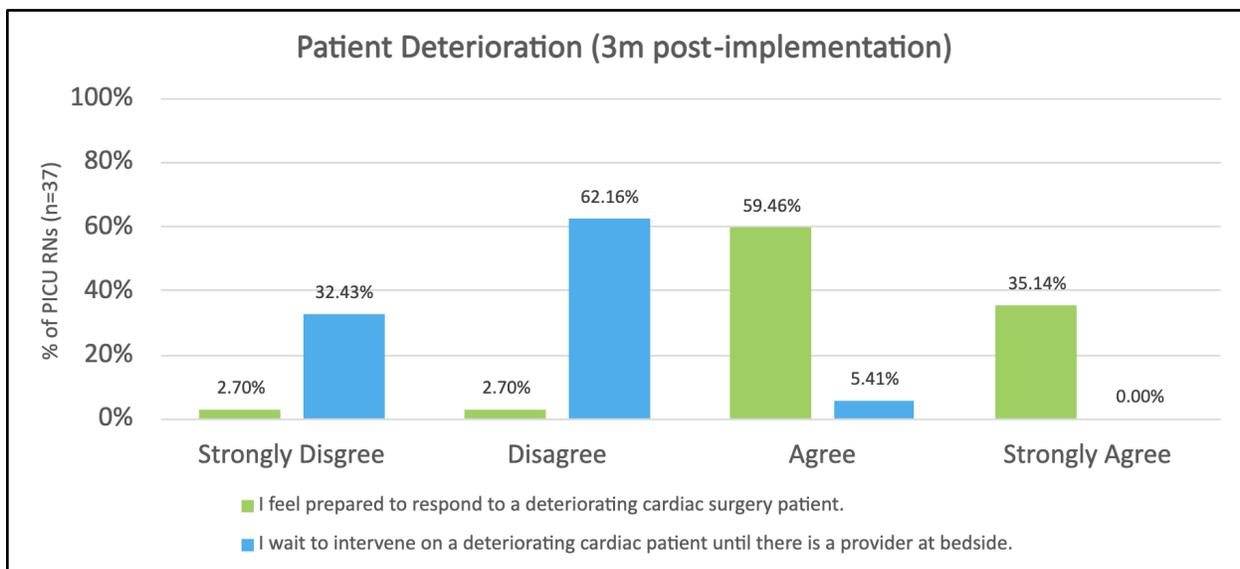
**Figure 3***Nurses Perspective of Planning as a Team, Pre-Implementation***Figure 4***Nursing Perspective on Prevention of Cardiac Arrest, Pre-Implementation***3-Month Post-Implementation**

Three months after implementation of the CAP bundle and huddle, nurses ( $n=37$ ) from the PICU completed the same anonymous nursing survey as previous with an additional question highlighting the

impact of the project on patient deterioration After implementation of the project, more than 75% of nurses reported most of the time or always that they were now aware of a mitigation plan for deterioration ( $n=30$ , 81.1%) (Figure 5). Nurses' perspective of being included in plan-of-care discussions ( $n=24$ , 64.9%), and knowing if their patient was an ECMO candidate ( $n=26$ , 70.3%) was advantageous (Figure 6). More than 90% of the nurses ( $n=35$ , 94.6%) continued to agree that formulating a specific plan for deterioration would decrease CA in the cardiac patients (Figure 7). Furthermore, nearly all the nurses surveyed ( $n=36$ , 97.3%) felt the CAP bundle and huddle helped them understand their patients' risk for deterioration better (Figure 8).

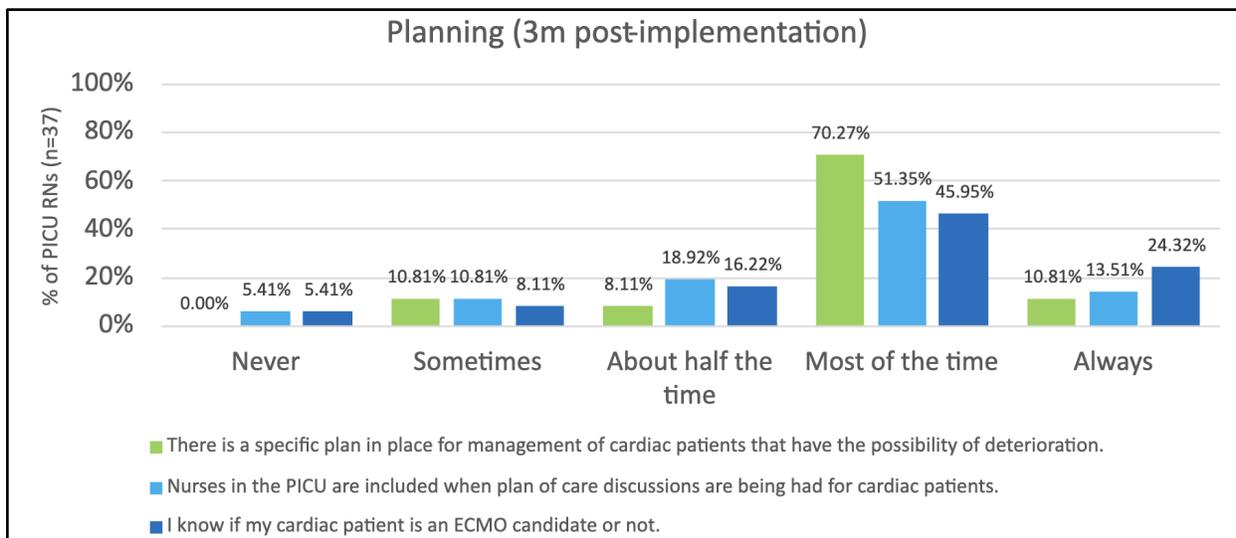
**Figure 5**

*Nurses Perspective of Patient Deterioration, 3-Month Post-Implementation*



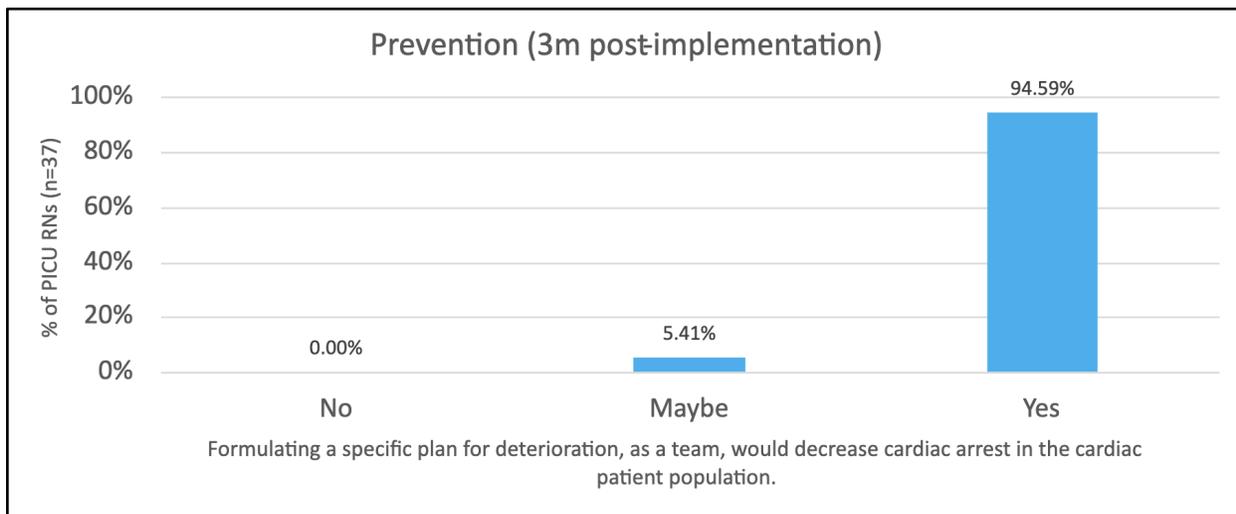
**Figure 6**

*Nurses Perspective of Planning as a Team, 3-Month Post-Implementation*



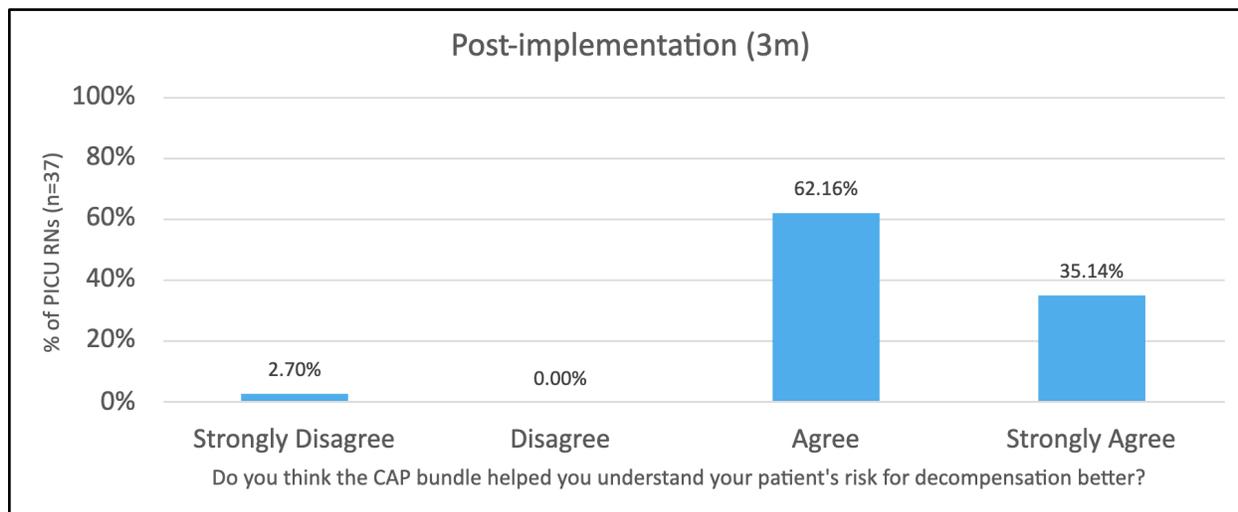
**Figure 7**

*Nursing Perspective on Prevention of Cardiac Arrest, 3-Month Post-Implementation*



**Figure 8**

*Nurses Increased Understanding of Patient's Deterioration Risk, 3-Month Post-Implementation*



### **6-Month Post-Implementation**

Nurses ( $n=29$ ) once again completed the nursing survey six months after implementation of the CAP bundle and huddle. At least 75% of the nurses continued to report that they were aware of a mitigation plan for deterioration,  $t(70) = -7.25$ ,  $p \leq 0.001$  ( $n=22$ , 75.9%) (Figure 9). More than 85% of the time, nurses ( $n=25$ , 86.2%) were included in plan-of-care discussions,  $t(70) = -5.21$ ,  $p \leq 0.001$ , and knew if their patient was an ECMO candidate,  $t(86) = -9.28$ ,  $p \leq 0.001$  ( $n=23$ , 79.3%) (Figure 10). Additionally, all nurses surveyed ( $n=29$ , 100%) reported the CAP bundle and huddle helped them understand their patients' risk for deterioration better (Figure 11).

Figure 9

*Nurses Perspective of Patient Deterioration, 6-Month Post-Implementation*

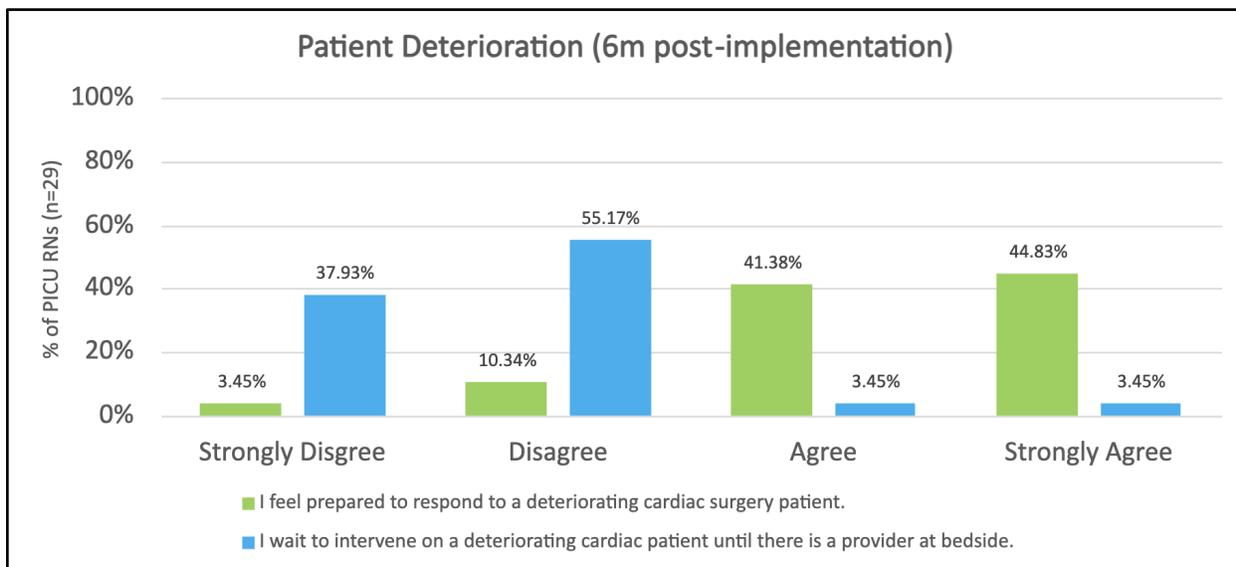
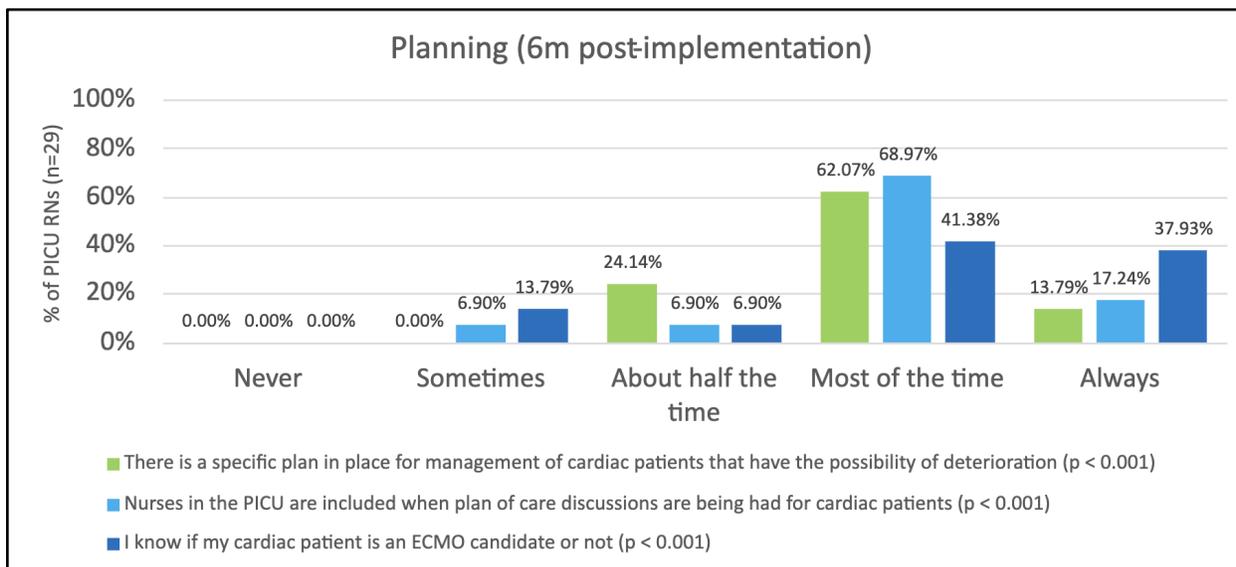


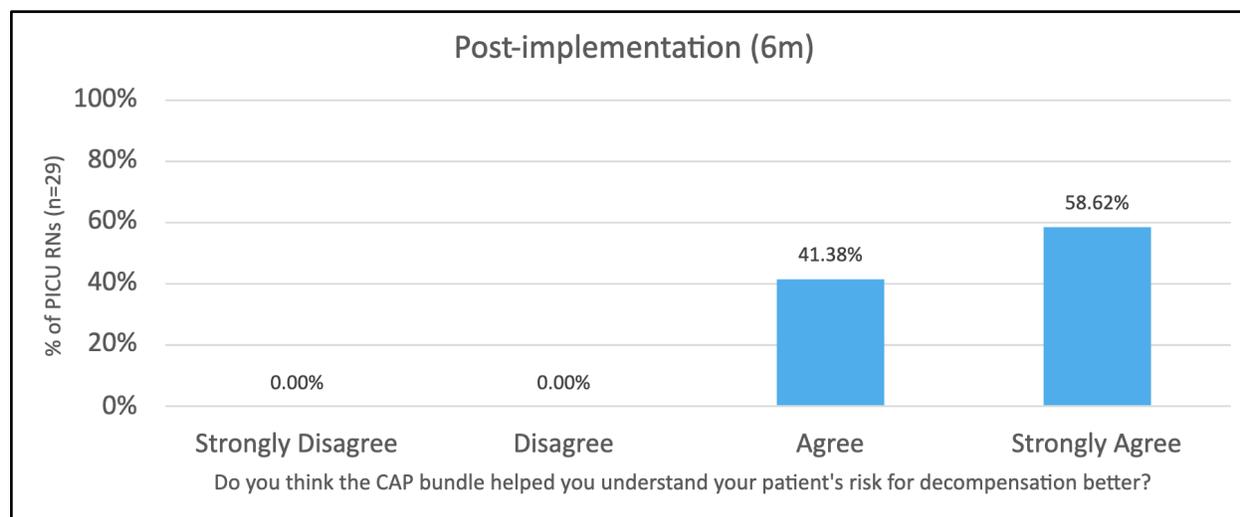
Figure 10

*Nurses Perspective of Planning as a Team, 6-Month Post-Implementation*



**Figure 11**

*Nurses Increased Understanding of Patient's Deterioration Risk, 6-Month Post-Implementation*

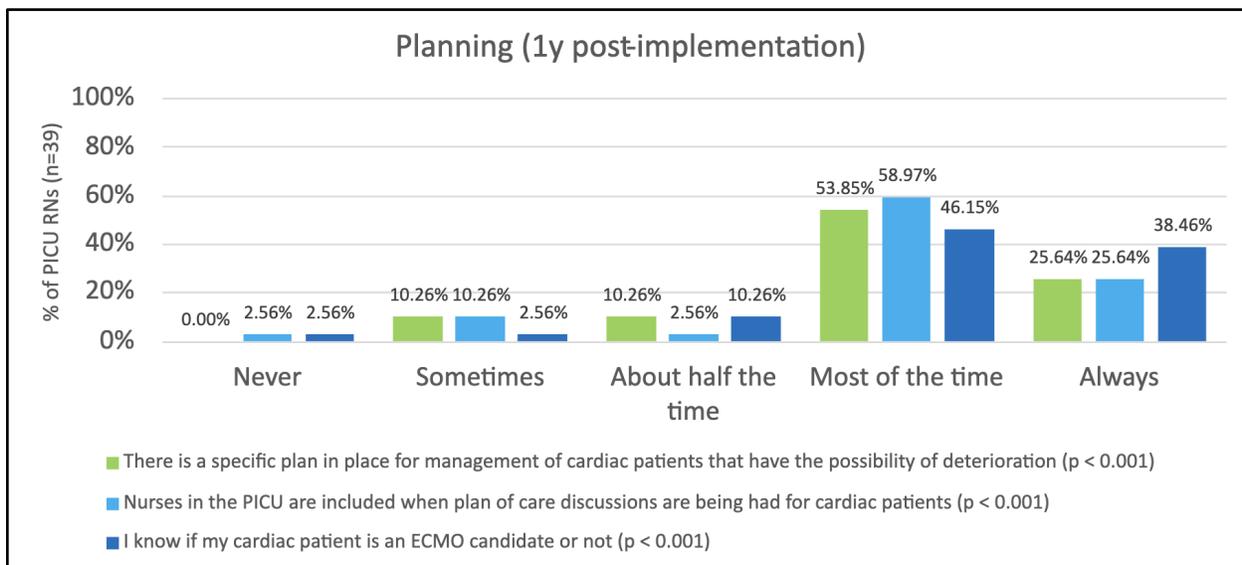


### **1-Year Post-Implementation**

The final survey was completed by nurses ( $n=39$ ) one-year post-implementation of the CAP bundle and huddle. After implementation of the project, nearly 80% of nurses ( $n=31$ , 79.5%) reported being aware of a mitigation plan for deterioration,  $t(80) = -7.25$ ,  $p \leq 0.001$  (Figure 12). In addition, more than 80% of nurses ( $n=33$ , 84.6%) were included in plan-of-care discussions,  $t(80) = -5.29$ ,  $p < 0.001$ , and knew if their patient was an ECMO candidate,  $t(71) = -8.78$ ,  $p \leq 0.001$  ( $n=33$ , 84.6%) (Figure 12). The comparison of the increase in nursing empowerment from pre-implementation through 1-year post-implementation can be seen in Figure 13. In addition, more than 95% of nurses reported having a specific plan for deterioration would decrease CA in the PICU (Figure 14). Nurses ( $n=31$ , 79.5%) felt prepared to intervene on their decompensating patient and were less likely to wait for a provider before doing so ( $n=8$ , 20.1%) (Figure 15). Additionally, nearly 95% of nurses surveyed ( $n=37$ , 94.9%) reported the CAP bundle and huddle helped them understand their patients' risk for deterioration better (Figure 16).

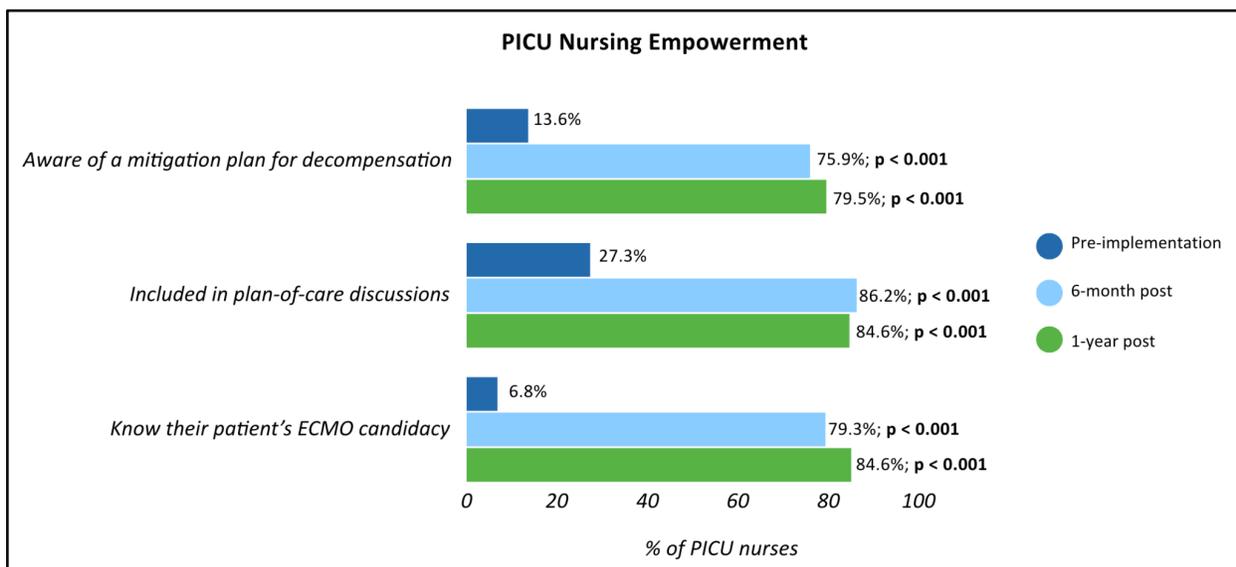
**Figure 12**

*Nurses Perspective of Planning as a Team, 1-Year Post-Implementation*



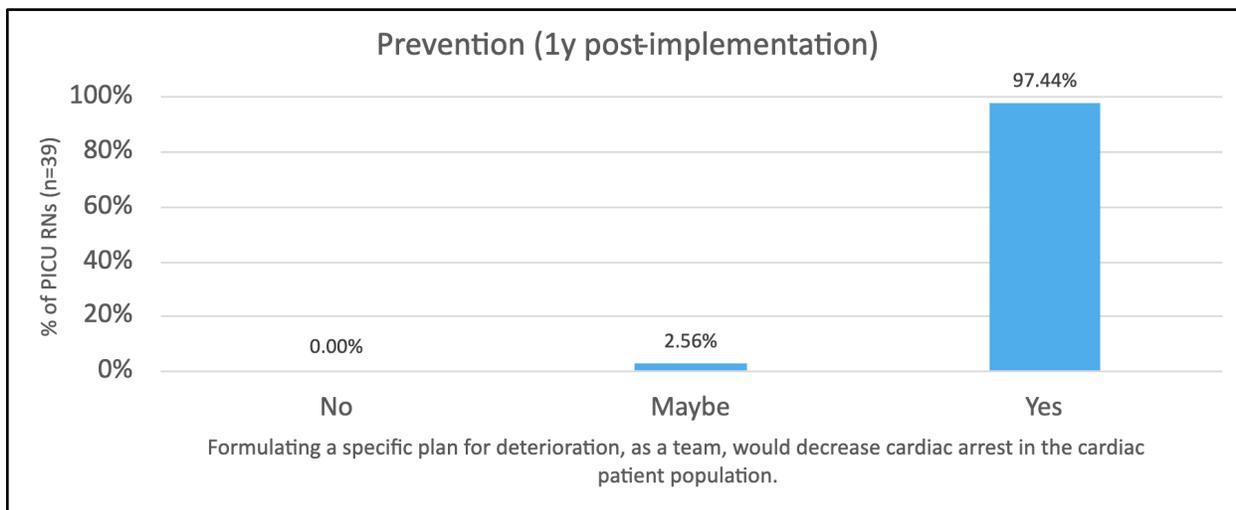
**Figure 13**

*Nursing Empowerment from Pre-Implementation through 1-Year Post-Implementation*

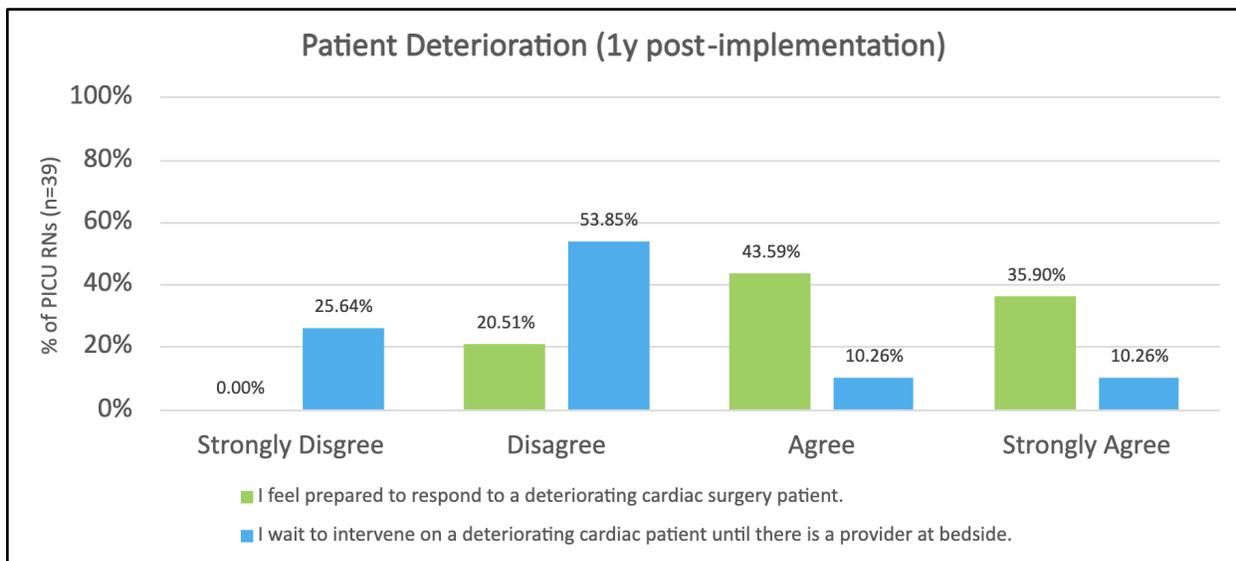


**Figure 14**

*Nursing Perspective on Prevention of Cardiac Arrest, 1-Year Post-Implementation*

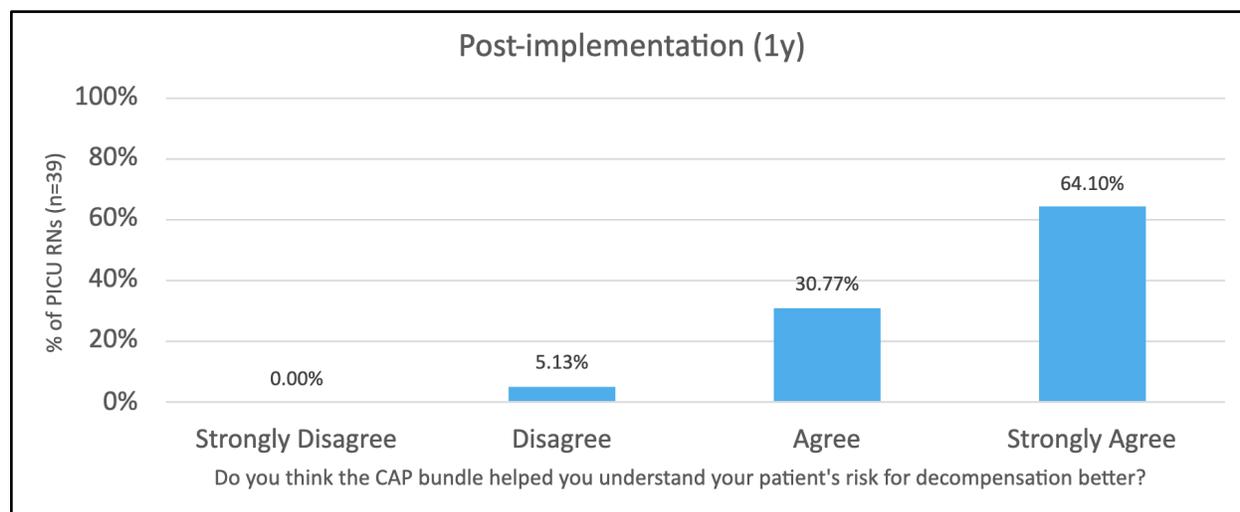
**Figure 15**

*Nurses Perspective of Patient Deterioration, 1-Year Post-Implementation*



**Figure 16**

*Nurses Increased Understanding of Patient's Deterioration Risk, 1-Year Post-Implementation*



### Discussion

The overall aim of this QI project was to implement a CAP bundle and huddle in a PICU with a subsequent evaluation of its impact. Specifically, the primary goal aimed to mitigate overall CAs among high-risk cardiac patients. Furthermore, a secondary aim was to measure the effects of the CAP bundle and huddle on nursing practice and empowerment. Despite not achieving the primary objective of reducing CAs, this QI initiative yielded promising results: Post-implementation, 95% of nurses exhibited increased readiness to manage a deteriorating patient, a trend maintained throughout the subsequent 6- to 12-months. Notably, the implementation of the CAP bundle successfully empowered PICU nurses to intervene earlier in cases of patient deterioration and enhanced their comprehension of patient risk for decompensation.

### Interpretation

There was no statistically significant improvement in CA rates amongst high-risk pediatric cardiac patients despite the implementation of the CAP bundle and huddle. This was not consistent with previous QI projects which demonstrated significant improvements after implementation of a CAP

bundle and huddle at other institutions (Riley et al., 2022b; Alten et al., 2022). However, after reviewing CAs, the majority of CAs had occurred in patients, who were not on the CAP bundle, accounting for 87% of cases. Notably, medical and post-catheterization patients encountered the highest incidences of CA.

While the initial aim was not achieved, there was a statistically significant increase in PICU nurse awareness of mitigation plans, their involvement in plan-of-care discussions, and understanding of ECMO candidacy. Overwhelmingly, nurses felt empowered to execute interventions faster on a patient who was decompensating. Nurses viewed the project favorably as an opportunity for continued improvement in reduction of CA rates with the use of future PDSA cycles. The sustained improvement in nursing empowerment at 6- and 12-months post-implementation further supports the continued use of the CAP bundle and huddle.

### **Limitations**

Several limitations hinder the generalizability of this QI project, notably its single-center implementation within a PICU, which was designed exclusively for high-risk cardiac patients. While the CAP bundle form delineated explicit patient criteria, the identification of children at risk for CA may have been influenced by providers' subjective assessments of stability and risk. Moreover, the nursing survey lacked use of a validated tool, potentially overlooking various factors influencing nursing practice and empowerment. Inconsistencies in nursing survey participation among staff members, coupled with frequent fluctuations in staffing compositions, may have introduced bias into the results over time. The reliance on manual data entry and computation, prone to human error despite ongoing data review for accuracy, could have impacted the analysis of results. Finally, the impact on patient safety was not explicitly evaluated and may have been impacted during the implementation of the CAP bundle and huddle.

### **Conclusion**

While the implementation of the CAP bundle resulted in a notable improvement in nursing empowerment, the primary aim of reducing CAs was not met initially. Nonetheless, through rigorous audits and patient tracking, insights into the demographic of patients not captured by the bundle, resulting in failure-to-rescue, will inform and guide future PDSA cycles. Continuous education and support from organizational leaders are essential to sustain and reinforce this improvement initiative. Moreover, the evaluation of the CAP bundle's impact on patient safety, including increased instances of emergency medication administration and adverse events, as well as its implications for medical-surgical patient populations, are areas warranting further exploration.

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### Appendix A

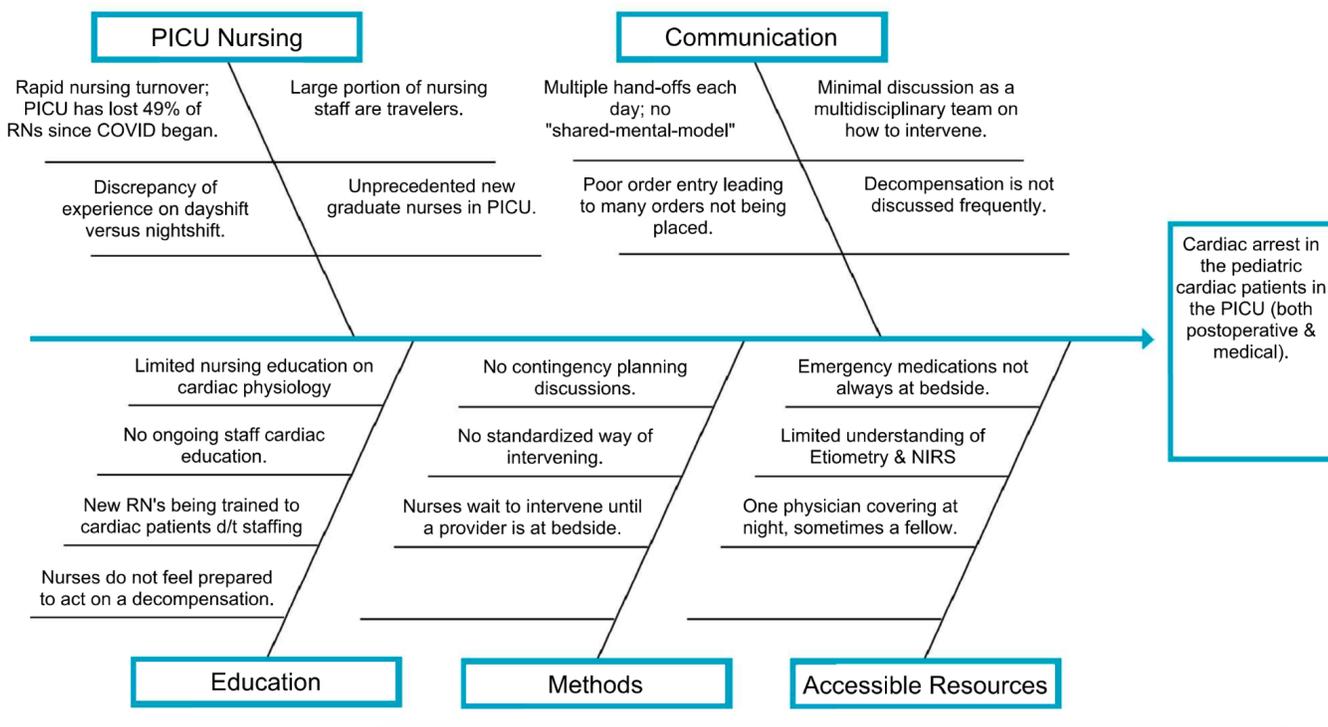
#### Cause and Effect Diagram

## Template: Cause and Effect Diagram

**Team:** Hillary Davault \_\_\_\_\_

**Project:** Cardiac Arrest Prevention (CAP) Bundle \_\_\_\_\_

- 1) Input the effect you'd like to influence.
- 2) Input categories of causes for the effect (or keep the classic five).
- 3) Input causes within each category.



Appendix B

Cardiac Arrest Prevention Bundle Form



**Cardiac Arrest Prevention (CAP) Plan**

Overall Trajectory	
Improving	
Same	
Worse	

Name: \_\_\_\_\_

**High Risk due to:**

- A. Postop admission from neonatal CPB surgery (minimum duration: 24 hrs after extubation)
- B. Postoperative BT shunt, PA band (minimum duration: 24 hrs after extubation)
- C. Admitted for active medical problem and intubated w/in first 4 hrs
- D. Severe pulmonary hypertension, postop or medical (minimum duration 24 hrs after extubation)
- E. Other \_\_\_\_\_

\*May discontinue bundle when patient has achieved minimum duration and demonstrated ongoing improvement

**Etiologies of clinical decompensation/cardiac arrest (and what it will look like):**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

**Action plan for mitigation:**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

**Additional Bedside Care Precautions:**

Preventative Measures	Medications	Equipment
<input type="checkbox"/> PRE-SEDATE with all noxious stimuli <input type="checkbox"/> No bath <input type="checkbox"/> CHG bath only <input type="checkbox"/> No weighing <input type="checkbox"/> Bed scale only <input type="checkbox"/> High Risk Suctioning Level _____ <input type="checkbox"/> No IPV <input type="checkbox"/> DO NOT break circuit - Inline suction only <input type="checkbox"/> High risk drip change <input type="checkbox"/> Additional RN <input type="checkbox"/> MD at bedside <input type="checkbox"/> Other _____	<input type="checkbox"/> Cardiac Code Pack (Dwindle Epi (10:1 in NS), Code dose Epi, Calcium Chloride (20 mg/kg) <input type="checkbox"/> Sodium Bicarbonate (2 mEq/kg) <input type="checkbox"/> NS or LR (5-10 mL/kg) <input type="checkbox"/> Opioid bolus <input type="checkbox"/> Neuromuscular blockade <input type="checkbox"/> Other _____	<input type="checkbox"/> External Pacemaker at bedside <input type="checkbox"/> Zoll pads at bedside <input type="checkbox"/> Defibrillator ___ joules (2/kg) <input type="checkbox"/> Ensure T3/Etiometry monitor on <input type="checkbox"/> NIRS: set to baseline and lower limits w alarm <input type="checkbox"/> Other _____

\*Notify provider when patient deviates outside of below thresholds

Parameter	AM Thresholds	PM Thresholds	No Change
HR			<input type="checkbox"/>
BP	/	/	<input type="checkbox"/>
MAP			<input type="checkbox"/>
O2 Sat			<input type="checkbox"/>
CVP/RA			<input type="checkbox"/>
NIRS (C/R)			<input type="checkbox"/>
ETCO2 or PaCO2			<input type="checkbox"/>
Lactate			<input type="checkbox"/>
SvO2 or AVO2Δ			<input type="checkbox"/>
Other			<input type="checkbox"/>

ECMO Discussion
ECMO: <input type="checkbox"/> YES <input type="checkbox"/> NO
ECPR: <input type="checkbox"/> YES <input type="checkbox"/> NO
<input type="checkbox"/> PERIPHERAL <input type="checkbox"/> CENTRAL
U/S MAPPING NEEDED?
<input type="checkbox"/> YES, ORDERED <input type="checkbox"/> DONE <input type="checkbox"/> NO

**Appendix C**

*Bundle Huddle Video Example*

CAP Bundle Huddle



## Appendix D

### *Pre/Post-implementation Nursing Survey*

#### Patient Deterioration

	Strongly Disagree	Disagree	Agree	Strongly Agree
I feel prepared to respond to a deteriorating cardiac surgery patient.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I wait to intervene on a deteriorating cardiac patient until there is a provider at bedside.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

#### Planning

	Never	Sometimes	About half the time	Most of the time	Always
There is a specific plan in place for management of cardiac patients that have the possibility of deterioration.	<input type="radio"/>				
Nurses in the PICU are included when plan of care discussions are being had for cardiac patients.	<input type="radio"/>				
I know if my cardiac patient is an ECMO candidate or not.	<input type="radio"/>				

#### Prevention

	No	Maybe	Yes
Formulating a specific plan for deterioration, as a team, would decrease cardiac arrest in the cardiac patient population.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Post-implementation

	Strongly Disagree	Disagree	Agree	Strongly Agree
Do you think the CAP bundle helped you understand your patient's risk for decompensation better?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What role do you have in the PICU?

- Staff nurse
- Traveler/agency nurse
- Float pool nurse

What other roles do you have in the PICU?

- Charge Nurse
- Rapid Response Nurse
- ECMO Specialist
- Preceptor

How many years of nursing experience do you have?

- 0-1 years
- 2-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 20+ years

How long have you worked in the Doernbecher PICU?

- 0-1 years
- 2-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 20+ years

Which shift do you work on?

- Dayshift
- Nightshift

Are you cardiac trained?

- Yes
- No

What is your age?

- 20-29
- 30-39
- 40-49
- 50-59
- 60+

What is your gender?

- Male
- Female
- Non-binary
- Transgender
- Prefer not to answer

What is your ethnicity?

- American Indian or Alaskan Native
- Asian/ Pacific Islander
- Black or African American
- Hispanic
- White/Caucasian
- Multiple ethnicity/Other
- Prefer not to answer

## Appendix E

### *IRB Request for Determination*



# IRB MEMO

Research Integrity Office

3181 SW Sam Jackson Park Road - L106RI  
Portland, OR 97239-3098  
(503)494-7887 irb@ohsu.edu

### NOT HUMAN RESEARCH

May 10, 2023

Dear Investigator:

On 5/10/2023, the IRB reviewed the following submission:

Title of Study:	Reducing Cardiac Arrest Utilizing a Pediatric Cardiac Arrest Prevention Bundle: A Quality Improvement Project
Investigator:	<a href="#">Sandra Banta-Wright</a>
IRB ID:	STUDY00025803
Funding:	None

The IRB determined that the proposed activity is not research involving human subjects. IRB review and approval is not required.

Certain changes to the research plan may affect this determination. Contact the IRB Office if your project changes and you have questions regarding the need for IRB oversight.

If this project involves the collection, use, or disclosure of Protected Health Information (PHI), you must comply with all applicable requirements under HIPAA. See the [HIPAA and Research website](#) and the [Information Privacy and Security website](#) for more information.

Sincerely,

The OHSU IRB Office

## Appendix F

### Letter of Support from Clinical Agency

Date: March 1st, 2023

Dear Hillary Davault,

This letter confirms that I, Joylyn Michaud, allow Hillary Davault (OHSU Doctor of Nursing Practice Student) access to complete his/her DNP Final Project at our clinical site. The project will take place from approximately March 2023 to March 2024.

This letter summarizes the core elements of the project proposal, already reviewed by the DNP Project Preceptor and clinical liaison (if applicable):

**Project Site(s):** Doernbecher Children's Hospital, Pediatric Intensive Care Unit (700 SW Campus Drive, Portland, Oregon 97239)

**Project Plan:**

Cardiac arrest is a known and unfortunate complication in the pediatric cardiac population that contributes to high morbidity and mortality. There are an estimated 15,200 pediatric in-hospital patients who receive cardiopulmonary resuscitation (CPR) each year. One of the earliest studies found that while cardiac arrest in the pediatric intensive care unit (PICU) population is relatively uncommon, it is also associated with poor outcomes. Initially, pediatric in-hospital cardiac arrest (IHCA) outcomes improved in the early 2000's. However, the rates of survival after pediatric IHCA have plateaued as more than half of children will not survive to hospital discharge. Furthermore, hospitalized children with cardiac disease have 10 times the risk of cardiac arrest as compared to non-cardiac patients. While there have been many factors identified that contribute to cardiac arrest in children with cardiac disease, there is no identified mechanism, standardized method, or protocol for reducing cardiac arrest in children with cardiac disease.

This QI project aims to reduce cardiac arrest rates in children with cardiac disease through the implementation of a CAP bundle. This project will utilize the Institute for Healthcare Improvement Quality Improvement's Plan-Do-Study-Act (PDSA) cycle as a framework. The use of PDSA cycles will allow for testing of change with the ability to observe, analyze, and modify the CAP bundle overtime. The aim of this project is to measure whether implementation of a CAP bundle will lead to a reduction of cardiac arrest in high-risk children. Ultimately, the goal of implementation of the CAP bundle is to reduce cardiac arrest events in high-risk pediatric cardiac patients. Specifically, the goal is to decrease cardiac arrest (CA) by 25% from 4.85 CA/1000 patient days to 3.65 CA/1000 patient days between March 2023 and March 2024.

The primary intervention for this QI project is the implementation of a CAP bundle form and bundle huddle. This CAP bundle form consists of five elements: reason for high-risk of cardiac arrest, clinical signs of decompensation/imminent cardiac arrest, action plan for mitigation, additional bedside precautions, and vital sign parameters with ECMO discussion. The bundle is designed to promote situational awareness and interdisciplinary communication to recognize and mitigate deterioration in high-risk cardiac patients. The bundle huddle is a formal, multidisciplinary bedside discussion that occurs separately from patient rounds. It is designed to create situational awareness and a shared mental model. In addition to the CAP bundle form and bundle huddle, a pre/post-implementation nursing survey will be utilized. These surveys will allow the CAP team to understand the bedside nursing perspective in the PICU. In order to ensure anonymity, survey participants were required to create a unique patient identifier so that subsequent surveys could be compared by individual participants while still maintaining anonymity. Some of the demographic questions including age, ethnicity, and gender will not require survey participants to respond. Data and survey responses will be kept secure via OHSU encryption and two-factor authentication. Any patient information on CAP bundle forms will be deidentified.

The outcome measure for this QI project is the reduction CA per 1000 patient days from March 2023 through March 2024 tracked quarterly. Process measures will include percentage of PICU nurses that completed the pre-implementation survey, percentage of PICU nurses that completed post-implementation surveys, collection of completed CAP bundle forms, and a QR code survey filled out at the end of each huddle. A balancing measure for this project is increased utilization of cardiac code pack medications.

During the project implementation and evaluation, Hillary Davault will provide regular updates and communicate any necessary changes to the DNP Project Preceptor. Our organization looks forward to working with this student to complete their DNP project. If we have any concerns related to this project, we will contact Hillary Davault and Sandra Banta-Wright, student's DNP Project Chairperson.

Regards,

Joylyn Michaud, MN, CPNP-AC, FNP (DNP Project Preceptor)  
Nurse Practitioner, Pediatric Cardiology  
Instructor of Pediatrics, Division of Critical Care, School of Medicine  
[michaud@ohsu.edu](mailto:michaud@ohsu.edu)  
503-494-1544

  
Signature

  
Date Signed