DNP Project: Perioperative Temperature Monitoring

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Abstract

Inadvertent perioperative hypothermia is defined as a core body temperature less than 36 ^{o}C and has many documented adverse outcomes such as postoperative infections, increased perioperative blood loss, increased extubation times, and increased morbidity and mortality. Under anesthesia, patients are at increased risk for hypothermia and associated complications, making intraoperative temperature monitoring a crucial standard defined by both anesthesiologist and CRNA national organizations. The aim of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and the effectiveness of a newly developed intraoperative temperature monitoring educational tool through surveys administered prior to and after a period of utilization of the tool. Major findings revealed a high confidence level among participants regarding knowledge of intraoperative heat loss, populations and procedures at increased risk of heat loss, and ability to identify core temperature sites. Major variability was found in preferred temperature modality or site that may be attributed to lack of equipment, convenience, and accessibility to patient during procedure. Overall, understanding of temperature loss during the perioperative period as well as knowledge of national standards was high among participants. Variance in practice provides opportunities for future projects addressing variance and effectiveness of perioperative temperature monitoring practices.

Keywords: inadvertent perioperative heat loss, general anesthesia, CRNAs, quality improvement

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Section 1. Introduction

Background

Inadvertent perioperative hypothermia, or IPH, is defined as a core body temperature less than 36 ^{o}C and has many documented adverse outcomes such as postoperative infections, increased perioperative blood loss, increased extubation times, and increased morbidity and mortality (Riley & Andrzejowski, 2018). There are many external and patient-related factors that influence the extent of hypothermia during the perioperative period, including comorbidities, long term medications, type and duration of anesthetics used, and type and duration of surgical procedure performed (Rauch et al., 2021). To appreciate the problem, thermoregulation, along with the challenges of maintaining thermoregulation in the perioperative period, must first be understood.

Many cellular mechanisms such as transport proteins, or enzymes, rely heavily on the hypothalamus to maintain a tight control of temperature, typically varying plus or minus 1 ^{o}C even in the face of extreme environments or physiological states to maintain adequate function at the cellular level and sustain life (Riley & Andrzejowski, 2018). In healthy individuals, homeostasis is maintained under normal conditions, however, under general anesthesia this protective mechanism is altered by the anesthetics and places patients at increased risk for hypothermia during an operation.

Heat loss under general anesthesia is best explained in three stages: redistribution, linear, and plateau, in that order. During the first hour after induction of anesthesia, vasodilation of the periphery will cause a concentration gradient driven redistribution of heat from the core to the peripheral circulation that is typically 1-2 ^{o}C cooler, and redistributed heat is lost to colder ambient operating room temperature (Rauch et al., 2021). Because the body cannot vasoconstrict the peripheral vasculature to counter the temperature gradient from the core temperature while

under general anesthesia, this phase is inevitable and cannot be actively countered. This phase can be reduced, however, using pre-warming in the preoperative period which has been demonstrated to reduce the core to periphery gradient, thus reducing heat lost to redistribution (Rauch et al., 2021). Although a helpful prophylactic measure, pre-warming requires at least an hour of time and patient cooperation to be effective and may not be feasible in many situations. The linear phase generally occurs during the second- and third-hour post-induction. This linear drop in core temperature will last until an autoregulatory threshold is met, which is approximately 34.5 ^{o}C (depending on anesthetic agent and concentration), at which point vasoconstriction of the periphery resumes, leading the patient into the plateau phase where active warming is once again effective.

Regardless of external or patient-related factors and preemptive or active interventions during the perioperative period, heat loss is an inevitable but expected outcome during surgery. For these reasons, active and accurate monitoring is not only necessary in preventing or limiting adverse effects related to perioperative hypothermia but should also be a widespread and accepted standard of care amongst anesthesia providers. In the United States, both the American Association of Nurse Anesthetists (AANA; 2019) and the American Society of Anesthesiologist (ASA; 2021) include temperature monitoring as a part of the overall monitoring standards for anesthesia providers. Standard IX, Part D of the AANA monitoring standards for anesthesia providers requires patients' temperature to be monitored "When clinically significant changes in body temperature are intended, anticipated, or suspected" (AANA; 2019, p. 3). Similarly, Standard 2.4 of the ASA monitoring standards identifies the objective "to aid in the maintenance of appropriate body temperature during all anesthetics" by upholding the standard of care that "every patient receiving anesthesia shall have temperature monitored when clinically significant

changes in body temperature are intended, anticipated or suspected." (ASA; 2021, p. 3). As pointed out by the Anesthesia Patient Safety Foundation (APSF), it is important to remember that evidence-based standards such as these are more than recommended guidelines, rather they serve as minimum requirements to be upheld by the respective providers (Hendrickx, 2019). Deviation from the standard would not only put the patient at unnecessary risk but also expose liability on the part of the provider in the event of adverse outcomes and would be difficult to defend legally (Hendrickx, 2019). The multifactorial nature of perioperative heat loss makes it a complex matter to manage, however, the availability of proven temperature management and monitoring applications and well-established national monitoring standards, perioperative temperature monitoring should continue to be a mainstay in prevention of inadvertent perioperative hypothermia.

Organizational Needs Statement

The partnering organization serves a largely rural population in the eastern part of North Carolina. In 2019, the organization conducted over 49,000 surgeries, which means there were more than 49,000 instances when a patient had potential risk for developing perioperative IPH. With both anesthesiologists and Certified Registered Nurse Anesthetists (CRNAs) practicing at the partnering organization, adequate, appropriate, and accessible temperature monitoring devices are provided not only to adhere to providers' respective practice standards but also to ensure patient safety in alliance with the participating organization's value of safety aimed at "achieving zero harm to patients, visitors, families and team members." Beyond patient safety, organizations must consider the financial aspects of maintaining reimbursement for costly procedures to ensure the longevity of the organization and future availability of care to the community they serve. As of 2021, the Merit-based Incentive Payment System, or MIPS,

included perioperative temperature monitoring as a high priority patient safety domain required to be reported by eligible clinicians in the domain of all patients, regardless of age, who undergo surgical or therapeutic procedures under general or neuraxial anesthesia of 60 minutes duration or longer (Centers for Medicare and Medicaid, 2021). Not only does the MIPS targeted patient safety domain of perioperative temperature monitoring align with a core value of safety at the participating organization, but it also parallels the national standards for both anesthesiologists and CRNAs as previously mentioned, directed at the goal of maintaining patient safety through appropriate perioperative temperature monitoring.

Problem Statement

IPH is defined as a temperature of less than 36 ^{o}C and can lead to increased surgical blood loss, increased postoperative infections, increased extubation times, increased mortality, and increased medical costs (Riley & Andrzejowski, 2018). Despite the existence of well-developed evidence, standards of care, and available tools for countering hypothermia in the operating room, if these are not utilized in practice IPH will continue to occur and patients will continue to experience preventable adverse outcomes. These adverse events represent both a breech in patient safety and a potential for decreased reimbursement to the organization.

Purpose Statement

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and the effectiveness of a newly developed intraoperative temperature monitoring educational tool through surveys administered prior to and after a period of utilization of the tool.

Section II. Evidence

Description of Search Strategies

The purpose of this literature review was to examine current evidence and recommendations addressing perioperative temperature monitoring. The PICOT question used to guide the search strategy was: How do CRNAs perceive the effectiveness of their current intraoperative temperature monitoring practice and the educational resource tool designed to increase knowledge and awareness of appropriate temperature in the intraoperative setting.

A current literature search was conducted using the databases PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL) as well as the search engine Google Scholar. Keywords for the main concepts were combined in the search using Boolean operators. The search strategy used to query PubMed was (((temperature monitoring) AND (anesthesia OR anesthetist OR anesthesiologist)) AND (perioperative OR surgery OR operating room)) AND (complications). This search strategy pulled in the MeSH terms *temperature*; *monitoring*; *physiologic*; *anesthesia; anesthetists*; *anesthesiologist*; *operative*; and *operating rooms*. Limits applied included publication in the most recent 5 years (2016-2021) and English language. CINAHL was searched using a combination of keywords and subject headings identified using the keywords *hypothermia, core body temperature, nurse anesthetist, general anesthesia, perioperative,* and *intraoperative*. Google Scholar was searched using the same search strategy as PubMed. See Appendix A for a list of keywords, MeSH terms, and subject terms utilized in searches. See Appendix B for search strategies and numbers of articles found and kept using structured searching. Additional evidence and information were identified by reviewing related and referenced articles as well as the websites and resources of anesthesia organizations. A limitation of the initial search strategy was that it did not sufficiently address CRNA perceptions,

standards, or utilization of quality improvement tools. Searches were then expanded to include the keywords *perceptions, education,* and *standards*.

Initial searches produced hundreds of articles, however, most pertained to either the physiologic effects of hypothermia or specific temperature monitoring device use. After full text review of the initial and expanded literature searches, six articles were identified as having pertinent evidence supporting intraoperative temperature monitoring improvement, access or knowledge of temperature monitoring educational resources, and awareness or belief in evidenced-based intraoperative monitoring guidelines. These articles were synthesized based on framework, tools, sample size, interventions, and results (see Appendix C). Based on Melnyk and Fineout-Overholt's (2019) levels of evidence hierarchy, evidence identified included three qualitative studies (Level 6), two quality improvement papers (Level 6), and one descriptive study (Level 6).

Selected Literature Synthesis

Knowledge/Beliefs/Attitudes/Awareness

As previously described, there is no shortage of evidence supporting standardized and evidence-based intraoperative temperature monitoring and management. Findings of this review reinforce that this remains true globally, with a variety of national and international guidelines such as the AANA and ASA perioperative temperature monitoring standards IX and 2.4 respectively (AANA, 2019; ASA, 2021) as well-known examples of evidence-based standards. Despite the availability of practice guidelines to follow, IPH has been reported to occur at rates as high as 90% among elective surgeries, 54% in general surgeries, and at 80% in obstetric surgeries when spinal anesthesia was also used (Inal et al., 2017; Munday et al., 2019). Equally concerning, one observation found up to 20% of patients observed had no documented

intraoperative temperature monitoring through the duration of the procedure (Inal et al., 2017). All patients were in areas with available national evidenced-based guidelines for perioperative temperature monitoring. Unfortunately, there is a true gap between clinical practice and care described in internationally available guidelines, triggering many organizations to investigate why this continues to occur.

A guideline can provide a solid foundation to standardized practice if that guideline can be translated into practice. Before trying to uncover the factors that impede or enable successful introduction of a guideline into practice, Gustafsson et al. (2017) and Inal et al. (2017) first focused on uncovering providers' awareness of the guideline and knowledge of the content within it was performed. Both Gustafsson et al. (2017) and Inal et al. (2017) demonstrated that awareness of evidence-based guidelines among a combined 250 participating anesthesiologists and CRNAs was high across the board, however, both discovered inadequate knowledge of the contents within the guidelines and, in some cases, inadequate knowledge of recommended intraoperative hypothermia management. Both qualitative studies found varying intraoperative temperature monitoring techniques, and a very low adherence to respective national guidelines. Their findings suggest that publication and awareness alone do not result in clinical practice change.

Demographic, social, cultural, or even national influence may play a role in the uptake of new clinical practices, thus this uptake may vary from place to place (Inal et al., 2017). The theoretical domains framework (TDF) can be adapted to various research designs and serve as a framework for identifying and describing factors influencing behavior (Munday et al., 2019). Boet et al. (2017) and Munday et al. (2019) developed similar but separate qualitative studies, using the TDF, specifically designed to identify enablers and barriers to the implementation of

established standards and guidelines of perioperative temperature monitoring and management among anesthesia providers. Between the two studies, 27 participants were surveyed, and each study investigated 14 domains and identified 9 overlapping key domains: knowledge; social/professional role and identity; beliefs about capabilities; beliefs about consequences; reinforcement; memory, attention, and decision processes; environmental context and resources; social influence (Boet et al., 2017, pp. 584; Munday et al., 2019, p. 398).

Within the identified literature, knowledge, reinforcement, memory, environmental context and resources, and social influences served as fruitful area for prior, and proposed future interventions to increase adherence to standardized on intraoperative temperature monitoring guidelines (Boet et al., 2017; Munday et al., 2019). Taking key domains into consideration moving forward, interventions suggested by both Boet et al. (2017) and Munday et al. (2019) for addressing these individual barriers include reminder systems, audits, and feedback (reinforcement/memory); and organizational support and champions (social influences). A consensus between both TDF-driven qualitative studies predicted the highest chance of success in clinical practice change must involve a multi-modal and team-based approach as the perioperative setting involves a large interdisciplinary team operating on a daily basis (Boet et al., 2017; Munday et al., 2019).

Intervention/Quality Improvement

As addressed in the previous section, awareness and knowledge alone will not change clinical practice and improve adherence to a standard practice of care. The primary stakeholders (i.e., the anesthesia providers) must have an invested system in which adherence and standardization is promoted. In the pertinent literature identified, authors presented multiple ways to do so with varying success rates. Despite variability, three major themes emerged from

the quality improvement bundles: education provided to participants, care bundles developed and implemented using plan-do-study-act (PDSA) cycles, and electronic and/or paper checklist/reminder alerts (Duff et al., 2018; Kim et al., 2013).

Typically care bundles are comprised of three to six high-impact evidence-based recommendations and have been used to address many iatrogenic medical outcomes with much success (Kim et al., 2013). Most notably, care bundles were used early on in Michigan intensive care units to reduce central line-associated bloodstream infections, resulting in not only an initial 66% reduced infection rate but also sustained reduction over ten years (Kim et al., 2013). Using the Institute of Healthcare Improvement model, Kim et al. (2013), developed an intraoperative hypothermia care bundle and measured the incidence of intraoperative hypothermia instances among 1,758 cases in stage 1 (preintervention), 2,118 in stage 2 (intervention), and 3,656 in stage 3 (postintervention). Addressing pediatric intraoperative hypothermia, the authors developed components of their care bundle through 6 cycles of PDSA, only retaining elements determined to be most efficacious, resulting in eight total interventions. To increase compliance, an electronic reminder was added to the electronic medical record (EMR) with an available spot for documentation. After addition of the EMR reminder, bundle compliance increased and ultimately resulted in an over 50% reduction in pediatric IPH (Kim et al., 2013).

Adapting the thermal care bundle from the IHI collaborative model using existing knowledge to address healthcare gaps with the goal of helping participating organizations make rapid, measurable, and sustainable in the area of focus, Duff et al. (2018), also used a series of PDSA cycles to finalize interventions to be included in the bundle. Unlike the previous bundle, Duff et al. placed a higher emphasis on documentation and compliance with the bundle by employing several team leaders, experts, and facilitators who provided ongoing training,

mitigation to barriers, and audits, including direct feedback to participants (2018). Four hundred adult EHR audits were performed pre-intervention and 400 post-intervention, after exclusions, 700 were used. The compliance and documentation of intraoperative monitoring and management was high using this model, and like the previous bundle included the use of EMR reminders and increased availability of documentation to reinforce behavior in real time. Despite heavier involvement of team leaders, experts, and facilitators to increased compliance, as well as increased educational resources provided with the thermal care bundle, there was no significant positive impact on the incidence of IPH, rather there was a slight increase (Duff et al., 2018), in contrast to the decrease in IPH incidence seen in the pediatric quality improvement design (Kim et al., 2013). Upon further review, the authors concluded that the negative impact might not accurately reflect an increased incidence of IPH, rather it likely came from increased level of documentation and awareness of intraoperative temperature, leading the authors to suggest perhaps the pre-intervention incidence of IPH was higher than reported (Duff et al., 2018).

Beginning with education, Duff et al. (2018) and Kim et al. (2013) used similar strategies in educating participants in both background knowledge on temperature monitoring and IPH, as well as instruction on the use of their respective implementation bundles. Taking it a step further, Duff et al., who implemented the IHI collaborative thermal care bundle, held monthly conference calls for the participants, provided electronic and paper resources, and provided regular feedback with local project experts. Also, during these calls, new care bundle implementation barriers that arose were discussed and strategies to mitigate them provided. The continued team involvement was the primary variable separating the two intervention studies. Kim et al. found a decrease in IPH greater than Duff et al., however, the findings of Duff et al. were able to give insights on the efficacy of the bundle with respects to participant compliance rates among various care bundle

measures such as a 23% improvement in IPH risk assessment, 52% increase in prewarming, and 10% increase in appropriate temperature monitoring of intraoperative patients. Kim et al. did not provide such insight.

Clinical practice change and quality improvement cannot rely on single factors, and as essential as evidence-based guidelines are in closing the gap between evidence and clinical practice, guidelines alone will not produce change (Boet et al., 2017). Involved parties must be aware and knowledgeable of the evidence behind change as well as willing to identify factors that may impede or facilitate change. After these key factors have been identified and all parties are prepared to implement change, a multi-modal approach (using key identified domains) should be taken using well developed bundles that allow for ongoing education, reevaluation, and constant reinforcement. By bundling the most effective techniques commonly used to prevent hypothermia, quality improvement models, as previously discussed, can contribute to standardized care and sustained reduction in IPH (Kim et al., 2013).

Project Framework

The project implementation strategy utilized in this project was adapted from the model of improvement provided by the Institute of Healthcare Improvement (IHI) using a single PDSA cycle. Quality improvement efforts performed using the PDSA cycle have improved health care processes and outcomes among hundreds of healthcare organizations in several countries (IHI, 2021). With the ability to cycle through the process multiple times, the PDSA method addresses three objectives: setting aims through time-specific and measurable outcomes in a specific population, establishing measures using quantifiable methods to determine if change led to improvement, and selecting changes by incorporating key stakeholders with valuable experience and outlook (IHI, 2021). The PDSA cycle is highly effective because it not only allows for

individualization structured for an organization's needs but also encourages flexibility, reevaluation, and scrutiny of process to produce the most favorable process leading to the best patient outcomes.

Planning of this project began with the guidance of an experienced CRNA serving as project chair to guide literature review, intervention design, and participant selection. For this project, the *plan* was designed based on the aim of assessing perioperative hypothermia knowledge and perceptions of CRNAs at the partnering organization. Next, the implementation of the plan (*do*) was accomplished by providing an educational resource on perioperative hypothermia to CRNAs. The *study* portion of this project was accomplished through the analysis of pre- and post-implementation survey results. The final step (*act*) involved applying what was learned from the study portion to the interventional tool. In this project, the act step included presenting findings and future suggestions backed by these findings to participants from the partnering organization.

Ethical Considerations and Protection of Human Subjects

Prior to beginning the formal approval process for this project, the primary investigator completed required ethical training though the Collaborative Institutional Training Initiative (CITI) program (https://about.citiprogram.org/). To evaluate the need for full Institutional Review Board (IRB) approval, a special quality improvement/quality assurance assessment was completed through a collaborative process set up between the East Carolina University (ECU) College of Nursing and the ECU University and Medical Center Institutional Review Board (UMCIRB). See Appendix D. Additionally, facility approval was submitted and obtained through the research office of the partnering organization in conjunction with the ECU UMCIRB (Appendix D). Local unit approval to collect data was obtained from a site contact person whose

signature was included on the organizational approval form. The intervention, an educational resource provided to CRNAs at the partnering organization, contained no information outside of that commonly practiced within the facility. Participants could refer to the resource at their discretion and were not required to participate. This intervention posed no potential harm, inequality, or inequity to participants or patients at the participating organization and no patient information or data was gathered.

Section III. Project Design

Project Setting

This quality improvement project was carried out in the general surgery procedure areas of the partnering organization's main facility, including the preoperative holding, intraoperative area, and post-operative setting. The partnering organization serves 29 counties in the eastern part of the state and is made up of nine hospitals in total. The surgery department of the partnering facility provides a variety of surgical procedures within a variety of specialties such as gastroenterology, orthopedics, gynecology, pediatric, and cardiovascular. Anesthesia services are provided by a team of CRNAs and anesthesiologists. The CRNA clinical faculty member familiar with the organization and staff facilitated recruitment of participants. The Student Registered Nurse Anesthetist (SRNA) team lead also had direct access to the project setting during the intervention period as part of their clinical experience, which allowed them to interact with participants and support the project in person.

Project Population

The project participants included CRNAs at the partnering organization recruited by the clinical faculty member. These CRNAs work within the designated project setting. Facilitators included the team lead being in direct contact with the project participants as well as ongoing communication with the clinical faculty member throughout implementation. Potential barriers included other responsibilities of selected CRNAs that allowed less time for project intervention participation and/or unwillingness of the CRNAs to allot extra time for project participation.

Project Team

The project team consisted of one primary SRNA serving as the team lead, as well as three other SRNAs working on the same project topic. The team of four SRNAs collectively

designed the project and intervention guide but each carried out individual implementation as team-lead in their respective intraoperative area. The project chair was a clinical assistant professor in the nurse anesthesia program who used clinical expertise to help mold a project design that is feasible, manageable, and clinically relevant. The director of clinical education, also a CRNA, served as the clinical contact person, organizing the clinical rotation of the team lead to place them at the location during data collection, recruiting CRNAs at the partnering organization, and assisting with obtaining a signed letter of acknowledgement that data was to be collected on the unit. The program director oversaw all parts of project to ensure DNP project objectives were met. Lastly, the course director aided the team in scholarly research, project organization, and adherence to doctoral level writing and data presentation.

Methods and Measurement

The purpose of this project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for perioperative temperature monitoring and the effectiveness of the newly develop perioperative temperature monitoring educational guide. The project was developed using the PDSA Cycle. The initial email (See Appendix E) to each individual participant included the educational resource (see Appendix F) as a handout that could be saved to a personal device along with a presentation including voice-over. Attached to the initial email was a link to a pre-survey (See Appendix G) assessing the CRNAs' perceptions and knowledge of perioperative temperature monitoring to be completed prior to reviewing the educational guide. Each participant was then instructed to review and utilize the guide at his or her leisure in his or her practice over the following 2 weeks. After pre-intervention survey completion, the educational resource guide was to be used by participating CRNAs for two weeks, after which post-intervention surveys (See Appendix G) mirroring many of the pre-

intervention survey questions were distributed and collected. During the two weeks of educational guide use, CRNAs were able to contact the team lead via email for any clarification. The participants' pre- and post-implementation survey data was gathered via Qualtrics surveys, resulting in a mixture of comparative nominal and ordinal outcome measures related to CRNA knowledge and perceptions of perioperative temperature monitoring in his or her practice setting. The resulting data was analyzed by comparing knowledge and perceptions gathered from participants before and after the educational guide was provided.

Measurable outcomes identified and collected addressing CRNAs' perceived knowledge, awareness, and confidence regarding several factors of perioperative temperature monitoring and provided as nominal level, ordinal level, and open-ended responses. Next, the intervention was shared as an educational resource guide including current evidence-based practice for perioperative temperature monitoring. Participant recruitment of CRNAs was carried out by the clinical contact person at the participating organization. Approval for unit data collection was obtained through a letter of acknowledgment signed by the clinical contact person. Lastly, organizational approval was submitted and obtained through the research office of the partnering organization in conjunction with the ECU UMCIRB (See Appendix D)

Initial contact was made with participants by the team lead via email which included an introduction, appreciation for participation, and brief overview of the project aim. Included in that initial email were links to the pre-intervention survey as well as the education guide as well as video instructions on how to participate. Results were reviewed and summarized with the project chair, and future changes to the plan were based on identified issues. Future suggested changes were presented, along with project outcomes, to the CRNA program students and

faculty as well as participants from the partnering organization but were not implemented in a second PDSA cycle.

Section IV. Results and Findings

Results

The purpose of this project was to assess CRNAs' perceptions of the effectiveness of their current practice for perioperative temperature monitoring and the effectiveness of a newly developed perioperative temperature monitoring educational guide provided to the CRNAs. The participants were provided with both a pre- and a post-survey via Qualtrics which addressed their perceptions regarding their current confidence, strategies, equipment, knowledge, and resources for perioperative temperature monitoring. The pre-survey included a total of 9 questions while the post-survey addressed 12 questions, one including an open-ended response. Between both surveys there was a total of 6 questions that mirrored each other in the hopes of gathering comparable data for pre- and post-intervention with the educational resource guide.

The pre-surveys were first distributed to each participant via Qualtrics link provided in an introduction email, followed by distribution of the educational resource that remained available to participants during the two-week period. A total of 6 out of 6 participants responded to the pre-survey. During the interim two-week period, participants had access to the education resource and were encouraged to use it as a reference for any perioperative temperature monitoring/management questions that may arise. During this period, contact information for project-lead was provided for any clarification or questions that arose. After a two-week period, post-surveys were distributed and a total of 5 out of 6 participants provided post-survey responses. Data collection was accomplished through Qualtrics, then data were transferred to

Excel for analysis. Three charts were generated comparing data from similar or identical questions on both the pre- and post-surveys.

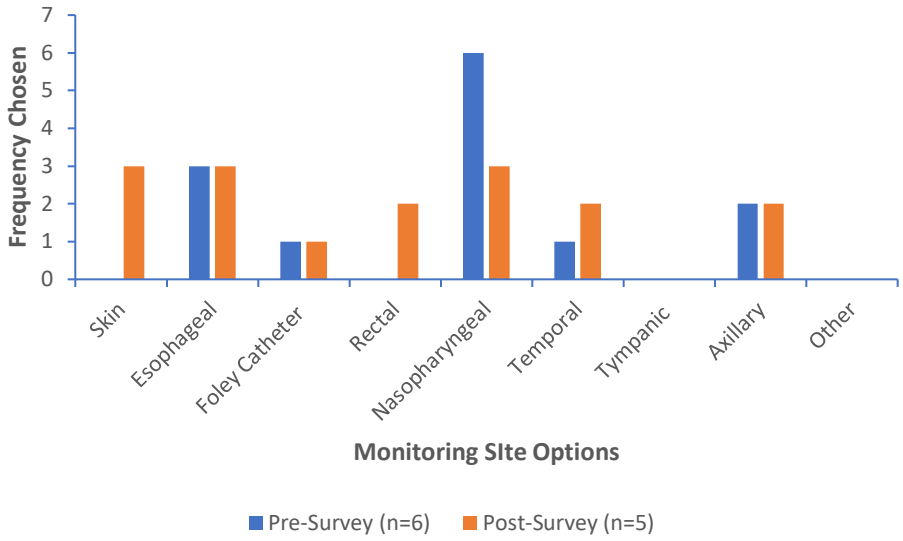
Data Presentation

Responses from the pre-survey demonstrated that only half of the CRNAs reportedly received education on temperature monitoring polices and standards for their surgical setting prior to educational tool distribution, but all respondents were aware of the AANA national standard for perioperative temperature monitoring. Despite this, all respondents reported high confidence levels on Likert-scale style questions about their current perioperative temperature monitoring knowledge, ability to identify patients or procedures at high risk of perioperative heat loss, and their ability to identify core body temperature sites. With a wide variety of preferred temperature modality sites and devices chosen (see Figure 1), five of six respondents reported confidence in these temperature monitoring modalities available in their practice, while one respondent reported being neutral.

Prior to distributing the educational resource, 3 participants reported it would require 1-3 minutes to access a temperature monitoring reference, 2 reported it would require 4-6 minutes and 1 that it would require more than 10 minutes. This was additionally measured in the post-survey (Figure 2). After the educational resource was provided, all the CRNAs had the ability to readily access AANA national standards on perioperative temperature monitoring, and a decreased time to access the provided educational tool via smartphone to 6 minutes or less among all respondents (Figure 2).

Figure 1

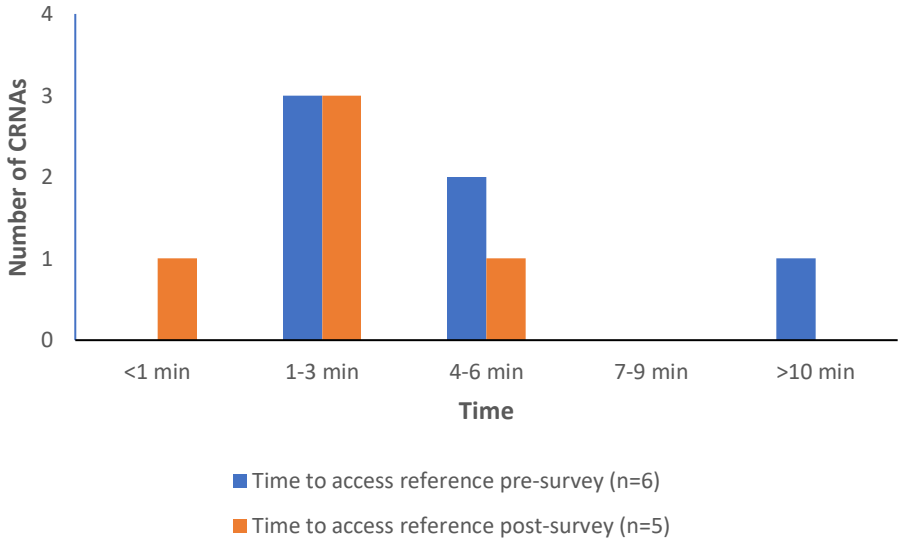
Preferred Intraoperative Temperature Monitoring Modality/Site



Note: More than one modality/site able to be chosen as there are multiple available in practice and may be more appropriate for different case types.

Figure 2

Time to Access Temperature Monitoring Reference

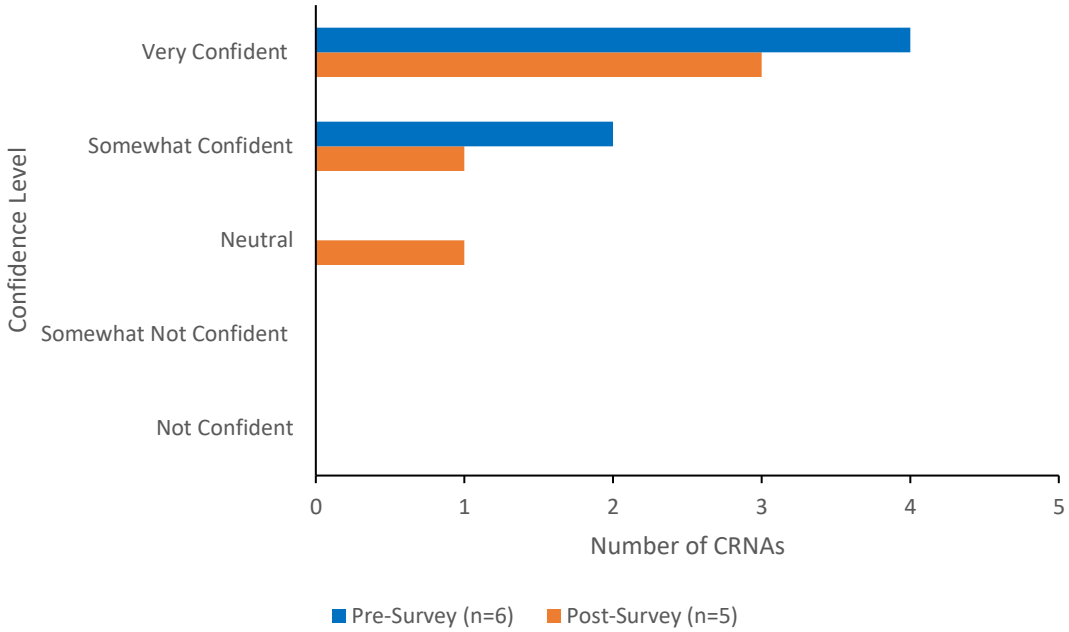


Note. Pre-survey responses reflect estimated time it would take CRNA to access evidence-based reference regarding perioperative temperature monitoring. Post-survey responses reflect estimated time it would take CRNA to access educational tool provided electronically via smartphone.

Despite the quicker access to the educational resource, less than half responded *Likely* to utilize this resource. After implementation of the educational resource, confidence levels regarding ability to identify core temperature site, identify population or procedure at increased risk of heat loss, and overall knowledge of perioperative temperature monitoring all decreased slightly in the post-survey responses. Reported confidence in ability to identify core temperature site decreased over time. All CRNA participants reported *Somewhat Confident* or higher on the pre-survey whereas less than half reported *Neutral* or lower on the confidence scale in the post-survey. Confidence in ability to identify patient or procedure at increased risk of heat loss also decreased over time. In the pre-survey all CRNAs reported *Somewhat Confident* or higher. In contrast, in the post-survey just over three quarters of participants reporting *Somewhat Confident* or higher (see Figure 3). Overall confidence in perioperative temperature knowledge also declined from all participants reporting *Somewhat Confident* or higher responses in comparison to those from the post-survey where almost half of participants reported *Neutral* or lower confidence.

Figure 3

Confidence Level in Ability to Identify High Risk Patient or Procedure for Perioperative Heat Loss



Note. *Pre-survey* responses reflected are those prior to the introduction and use of educational resource whereas post-survey responses reflect confidence levels after utilization of education resource.

After working with the provided educational resource, all respondents reported intent to utilize intraoperative temperature monitoring in 75-100% of cases. When CRNAs were once more asked their preferred temperature monitoring modality or site there was still a spread (see Figure 1), but with *Nasopharyngeal* selected less frequently.

As an additional point, the post-survey inquired about the CRNAs' experiences with the post-operative care unit (PACU) temperature correlating with the intraoperative temperature reading. Almost half responded that 50-75% of the time the temperatures correlate well. As a follow up, an open-ended question asked for recommendations that might improve a lack of correlation between intraoperative temperature and PACU temperature reading. One respondent replied *PACU should check a core temperature*, and another *Use the same type of thermometer*

and same site for assessment. At the end of the post-survey, one open-ended question addressed perceived barriers to preventing intraoperative heat loss in the CRNAs' practice. Three responses were received: *Lack of equipment*, S*urgeon and OR staff requesting colder temperatures*, and *Need to keep patients cool during procedures*. The last free response question asked participants to share recommendations to strengthen the educational resource. One responded, *Textbooks do not all agree about accurate core temperature sites* and another *No – I think this was already well-known knowledge by most staff CRNAs*.

Analysis

The closely mirrored pre- and post-survey questions provided good insight into what deficits the education resource may have had and points of education or clarity that could be approached in future quality improvement efforts. Some key points derived through comparison of pre- and post-survey responses included a perceived reduction in access time to resources about perioperative temperature monitoring as well as an overall high confidence level in perioperative temperature monitoring when identifying core sites and at-risk populations and procedures. Of all modalities chosen, nasopharyngeal was chosen most frequently despite not being a core temperature site. Potential factors for this preference may be high availability, ease of accessibility and patient/provider convenience. Overall knowledge about core temperature sites and monitoring seems high among most practicing CRNAs and remains as a standard practice. There were, however, a few areas exposed by the pre- and post-surveys that implicate a need for future education and redesign of the educational resource as well as areas of the survey questions that need more clarity to better assess the participants.

Confidence in ability to identify core temperature sites, pre- and post-survey items demonstrated what appeared to be a reduction in confidence levels of participants after being

provided the educational resource. While this may have corrected what some participants believed to be core temperature sites or provided additional sites not believed to be core sites initially, it is also important to note that some textbooks have slightly varying accepted core temperature sites. However, as discussed previously, there are four main universally accepted core temperature sites. Confidence in ability to identify high risk patient populations or procedures also demonstrated a reduction in confidence from pre- to post-survey after the educational resource was provided. This reduction in confidence level may indicate further need to develop the educational resource to be clearer and more concise on these areas, or perhaps provide knowledge that a CRNA was not aware of or had not utilized in practice. After the education resource was distributed, post-survey findings demonstrated a reduction in CRNAs selecting nasopharyngeal as a preferred choice for intraoperative temperature monitoring. This may represent new knowledge in that it is not a recognized core temperature site, and be attributable to provision of the educational resource.

The post-survey also included a few open-ended questions. One question asked for recommendations for addressing variance seen in practice between intraoperative and PACU temperature readings. One respondent replied *PACU should check a core temperature,* and another responded *Use the same type of thermometer and same site for assessment*. Many cases require a great deal of effort to maintain intraoperative normothermia in patients under general anesthesia, PACU temperature readings below the acceptable limits of normothermia reflects poorly on the intraoperative temperature management of the patient. These PACU temperatures are generally taken immediately upon patient arrival to PACU but often at monitoring sites different from what was used intraoperatively. Reported barriers to intraoperative temperature management by CRNAs included *Lack of equipment*, *Surgeon and OR staff requesting colder*

temperatures, and *Need to keep patients cool during procedures*. These responses provide an excellent window into the reality of theory versus practice and provide potential foci for future quality improvement inquiries.

Section V. Implications

Financial and Nonfinancial Analysis

If implemented within the organization, this project would be low cost and low risk yet potentially offer benefits to patient outcomes. If proposed implementation resulted in improved intraoperative temperature management, there is a potential for indirect financial benefits of this quality improvement. Appropriate temperature management can prevent adverse post-operative outcomes, thus allowing for timely PACU discharge. Increased PACU stay, admission to the hospital after surgery, or extended time in the operating room can all contribute to substantial cost and resource burden on the hospital as well as increased charges to the patient. Actual costs of operating room and PACU time depend on the complexity of the procedure, the staff involved, as well as equipment that may be required for the procedure, however, anesthesia time is almost universally charged by the minute and will be charged for each minute the patient is under the anesthesia provider's care. For example, if a patient experiences delayed awakening, pain relief, or other complications that prevent prompt discharge from the PACU, this can back up the availability of spaces and staff, thus forcing subsequent patients to be placed on PACU hold, keeping them in the operating room longer than needed and being charged anesthesia and operating room cost.

The project does not propose a change in practice, nor does it call for additional resources or supplies. Beginning with implementation, the educational resource could be both electronically and physically distributed (i.e., paper/laminated pocket resource) to all CRNAs. After implementation, the education resource could serve as a reference to CRNAs to identify core temperature sites as well as high risk populations and procedures. This could contribute to an increased preoperative identification of increased perioperative heat loss risk and prompt the

CRNA to incorporate heat loss prevention methods (e.g., humidifier, Bair hugger, foil cap, etc.), into their care plan for this procedure. These methods and supplies already exist and are regularly stocked at the facility. There is a potential for increased usage of these supplies, resulting in increased demand and cost, however, most practice already use these tools daily. Workflow should not be affected as the resource guide was shown to be accessed in less than 3 minutes by most respondents. The risk involved with implementing findings of this project would be very low as it would not require added patient intervention to already established standards and it promotes higher degrees of temperature monitoring and heat loss management that have been shown to prevent adverse surgical outcomes. Overall, this project has the potential to benefit practice, by reducing adverse outcomes preventable by heat loss management intraoperatively, as well as patient satisfaction through improved outcomes.

Implications of Project

Inadvertent heat loss during the intraoperative period is inevitable regardless of preemptive or active interventions. Therefore, accurate perioperative temperature monitoring is crucial in heat loss management to reduce potential adverse outcomes of heat loss such as increased blood loss, increased morbidity and mortality, increased post operative infections, and other issues (Riley & Andrzejowski, 2018). The pre-survey addressed both awareness of AANA monitoring Standard IX, Part D, placing temperature monitoring as a national standard for any patient with intended or anticipated body temperature changes (2019), and knowledge of both perioperative heat loss and patients or procedures at increased risk. All CRNA participants confirmed awareness of national temperature monitoring standards, and confidence in their ability to identify patients or procedures at high risk. Though there is already high confidence among CRNAs in identifying patients and procedures at increased risk for perioperative heat

loss, future QI projects may be useful in closing the gap even further so that most, if not all, CRNAs can accurately identify these at-risk populations and procedures fully in order to uphold the AANA standard of care among the providers.

Gustafsson et al. (2017) and Inal et al. (2017) demonstrated that awareness of evidence-based guidelines among a combined 250 participating anesthesiologists and CRNAs was high across the board. This was similar to what was found in this project's pre-survey responses, however, unlike the other quality improvement projects, the knowledge of the actual contents of this standard was not surveyed, which may or may not have yielded similar results. Understanding participants' knowledge on actual content in future projects may better serve to direct quality improvement efforts. Both qualitative studies found varying intraoperative temperature monitoring techniques and a very low adherence to respective national guidelines, which suggests that awareness alone does not result in clinical practice change. Not unlike the results found in this project, awareness was high, yet there was a wide variety of preferred monitoring modalities/sites for temperature monitoring as well as no assessment of knowledge of contents about the AANA monitoring standard or techniques to manage IPH. Creating a standardized approach to increase adherence to clinical practice guidelines within an organization may contribute to greater compliance and increase knowledge in the process. With the goal of increasing awareness, knowledge, and adherence to clinical practice guidelines, as they serve to reduce adverse patient outcomes, utilizing the TDF may help improve success rates in future QI projects. Knowledge, reinforcement, memory, environmental context and resources, and social influences are all domains of behavioral change that have served as targets for past and proposed future intervention projects to increase adherence to standardized guidelines (Boet et al., 2017; Munday et al., 2019).

Clinical practice change and quality improvement do not rely on one single factor, and although evidence-based guidelines are essential in bridging evidence and clinical practice, guidelines alone will not produce change (Boet et al., 2017). The organization and CRNAs have been shown to be aware of standards but knowledge of both the standards and strategies to mitigate IPH must be present to begin facilitating change in practice. Further, both barriers and facilitators to the uptake of guidelines must be identified among organizations to produce success and adherence to implementation. Taking these factors into account, a personalized bundle or strategy can be produced to fit organizational needs. Once developed, the use and availability of resources and tools such as a supportive environment for quality improvement, including leadership involvement, team/project leads, reevaluation, ongoing education, and supportive reinforcement, can contribute to increased adherence and prolonged sustainability of the bundle.

Given the results of both the pre- and post- surveys, awareness and overall confidence in knowledge regarding perioperative heat loss does not appear to be lacking; rather, there is some variability in modality or site chosen to monitor temperature. Only half of participants reported having received education on temperature monitoring policies or standards in their respective surgical setting. The reported preferred temperature monitoring modality could reflect what is most readily available or affordable at an organization (i.e., nasopharyngeal is quick, easy, and least invasive) accessibility to the patient during the procedure, or a variety of other reasons. Further research could investigate participants' reasons for choosing their preferred modalities. While only half of the participants reported receiving education on organization-specific standards regarding temperature monitoring, all participants still reported initial high confidence levels in overall knowledge of perioperative heat loss. This finding reflected a good core physiologic understanding developed in training among CRNAs regarding perioperative heat

loss despite organizational education. This may point to the need for something as simple as an area of education or organization-specific standards that could be reinforced on a timely basis. Nevertheless, the received responses point to a high overall confidence in knowledge of perioperative heat loss and temperature monitoring, as well as awareness of national standards. The variability in preferred modalities and reported lack of setting specific policies may indicate a need for reinforcement of organizational standards and policies. Increasing or adding monitoring modalities (e.g., more esophageal probes, increased utilization of foley monitoring if one present, etc.) may also be useful.

Increasing the knowledge and adherence to a set organizational standard that mirrors nationally recognized temperature monitoring standards has the potential to positively impact patient outcomes. By standardizing care and using appropriate monitoring for specific patients and procedures, adverse outcomes such as increased bleeding, increased postoperative infections, increased extubation times, and other morbidities could be reduced. Reducing IPH would not only improve patient outcomes, but it would also favor the organization as a whole as it could lead to reduced costs associated with prolonged procedure times (e.g., increased extubation time, prolonged bleeding, etc.) and increase healthcare reimbursement by avoiding preventable adverse outcomes in the perioperative period.

Sustainability

If the organization were to utilize the knowledge obtained from this QI project, the financial and effort costs would be low, however, there may be a need for additional assessment and QI inquiries prior to implementation. Expanding this project, the organization would benefit from first investigating knowledge of employees about both national standards and ability to implement strategies in preventing or correcting intraoperative heat loss. Understanding

knowledge deficits and clinical experiences might provide insight into education needs that the project may focus on. Further, understanding which temperature monitoring modalities or sites are chosen by practitioners, and why, would provide insight into potential barriers and facilitators to adherence to organizational standards.

Once established, standards would need to be disseminated with appropriate education, reinforcement, and periodic reevaluation to achieve predetermined organizational goals regarding adherence and documented monitoring practices. A series of PDSA cycles may be necessary to find a suitable and sustainable care bundle to make education and policy adherence long lasting. Using knowledge learned from previous QI projects may aid in establishing an organization-specific bundle which could prove to be the most efficient route to provoke sustainability among CRNAs in monitoring and managing perioperative temperature. Duff et al. (2018) provided an excellent model by placing a higher emphasis on documentation and compliance with the bundle itself, after the bundle had been well-established for organizational needs. They then used team leads, experts, and facilitators to provide on-going training, mitigate barriers, and audits, including direct feedback to participants to help sustain improvement promoted by the bundle. Rather than fixating on specific aspects of the bundle, Duff et al. (2018) found better overall improvement by maintaining consistency and adherence to the established bundle. Moving forward, the organization has an excellent opportunity to provide efficient standardization of care as the core knowledge and confidence among CRNAs is already present. Expanding on the substantial knowledge, expertise, and experience of the CRNAs, the organization has the opportunity to efficiently standardize temperature monitoring in practice by addressing any equipment needs, identifying any barriers to appropriate temperature monitoring,

and disseminating/reinforcing organizational standard or policy regarding temperature monitoring and management.

Dissemination Plan

Upon completion of data analysis and poster creation, the poster was presented to CRNA program department members and students. The CRNAs who participated in the project were also invited. During the presentation, the project chair, program director, project participants, and others had the opportunity to see data visualizations, hear a brief verbal report, and had a chance to ask any questions or for clarifications. The final version of this project paper was submitted to The Scholarship, the East Carolina University digital repository.

Section VI. Conclusion

Limitations

Limitations of the quality improvement project include a small sample size, potentially misinterpreted survey questions, and a time limitation that would not allow for a repetition of the PDSA cycle in following up with reported post-survey results. The sample size was only 6 pre- and 5 post-survey participants, which in and of itself may distort comparative results on similar pre- and post-survey questions. Beyond that, the sample size is only a small fraction of the total amount of practicing CRNAs in the organization. If used for future implementation efforts, it would be recommended to use a much larger sample size.

After analysis of survey responses, a potential limitation is the percentage of cases in which CRNAs used intraoperative temperature monitoring. In both pre- and post-survey responses, not all participants reported 75-100% of cases where intraoperative temperature monitoring was included. It is important to note that there are many cases in which standards do not require temperature monitoring as general anesthesia is not used (e.g., cesarean sections under spinal or epidural anesthesia, regional anesthetic techniques, etc.). So, this anomaly likely reflects a problem with the format of the questions. A future recommendation in addressing this question would be to include the distinction of patients under general anesthesia versus regional techniques. Another question under analysis that proved to be unclear was preferred method of temperature monitoring modality or site. The question allowed for multiple responses but did not provide appropriate context or factor in facility availability. In future QI projects, it may prove beneficial to repeat this question along with further questions that assess the modalities available, access to patient monitoring sites, and a rationale for the chosen modality.

Given a small window of time to conduct the surveys, provide an analysis, and complete the project, there was limited time which did not allow for repeated PDSA cycles. PDSA cycle repetition can be highly effective as it allows for individualization structured for an organization's identified needs and limitations while encouraging flexibility, reevaluation, and scrutiny of process, as mentioned previously, to produce the most efficient process or bundle that leads to better patient outcomes.

Recommendations for Future Implementation and/or Additional Study

If this process were to be reproduced, recommendations would include increasing the number of participants, extending the time frame to allow for repetition through more than a single PDSA cycle, and adjusting survey questions to gain further clarity. Given the organization's large number of CRNAs, a larger sample of more than 6 participants would be beneficial in capturing a better representation of practice among providers in the organization. Extending the time frame to allow for repeated PDSA cycles would support the final recommendation of clarifying survey questions. Understanding the confidence and awareness of temperature monitoring of the organization's CRNAs is an excellent starting point, however, further inquiries would address the *why*. For instance, understanding why the CRNAs did or did not choose a specific modality or site as a preferred method even if it is an accepted core temperature site may bring to attention barriers to using this method.

If QI efforts are aimed at improving patient outcomes through the prevention of IPH, additional concepts to be added to this project should include participating CRNAs' knowledge of methods to prevent IPH, available methods to address IPH, and potential for multi-disciplinary efforts to address this issue. By addressing knowledge of methods to prevent IPH, any gaps in knowledge can be addressed through organizational education efforts with

continuing support and reevaluation. Simply knowing it exists but not knowing how to mitigate IPH will not facilitate any efforts to improve patient outcomes. Assessing current methods and materials available to CRNAs to mitigate IPH may reveal potential barriers to CRNAs carrying out these prevention methods.

As with almost all patient outcomes, it is multidisciplinary efforts that contribute to a positive impact. In the CRNA realm, most efforts are active or reactive as they will not care for the patient until that patient is already in the intraoperative phase. Methods such as intravenous fluid warming, Bair hugger application, and foil cap application all occur in the intraoperative period but, as discussed previously, will not mitigate the first phase of heat loss under general anesthesia. One example to preemptively mitigate some intraoperative heat loss is use of prewarming the patient during the preoperative period. This would require a multidisciplinary collaboration between the preoperative staff, CRNAs, and the surgical team to allow for adequate prewarming time.

This project demonstrated there is a high confidence among CRNAs regarding temperature monitoring standards, core temperature sites, and patients and procedures at high risk. This is a good starting point for quality improvement as confident practitioners may be more willing to integrate standardized practices once readily available. By addressing some of the points identified but not addressed in this project, future projects can offer greater potential for successful and long-lasting quality improvement in this and other organizations.

References

American Association of Nurse Anesthetists. (2019, February 19). *Standards for nurse anesthesia practice*. https://www.aana.com/docs/default-source/practice-aana-com-web-documents-(all)/professional-practice-manual/standards-for-nurse-anesthesia-practice.pdf?sfvrsn=e00049b1_20

American Society of Anesthesiologist. (2021). *Standards for basic anesthetic monitoring*. https://www.asahq.org/standards-and-guidelines/standards-for-basic-anesthetic-monitoring

Boet, S., Patey, A. M., Baron, J. S., Mohamed, K., Pigford, A. E., Bryson, G. L., Brehaut, J. C., & Grimshaw, J. M. (2017). Factors that influence effective perioperative temperature management by anesthesiologists: A qualitative study using the theoretical domains framework. *Canadian Journal of Anesthesia, 64*(6), 581-596. https://doi.org/10.1007/s12630-017-0845-9

Centers for Medicare and Medicaid (2021). *Quality ID #424: Perioperative temperature management*. https://qpp.cms.gov/docs/QPP_quality_measure_specifications/CQM-Measures/2021_Measure_424_MIPSCQM.pdf

Duff, J., Walker, K., Edward, K., Ralph, N., Giandinoto, J., Alexander, K., Gow, J., & Stephenson, J. (2018). Effect of a thermal care bundle on the prevention, detection, and treatment of perioperative inadvertent hypothermia. *Journal of Clinical Nursing, 27*(5-6), 1239-1249. https://doi.org/10.1111/jocn.14171

Gustafsson, I. L., Elmqvist, C., From-Attebring, M., Johansson, I., & Rask, M. (2017). The nurse anesthetists' adherence to Swedish national recommendations to maintain normothermia

in patients during surgery. *Journal of Perianesthesia Nursing 32*(5), 409-418. https://doi.org/S1089-9472(16)30241-6

Hendrickx, J. (2019). Anesthetic monitoring recommendations: How consistent are they across the globe? *APSF Newsletter, 34(2), 34-26*. https://www.apsf.org/article/anesthetic-monitoring-recommendations-how-consistent-are-they-across-the-globe/

İnal, M. A., Ural, S. G., Çakmak, H. Ş, Arslan, M., & Polat, R. (2017). Approach to perioperative hypothermia by anaesthesiology and reanimation specialist in turkey: A survey investigation. *Turkish Journal of Anaesthesiology and Reanimation, 45*(3), 139-145. https://doi.org/10.5152/TJAR.2017.81567

Institute for Healthcare Improvement. (2021) *How to improve.* http://www.ihi.org/resources/Pages/HowtoImprove/default.aspx

Kim, P., Taghon, T., Fetzer, M., & Tobias, J. D. (2013). Perioperative hypothermia in the pediatric population: A quality improvement project. *American Journal of Medical Quality, 28*(5), 400-406. https://doi.org/10.1177/1062860612473350

Melnyk, B. M. & Fineout-Overholt, E. (2019) *Evidence-based practice in nursing and healthcare: A guide to best practice.* (4th ed.). Wolters Kluwer.

Munday, J., Delaforce, A., Forbes, G., & Keogh, S. (2019). Barriers and enablers to the implementation of perioperative hypothermia prevention practices from the perspectives of the multidisciplinary team: A qualitative study using the theoretical domains framework. *Journal of Multidisciplinary Healthcare, 12*, 395-417. https://doi.org/10.2147/JMDH.S209687

Rauch, S., Miller, C., Bräuer, A., Wallner, B., Bock, M., & Paal, P. (2021). Perioperative hypothermia-A narrative review. *International Journal of Environmental Research and Public Health, 18*(16), 8749. https://doi.org/10.3390/ijerph18168749

Riley, C., & Andrzejowski, J. (2018). Inadvertent perioperative hypothermia. *BJA Education, 18*(8), 227-233. https://doi.org/10.1016/j.bjae.2018.05.003

Appendix A

Literature Concept Chart

	Concept 1: Temperature Monitoring	Concept 2: Anesthesia	Concept 3: Perioperative
Keywords (these are the "normal" words you would use anywhere)	Temperature Monitoring Hypothermia Core Body Temperature	Anesthesia Nurse Anesthetist General Anesthesia	Perioperative Intraoperative
PubMed MeSH (subject heading specific to PubMed)	"temperature"[MeSH Terms] "monitoring, physiologic"[MeSH Terms]	"anesthesia"[MeSH Terms] "nurse anesthetists"[MeSH Terms] "anesthesiologist" [MeSH Terms]	"operative" [MeSH Terms] "operating rooms" [MeSH Terms]
CINAHL Subject Terms (Subject headings specific to CINAHL)	(MH "Rectal Body Temperature") (MH "Axillary Body Temperature") (MH "Core Body Temperature") (MH "Body Temperature Changes") (MH "Body Temperature") (MH "Monitoring, Physiologic") (MH "Temperature") (MH "Skin Temperature") (MH "Intraoperative Monitoring") (MH "Tympanic Body Temperature")	(MH "Anesthesia") (MH "Education, Nurse Anesthesia") (MH "Post Anesthesia Care Units") (MH "Anesthesia, Inhalation") (MH "Anesthesia, General") (MH "Anesthesia, Intravenous") (MH "Intraoperative Awareness") (MH "Post Anesthesia Care") (MH "Anesthesia Induction")	(MH "Perioperative Care") (MH "Perioperative Medicine") (MH "Perioperative Nursing") (MH "Preoperative Care") (MH "Postoperative Care") (MH "Intraoperative Care")

Appendix B

Literature Search Log

Search date	Database or search engine	Search strategy	Limits applied	Number of citations found/kept	Rationale for inclusion/exclusion of items
09/21/2021	PubMed	(((temperature monitoring) AND (anesthesia OR anesthetist OR anesthesiologist)) AND (perioperative OR surgery OR operating room)) AND (complications)	2016-2021 English	65 found /16 kept	Intraoperative focus, temperature monitoring/management or hypothermia mentioned/ Not applicable
09/22/2021	CINAHL	(MH "Rectal Body Temperature") OR (MH "Axillary Body Temperature") OR (MH "Core Body Temperature") OR (MH "Body Temperature Changes") OR (MH "Body Temperature") OR (MH "Monitoring, Physiologic") OR (MH "Temperature") OR (MH "Skin Temperature") OR "Temperature monitoring" OR (MH "Intraoperative Monitoring") OR (MH "Tympanic Body Temperature") AND (MH "Anesthesia") OR "Anesthesia" OR (MH "Education, Nurse Anesthesia") OR (MH "Post Anesthesia Care Units") OR (MH "Anesthesia, Inhalation") OR (MH "Anesthesia, General") OR (MH "Anesthesia, Intravenous") OR (MH "Intraoperative Awareness") OR (MH "Post Anesthesia Care") OR (MH "Anesthesia Induction") AND "Perioperative" OR (MH "Perioperative Care") OR (MH "Perioperative Medicine") OR (MH "Perioperative Nursing") OR (MH "Preoperative Care") OR (MH "Postoperative Care") OR (MH "Intraoperative Care")	2016-2021 English Peer-Reviewed	490 found/ 6 kept	Intraoperative focus, temperature monitoring/management or hypothermia mentioned/ Not applicable
09/21/2021	Google Scholar	(Temperature monitoring OR Temperature management OR hypothermia) AND (anesthesia OR general anesthesia OR nurse anesthetist OR Anesthesiologist) AND (perioperative OR intraoperative OR operating room) AND (education OR adherence OR framework OR Guideline)	2016-2021 English	8260 found/ 56 kept (20 pages reviewed)	Intraoperative focus, temperature monitoring/management or hypothermia mentioned/ Not applicable
09/23/2021	OneSearch	(temperature monitoring) AND (anesthesia OR anesthetist OR anesthesiologist) AND (perioperative OR surgery OR operating room) AND (guideline OR standard OR framework)	2016-2021 English Peer-reviewed	4,486 found/15 Kept (100 titles reviewed)	Intraoperative focus, temperature monitoring/management or hypothermia mentioned/ Not applicable

Appendix C

Literature Matrix

Author, Title, Journal.	Purpose & Conceptual Framework or Model	Design and Level of Evidence	Setting	Sample	Tool/s and/or Intervention/s	Results
Boet, S., Patey, A. M., Baron, J. S., Mohamed, K., Pigford, A. E., Bryson, G. L., Brehaut, J. C., & Grimshaw, J. M. (2017). Factors that influence effective perioperative temperature management by anesthesiologists: A qualitative study using the theoretical domains framework. *Canadian Journal of Anesthesia, 64*(6), 581-596. https://doi.org/10.1007/s12630-017-0845-9	Using TDF-embedded interviews of anesthesia providers at an academic hospital, barriers, enablers, and other factors were identified that influence temperature management by anesthesiologists during the perioperative period. Theoretical Domains Framework (Determinants of clinical behaviors)	Level 6 Qualitative Study	Hospital	15 Questionnaire Participants	Semi-Structured interviews based on 14 domains	Nine theoretical domains were identified as determinants of perioperative temperature management practices. Authors suggest these domains can serve as starting points for evidence-based quality improvement projects.
Duff, J., Walker, K., Edward, K., Ralph, N., Giandinoto, J., Alexander, K., Gow, J., & Stephenson, J. (2018). Effect of a thermal care bundle on the prevention, detection, and treatment of perioperative inadvertent hypothermia. *Journal of Clinical Nursing, 27*(5-6), 1239-1249. https://doi.org/10.1111/jocn.14171	Aimed to improve prevention, detection, and treatment of IPH in adults through the implementation of a Thermal Care Bundle. IHI Collaborative Model	Level 6 Quality Improvement	Hospital	400 Adult Patient charts (Pre) 400 Adult patient charts (post) Randomized selection 729 total after exclusions	Pre & Post-Implementation Study (EHR Audit) SPSS Data Analysis Categorical data & Continuous data reported Comparison Z-test ($p < 0.05$)	Implementation showed an increased hypothermia risk assessment, temperature recording, and intraoperative active warming. The implementation did not impact the incidence of IPH at a statistically significant level.
Gustafsson, I. L., Elmqvist, C., From-Attebring, M., Johansson, I., & Rask, M. (2017). The nurse anesthetists' adherence to Swedish national recommendations to maintain normothermia in patients during surgery. *Journal of Perianesthesia Nursing 32*(5), 409-418. https://doi.org/S1089-9472(16)30241-6	Aimed to assess if Nurse Anesthetist had the knowledge, access, and adhered to recommended guidelines to maintain normothermia perioperatively. No framework or model mentioned	Level 6 Descriptive Survey	Hospital	56 Questionnaire Participants	Questionnaire	Access to guideline was high, Knowledge of guideline was about 50%, adherence was low.
İnal, M. A., Ural, S. G., Çakmak, H. Ş, Arslan, M., & Polat, R. (2017). Approach to perioperative hypothermia by anaesthesiology and reanimation	Aimed to investigate attitudes of anesthesiologist on perioperative temperature monitoring.	Level 6 Qualitative Study	Hospital	204 Questionnaire Participants	25 Item Questionnaire (electronic & paper)	A wide variability in temperature monitoring practices as well as hypothermia diagnosis and

specialist in turkey: A survey investigation. *Turkish Journal of Anaesthesiology and Reanimation*, *45*(3), 139-145. https://doi.org/10.5152/TJAR.2017.81567	No framework or model mentioned					treatment despite the established national guidelines.
Kim, P., Taghon, T., Fetzer, M., & Tobias, J. D. (2013). Perioperative hypothermia in the pediatric population: A quality improvement project. *American Journal of Medical Quality*, *28*(5), 400-406. https://doi.org/10.1177/1062860612473350	Reduced incidence of perioperative hypothermia by 50% Institute of Healthcare improvement model	Level 6 Quality Improvement	Hospital	1,758 Stage 1 preintervention 2,118 Stage 2 Intervention 3,656 Stage 3 postintervention	8 Item temperature management bundle (checklist & EHR notification) Education on proper use of bundle	53% Reduction in incidence of perioperative hypothermia in pediatric population. Bundle of most effective strategies to prevent hypothermia to design standardized care showed a sustained reduction in overall incidence.
Munday, J., Delaforce, A., Forbes, G., & Keogh, S. (2019). Barriers and enablers to the implementation of perioperative hypothermia prevention practices from the perspectives of the multidisciplinary team: A qualitative study using the theoretical domains framework. *Journal of Multidisciplinary Healthcare*, *12*, 395-417. https://doi.org/10.2147/JMDH.S209687	Aimed to identify barriers and enablers to perioperative hypothermia prevention practices among key stakeholders in perioperative temperature management. COM-B model of the Behavior Change Wheel Theoretical Domains Framework (TDF) Behavior Change Theory (BCT)	Level 6 Qualitative Study	Hospital	12 Interview Participants (Multidisciplinary)	Individual Structured Interviews addressing 14 domains outlined in TDF	Based on TDF-based interview response: Strategies likely to improve implementation of perioperative hypothermia preventions include the use of audits and feedback, reminders, and prompts, identified “champions” to lead improvements, and monthly agreed goals.

Note: EHR = Electronic Health Record IPH = Inadvertent Perioperative Hypothermia; MIPS = Merit-based Incentive Payment System; OR = Operating Room; Adapted from Evidence-based practice in nursing and healthcare: A guide to best practice (4th ed.), by B. M. Melnyk and E. Fineout-Overholt, 2019, p. 131.

Appendix D

Quality Assurance/Quality Improvement Project vs. Human Research Study (Requiring IRB approval) Determination Form

This worksheet is a guide to help the submitter to determine if a project or study is a quality assurance/quality improvement (QA/QI) project or research study and is involving human subjects or their individually identifiable information and requires IRB approval as defined by the Health and Human Services (HHS) or Food and Drug Administration (FDA). Once completed, please email the form to the [redacted] Health Center for Research and Grants ([redacted]CRG) CRG.Quality@[redacted]ealth.com. A CRG team member will contact you with the results of their review and may request additional information to assist with their determination. The determination will be made in conjunction with the UMCIRB office.

Please contact the [redacted]CRG with any questions at 252-847-1177 or CRG.Quality@[redacted]health.com.

For more guidance about whether the activity meets the definition of Human Subjects Research see https://rede.ecu.edu/umcirb/irb-faqs/definitions/ or https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html#c1

Project Title: Perioperative Temperature Monitoring		
Funding Source: None		
Project Leader Name: Garrett Reinhard/ Angela Ciuca	☐ Ed.D. ☐ J.D. ☐ M.D. ☐ Ph.D. ☐ Pharm.D. ☒ R.N. ☒ Other(specify):	
Job Title: ECU SRNA/ ECU CRNA Faculty	**Phone:** (252)-744-6446	**Email:** ciucaa18@ecu.edu
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Key Personnel/ Project Team members:

Name and Degree:	Department: (Affiliation if other than Vidant)	Email:
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QI/QA Assessment Checklist:

Consideration	Question	Yes	No
PURPOSE	Is the PRIMARY purpose of the project/study to: • IMPROVE care right now for the next patient? OR • IMPROVE operations outcomes, efficiency, cost, patient/staff satisfaction, etc.?	✔	
RATIONALE 1	The project/study falls under well-accepted care practices/guidelines or is there sufficient evidence for this mode or approach to support implementing this activity or to create practice change, based on: • literature • consensus statements, or consensus among clinician team	✔	
RATIONALE 2	The project/study would be carried out even if there was no possibility of publication in a journal or presentation at an academic meeting. (**Please note that answering "Yes" to this statement does not preclude publication of a quality activity.)	✔	
METHODS 1	Are the proposed methods flexible and customizable, and do they incorporate rapid evaluation, feedback and incremental changes?	✔	
METHODS 2	Are patients/subjects randomized into different intervention groups in order to enhance confidence in differences that might be obscured by nonrandom selection? (Control group, Randomization, Fixed protocol Methods)		✔
METHODS 3	Will there be delayed or ineffective feedback of data from monitoring the implementation of changes? (For example to avoid biasing the interpretation of data)		✔
METHODS 4	Is the Protocol fixed with fixed goal, methodology, population, and time period?		✔
RISK	The project/study involves no more than minimal risk procedures meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.	✔	
PARTICIPANTS	Will the project/study only involve patients/subjects who are ordinarily seen, cared for, or work in the setting where the activity will take place?	✔	
FUNDING	Is the project/study funded by any of the following? • An outside organization with an interest in the results • A manufacturer with an interest in the outcome of the project relevant to its products • A non-profit foundation that typically funds research, or by internal research accounts		✔

If all of the check marks are inside the shaded gray boxes, then the project/study is very likely QI and not human subject research. Projects that are not human subject research do not need review by the IRB.

In order to assess whether your project meets the definition of human subject research requiring IRB review or may qualify as a quality improvement/assurance activity, please provide the following information:

1. **Project Summary: In the space provided below, please provide a summary of the purpose and procedures.**

   Purpose: The purpose of this quality improvement project is to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and of a newly developed temperature monitoring/management guide. Procedures: A quick reference Perioperative Temperature Monitoring and Management Guide, based upon accepted national guidelines, will be developed. Anesthesia providers at [redacted] Medical Center will be asked several questions (through Qualtrics) about their perceptions of the adequacy of their currently used perioperative temperature monitoring and management practices and preparedness for prevention of inadvertent perioperative hypothermia. An educational presentation about the use of the newly developed evidence-based guide will be made available to them, and they will be asked to use the guide for two weeks. Upon completion of the two-week utilization period, they will be asked to complete a Qualtrics post-intervention questionnaire addressing their practices and preparedness for prevention of inadvertent perioperative hypothermia as well as the acceptability and adequacy of the guide in supporting best practice. No patient information will be recorded or maintained during this project.

2. **If the Primary purpose of your project/study is for QA/QI, have you obtained approval from the operational leader within your department or health system** [Please specify here whom and obtain their signature in the signature section below]: Dewayne Byrd, MSN, CRNA
   - ☒ **Yes**
   - ☒ **No** [Contact the appropriate operational leader for approval.]

Please note:

- By submitting your proposed project/study for QA/QI determination you are certifying that if the project/ study is established to qualify as QA/QI project, you and your Department would be comfortable with the following statement in any publications regarding this project: "This project was reviewed and determined to qualify as quality improvement by the [redacted] Health Center for Research and Grants."
- If you are submitting a Poster to Media Services for printing, you will need to also submit this Quality Improvement Worksheet or proof of your IRB Application and IRB Approval.
- If the [redacted]CRG determines the activity is not human subject research, then any presentation, publication, etc. should not refer to the activity as "human subject research," "exempt research," or "expedited research."
- If you would like the [redacted]CRG to verify that a project/study is not human subject research, please provide this form completed with the summary of your activity and any additional information to the [redacted]CRG at CRG.Quality@[redacted].com and the following will be completed and returned to you for your records.

NHSR vs. HSR Determination:

☐ **Not Human Subject Research:** [redacted]CRG has determined that based on the description of the project/study, approval by the IRB is not necessary. Any changes or modifications to this project may be discussed with the [redacted]CRG at that time to ensure those changes do not elevate the project to human research that would need IRB approval.
☐ **Human Subject Research:** This project/study requires review by the IRB prior to initiation. An application in the electronic IRB submission system should be submitted.

Approval Signatures:

[redacted] Operational Mgr/Leader: _____ Date: _____

[redacted]CRG Reviewer: _____ Date: _____

UMCIRB Office Staff Reviewer: _____ Date: _____

Attestation of Understanding

My signature below indicates that I fully understand that HIPAA Privacy standards as they apply to Quality Projects involving Protected Health Information and patient medical records as outlined below.

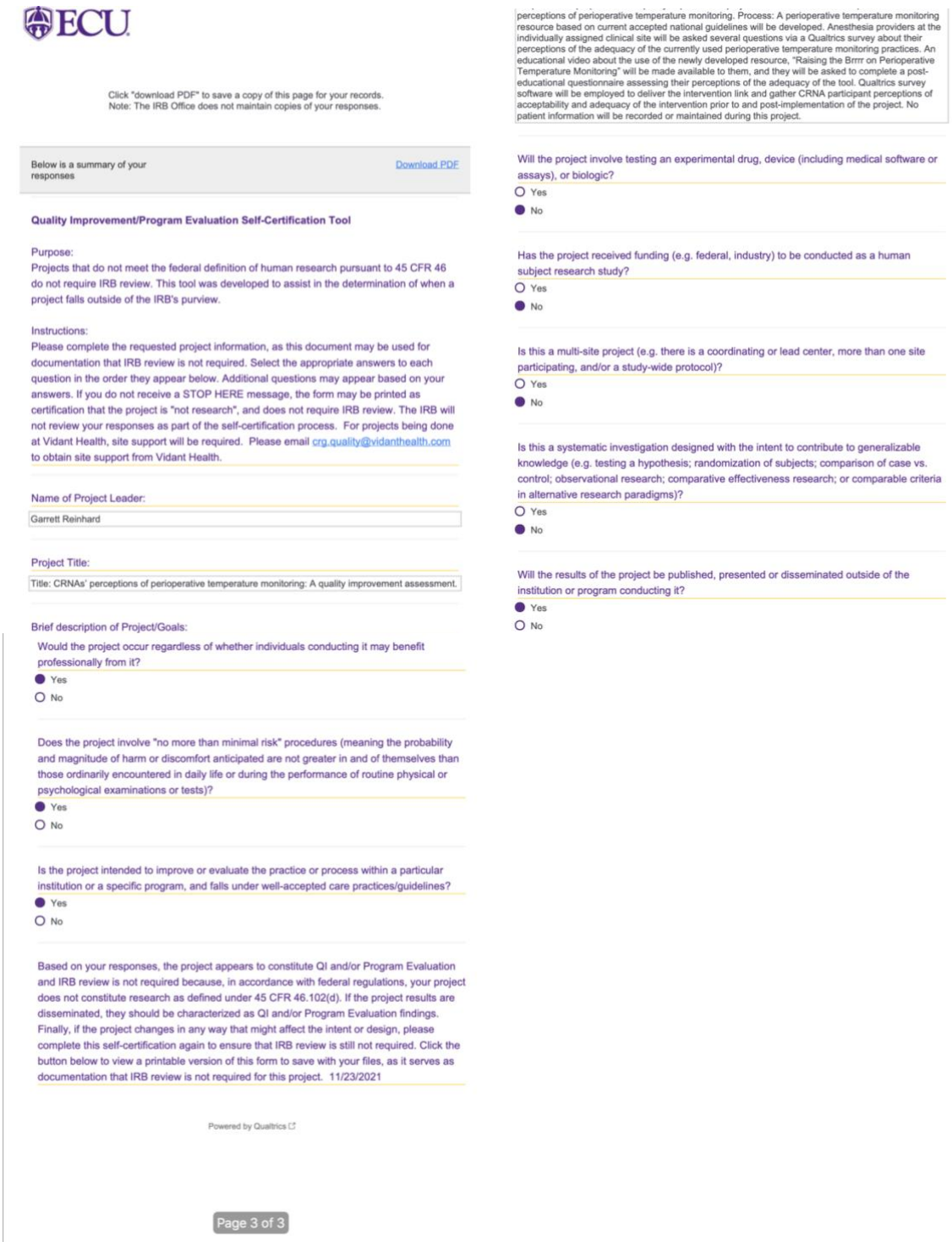
Under HIPAA's minimum necessary provisions, [redacted]Health must make reasonable efforts to limit PHI to the minimum necessary to accomplish the purpose of the use, disclosure or request.

Under HIPAA, a Covered Entity (i.e. [redacted] can disclose PHI to another CE (i.e. BSOM) for the following subset of health care operations activities of the recipient CE without needing patient consent:

- Conducting quality assessment and improvement activities
- Developing clinical guidelines
- Conducting patient safety activities as defined in applicable regulations
- Conducting population-based activities relating to improving health or reducing health care cost

[redacted]ealthcare data utilized in this project should not be shared outside of the CE without a fully executed data use/sharing agreement. [redacted]Health leadership reserves the opportunity to review all articles for dissemination/ publication for which [redacted]healthcare data has been utilized.

Project Leader Signature — Date: 02-23-2022



ECU

Click "download PDF" to save a copy of this page for your records.
Note: The IRB Office does not maintain copies of your responses.

Below is a summary of your responses — Download PDF

Quality Improvement/Program Evaluation Self-Certification Tool

Purpose:
Projects that do not meet the federal definition of human research pursuant to 45 CFR 46 do not require IRB review. This tool was developed to assist in the determination of when a project falls outside of the IRB's purview.

Instructions:
Please complete the requested project information, as this document may be used for documentation that IRB review is not required. Select the appropriate answers to each question in the order they appear below. Additional questions may appear based on your answers. If you do not receive a STOP HERE message, the form may be printed as certification that the project is "not research", and does not require IRB review. The IRB will not review your responses as part of the self-certification process. For projects being done at Vidant Health, site support will be required. Please email crg.quality@vidanthealth.com to obtain site support from Vidant Health.

Name of Project Leader:
Garrett Reinhard

Project Title:
Title: CRNAs' perceptions of perioperative temperature monitoring: A quality improvement assessment.

Brief description of Project/Goals:
perceptions of perioperative temperature monitoring. Process: A perioperative temperature monitoring resource based on current accepted national guidelines will be developed. Anesthesia providers at the individually assigned clinical site will be asked several questions via a Qualtrics survey about their perceptions of the adequacy of the currently used perioperative temperature monitoring practices. An educational video about the use of the newly developed resource, "Raising the Brrrr on Perioperative Temperature Monitoring" will be made available to them, and they will be asked to complete a post-educational questionnaire assessing their perceptions of the adequacy of the tool. Qualtrics survey software will be employed to deliver the intervention link and gather CRNA participant perceptions of acceptability and adequacy of the intervention prior to and post-implementation of the project. No patient information will be recorded or maintained during this project.

Would the project occur regardless of whether individuals conducting it may benefit professionally from it?
- (●) Yes
- ( ) No

Does the project involve "no more than minimal risk" procedures (meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)?
- (●) Yes
- ( ) No

Is the project intended to improve or evaluate the practice or process within a particular institution or a specific program, and falls under well-accepted care practices/guidelines?
- (●) Yes
- ( ) No

Based on your responses, the project appears to constitute QI and/or Program Evaluation and IRB review is not required because, in accordance with federal regulations, your project does not constitute research as defined under 45 CFR 46.102(d). If the project results are disseminated, they should be characterized as QI and/or Program Evaluation findings. Finally, if the project changes in any way that might affect the intent or design, please complete this self-certification again to ensure that IRB review is still not required. Click the button below to view a printable version of this form to save with your files, as it serves as documentation that IRB review is not required for this project. 11/23/2021

Powered by Qualtrics

Page 3 of 3

Will the project involve testing an experimental drug, device (including medical software or assays), or biologic?
- ( ) Yes
- (●) No

Has the project received funding (e.g. federal, industry) to be conducted as a human subject research study?
- ( ) Yes
- (●) No

Is this a multi-site project (e.g. there is a coordinating or lead center, more than one site participating, and/or a study-wide protocol)?
- ( ) Yes
- (●) No

Is this a systematic investigation designed with the intent to contribute to generalizable knowledge (e.g. testing a hypothesis; randomization of subjects; comparison of case vs. control; observational research; comparative effectiveness research; or comparable criteria in alternative research paradigms)?
- ( ) Yes
- (●) No

Will the results of the project be published, presented or disseminated outside of the institution or program conducting it?
- (●) Yes
- ( ) No

Appendix E

Initial Pre-Survey and Video Email to Participants

Dear [redacted] Health CRNAs,

Thank you for considering participating in a quality improvement project titled "Perioperative Temperature Monitoring." The purpose of this project is to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and the effectiveness of a newly developed perioperative temperature monitoring educational tool at [redacted] Medical Center, [redacted] SurgiCenter, and [redacted] Hospital.

Participation is voluntary and will involve completing a short pre-intervention questionnaire, viewing a brief PowerPoint with voiceover, utilizing an educational perioperative temperature monitoring tool in your CRNA practice for two weeks at your discretion, and completing a short post-intervention questionnaire when the two-week implementation period is over.

Each questionnaire should take less than 2-4 minutes to complete. The questionnaires were created and are completed using Qualtrics® survey software. The use of perioperative temperature monitoring tool falls within currently accepted practice in your work area. Your participation is voluntary and confidential. We will share the results of this QI study with you upon completion.

First, complete the pre-intervention questionnaire here.
Followed by viewing the "Raising the BRRR on Temperature Management" perioperative temperature monitoring educational tool PowerPoint as well as having access to a copy of the resource tool on an attached one-page PDF.

Again, thank you for your participation in our quality improvement project. If you have any questions you may reach out to me or Angela Ciuca (Project Chair) by email.

Sincerely,

Garrett Reinhard, SRNA at
reinhardg12@students.ecu.edu
Angela Ciuca, DNAP, CRNA - Project Chair at
ciucaa18@ecu.edu

Pre-Survey and Video Reminder Email to Participants

Hello [redacted] Health, CRNAs,

I just wanted to send a quick reminder about the ongoing DNP Project on Perioperative Temperature Monitoring. If you've already filled out the pre-survey and viewed the educational tool, thank you! If you haven't had a chance to yet, it's not too late and would be very helpful and much appreciated. There are still "Raising the BRRR on Temperature Management" perioperative temperature monitoring educational tool handouts via Email if you haven't already received one - you may use these at your discretion. After the end of next week, I will begin sending out the post-surveys.

Links:
Pre-survey
Please let me know if you have any questions and thank you again for your participation.

Sincerely,

Garrett Reinhard, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Post-Survey Email to Participants

Dear [redacted] CRNAs,

Thank you to everyone who has already completed my pre-survey and viewed the video! It's now time to complete the brief post-survey (link below).
If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and a video!) . The link to the survey is here. "Raising the BRRR on Temperature Management" perioperative temperature monitoring educational tool handouts are available for your use if you would like them, but their use is not mandatory for participation in this project.

If you've already completed the first survey, here is the link to the post-survey. It should take less than 2 minutes.

If anyone has questions or issues with the links, please let me know. Again, thank you to everyone for your help and for being excellent preceptors. I look forward to continuing my training with you at [redacted] Health.

Sincerely,
Garrett Reinhard, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Final Thank You Email to Participants

Dear [redacted] CRNAs,

I just wanted to say thank you so much to everyone for helping me out with my DNP Project! I have collected all the data that I need to proceed with data analysis and will then be finishing my paper. Once it's complete you all will be able to read it if you'd like.

Thank you again! I hope to work with you more in the future.

Take care,
Garrett Reinhard, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Appendix F

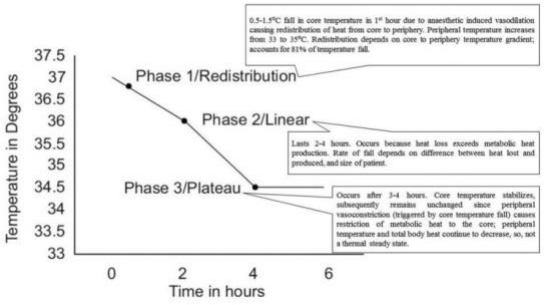
Educational

Causes of Hypothermia Under Anesthesia[1,6]

1) Exposure to a cold environment
2) Behavioral regulation is impaired or nonexistent
2) Anesthetic-induced impaired thermoregulation
   - Vasodilation promoting heat loss
   - Vasoconstriction, shivering, and non-shivering thermogenesis are less effective and have a reduced threshold for activation
   - Autonomic defense mechanisms
   - 20-30% reduction in metabolic rate
   - Inter-threshold range increases up to ten-fold poikilothermia

Mechanisms of Heat Loss Under Anesthesia

Conduction, convection, radiation, evaporation, and redistribution



Current Standard of Care

The current minimally accepted temperature is 36 °C.[2]

AANA Standard IX: Monitoring[2]

"When clinically significant changes in body temperature are intended, anticipated, or suspected, monitor body temperature. Use active measures to facilitate normothermia."

ASA Standards for Basic Anesthetic Monitoring[3]

"During all anesthetics, the patient's oxygenation, ventilation, circulation, and temperature shall be continually evaluated. To aid in the maintenance of appropriate body temperature during all anesthetics, every patient receiving anesthesia shall have temperature monitoring when clinically significant changes in body temperature are intended, anticipated, or suspected."

Potential Negative Outcomes[4]

- Alterations in pharmacokinetics of anesthetic drugs
- Enzymatic reduction
- Increased blood loss and transfusion requirements
- Surgical site infection and complications
- Delayed post-operative discharge

Raising the BRRR On Temperature Management

High risk Populations & Procedures[5]

Advanced Age >65	Recent burn
ASA Grade 2-5	Large fluid shifts
Pre-op temp <36 °C	Combined GA and RA
Pediatrics/Neonates	Prolonged duration of GA
Female > Male	Open abdomen
Low BMI	Orthopedics
Autonomic dysfunction	Trauma/Blood loss

References

1. Bindu, B., Bindra, A., & Rath, G. (2017). Temperature management under general anesthesia: Compulsion or option. *Journal of Anaesthesiology Clinical Pharmacology, 33*(3), 306-316. https://doi.org/10.4103/joacp.joacp_334_16
2. American Association of Nurse Anesthesiology. (2019). *Standards for nurse anesthesia practice*. Retrieved September 9, 2021 from https://www.aana.com/docs/default-source/practice-aana-com-web-documents-(all)/professional-practice-manual/standards-for-nurse-anesthesia-practice.pdf?sfvrsn=e0004961_20
3. American Society of Anesthesiologists. (2020). Standards for basic anesthetic monitoring. *Guidelines*, Statements, *Clinical Resources*. Retrieved September 9, 2021 from https://www.asahq.org/standards-and-guidelines/standards-for-basic-anesthetic-monitoring
4. Rauch, S., Miller, C., Bräuer, A., Wallner, B., Bock, M., & Paal, P. (2021). Perioperative hypothermia-A narrative review. *International Journal of Environmental Research and Public Health, 18*(16), 8749.
5. Riley, C. & Andrzejowski, J. (2018). Inadvertent perioperative hypothermia. *BJA Education, 18*(8), 227-233.
6. Warming devices and temperature monitoring. Rose G, & McLarney J(Eds.), (2014). *Anesthesia Equipment Simplified*. Retreived January 12, 2022 from https://accessanesthesiology.mhmedical.com/content.aspx?bookid=871&sectionid=51860184
7. Adimi, N., & Monahan, C. (2014). Monitoring temperature. In Freeman, B., & Berger, J. (Eds.), *Anesthesiology Core Review: Part One Basic Exam*. Retrieved January 10, 2022 from
8. Alex, G., & Chandran, N. (2021). Monitoring, breathing systems, and machines. In Ellinas H, & Matthes, K., & Alrayashi, W., & Bilge, A. (Eds.), *Clinical Pediatric Anesthesiology*. Retrieved January 10, 2022

Prevention of hypothermia[6,7]

- #1 Pre-operative warming (most effective)
- Passive warming – covering the patient with blankets and a headcover to minimize heat loss
- Active Warming – forced air cover (Bair Hugger), circulating water mattress/pads (Arctic Sun), heated fluids, maintaining ambient room temperature of 23 °C

Accepted core body sites[7,8]	Other monitoring sites[7,8]
Esophageal	Axillary
Bladder	Skin
Rectal	Nasopharyngeal
Right Atrium	Temporal
	Tympanic

Tools available for temperature monitoring[7,8]

Transesophageal probe
Foley catheter
Rectal temperature probe
Pulmonary artery catheter
Oral probe thermometer
Temporal scanner
Nasopharyngeal probe
Tympanic thermometer

ECU Nurse Anesthesia Program

Appendix G

Pre- and Post-Intervention Survey

Pre-Survey Questions

1) Have you ever received education on temperature monitoring policies or standards for your surgical setting?

a) Yes / No / Unsure

2) Are you aware of the AANA national standard for temperature monitoring?

a) Yes / No

3) If you had a question about perioperative temperature monitoring, approximately how long would it take you to access a reference of evidence-based guidelines to address your question?

a) <1 minute / 1-3 minutes / 4-6 minutes / 7-9 minutes / 10 or more minutes

4) How confident are you in your knowledge about perioperative temperature monitoring?

a) Not at all confident 1 2 3 4 5 Very confident

5) How confident are you in your ability to identify a patient or procedure at higher risk of intraoperative heat loss?

a) Not at all confident 1 2 3 4 5 Very confident

6) How confident are you in your ability to identify core temperature sites?

a) Not at all confident 1 2 3 4 5 Very confident

7) How confident are you that the temperature monitoring devices currently available to you accurately detect the patient's core body temperature?

a) Not at all confident 1 2 3 4 5 Very confident

8) During a normal work week (approximately 40-hour week) how often do you utilize temperature monitoring intraoperatively?

a) 0-25% of cases / 25-50% of cases / 50-75% of cases / 75-100% of cases

9) What is your preferred modality/site for temperature monitoring in the intraoperative setting?

(select all that apply)

a) Axillary

b) Skin

c) Esophageal

d) Foley catheter

e) Rectal

f) Nasopharyngeal

g) Temporal

h) Tympanic

i) Other _____

Post-Survey Questions

1) After this education, can you readily access the AANA national standard on temperature monitoring?

a. Yes / No

2) How likely are you to reference this material in your future practice?

a. Very unlikely / unlikely / neutral / likely / very likely

3) If you saved this educational tool to your smartphone/device, how long do you think it would take you to access this reference to address your questions about perioperative temperature monitoring?

a. < 1 minute / 1-3 minutes / 4-6 minutes / 7-9 minutes / 10 or more minutes

4) After reviewing this resource, how confident are you in your knowledge about perioperative temperature monitoring?

a. Not at all confident 1 2 3 4 5 Very confident

5) After reviewing this resource, how confident are you in your ability to identify a patient or procedure at higher risk of intraoperative heat loss?

a. Not at all confident 1 2 3 4 5 Very confident

6) After reviewing this resource, how confident are you in your ability to identify core temperature sites?

a. Not at all confident 1 2 3 4 5 Very confident

7) After reviewing this resource, how often will you utilize temperature monitoring intraoperatively?

a. 0-25% of cases / 25-50% of cases / 50-75% of cases / 75-100% of cases

8) In your practice, how often do you find that your last operating room temperature correlates well with the first PACU temperature?

a. 0% of the time / 25% of the time / 50% of the time / 75% of the time / 100% of the time

9) If you find the correlation between the operating room temperature and PACU temperature lacking, what recommendations do you have for how to improve this issue?

_____

10) After reviewing this material, which modality/site for temperature monitoring in the intraoperative setting are you most likely to use in practice? (select all that apply)

a. Axillary

b. Skin

c. Esophageal

d. Foley catheter

e. Rectal

f. Nasopharyngeal

g. Temporal

h. Tympanic

i. Other _____

11) In your opinion, what do you perceive as being barriers to preventing intraoperative hypothermia?

_____

12) Is there anything you feel could be added to strengthen this educational tool?

_____