# Nurse Anesthetists' Perceptions of Perioperative Temperature Monitoring and Management and the Impact of an Educational Intervention: A Quality Improvement Project

Miranda Daniels, BSN, SRNA

Maura McAuliffe, PhD, CRNA, FAAN, Project Chair

Nurse Anesthesia Program

College of Nursing, East Carolina University

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**Abstract**

Inadvertent hypothermia is a preventable, yet prevalent, adverse event among surgical patients during the perioperative period that is associated with negative patient outcomes and increased healthcare costs. This quality improvement project aimed to produce a better understanding of this problem in order to inform future quality interventions designed to reduce the incidence of inadvertent perioperative hypothermia. Perceptions of nurse anesthetists regarding perioperative temperature monitoring and management before and after receipt of an educational resource and presentation were assessed using Qualtrics pre- and post-surveys. Findings suggest that following the intervention there was an increase in awareness of the national standard on temperature monitoring for nurse anesthetists, an improvement in efficiency in accessing evidence-based guidelines and recommendations regarding temperature monitoring and management to support and help guide the CRNAs' clinical practice, an increase in the reported confidence level in the CRNAs' perceived knowledge about perioperative temperature monitoring and management, and an increased reported intention to utilize intraoperative temperature monitoring. Findings suggest that providing an educational presentation and an accompanying evidence-based resource on the physiology of and recommended practices for preventing inadvertent perioperative hypothermia could be a cost-effective means to facilitate a decrease in its incidence. Findings also suggest potential target areas for future interventions aimed at better understanding the phenomenon of inadvertent perioperative hypothermia and ways it may be prevented.

*Keywords:* nurse anesthetist, perioperative, temperature monitoring, temperature management, hypothermia

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## Section I. Introduction

### Background

Body temperature is a tightly regulated vital sign routinely monitored in the healthcare setting for its importance in maintaining normal physiological functioning. The mean core temperature in healthy individuals is 36.5 °C-37.3 °C (Bindu et al., 2017). The perioperative period is a vulnerable time for temperature fluctuations, which have the potential to cause a wide range of negative outcomes for both the patient and the healthcare organization. In some cases, such as complex cardiac surgery, hypothermia is desired and purposely induced as a means of physiological organ protection. However, in most instances hypothermia is unintentional, and it is reported that up to 70% of surgical patients experience inadvertent perioperative hypothermia (IPH; Sari et al., 2020). IPH is defined as an unintentional state of hypothermia experienced at any point during the perioperative period, which includes the preoperative, intraoperative, and/or postoperative phases. The most common thermal abnormality in the perioperative period and one of the main determinants of IPH is inadvertent intraoperative hypothermia (IIH), which is defined as hypothermia, a core temperature less than 36 °C, experienced in the intraoperative period (Bindu et al., 2017; Sari et al., 2020). Since nurse anesthetists are the primary healthcare providers during this time, this supports utilizing them as a target population when developing quality improvement interventions that explore the problem of IPH.

The mechanisms of heat loss during the perioperative period are the operating room environment, cold intravenous fluids, and anesthesia (Giuliano & Hendricks, 2017; Sari et al., 2020). Under the influence of general anesthesia, behavioral regulation of body temperature is abolished, and the patient relies on their healthcare providers and autonomic reflexes for thermal management (Bindu et al., 2017). However, these autonomic defenses are drastically impaired as

anesthetic medications increase the threshold for these responses to be initiated and the use of muscle relaxants eliminates the body's ability to increase temperature through shivering. The greatest drop in temperature is experienced during the first hour following induction of anesthesia; therefore, frequent temperature monitoring is imperative even in short cases so the anesthesia provider can detect and promptly address hypothermia. Reliable core temperature measurement sites for assessing this phenomenon include the pulmonary artery, distal esophagus, nasopharynx, and tympanic membrane (Bindu et al., 2017).

When the human body is not normothermic, most mechanisms that require physiological homeostasis are impaired and potentially harmful systemic responses are induced, significantly contributing to perioperative morbidity and mortality. Hypothermia prolongs the effect of anesthetic drugs, which can prolong the time spent on mechanical ventilation and lengthen the time to postoperative recovery (Ruetzler & Kurz, 2018). Hypothermia impairs coagulation and platelet function, causing hypothermic patients to experience more blood loss and require more blood product transfusions than normothermic patients. Studies have also demonstrated that hypothermia significantly increases the risk of infection, morbidity related to cardiac events, prolonged hospital stays, and patient discomfort and dissatisfaction (Boet et al., 2017; Lupo et al., 2019). These risks are highest among patients with prolonged surgery, extremes of age and body habitus, comorbidities, extensive burns, lower preoperative temperature, severe trauma, and major intraoperative fluid shifts (Bindu et al., 2017; Sari et al., 2020). Unintentional hypothermia in the perioperative period also has consequences for the healthcare organization in which it occurs, as it has been noted as coming at a monetary cost of $2,412 to $6,839 per patient (Boet et al., 2017).

Given the risk for hypothermia and its subsequent costs to both the patient and the organization, multiple organizations have published standards and guidelines regarding perioperative temperature monitoring and management. According to American Association of Nurse Anesthesiology (AANA, 2019) and American Society of Anesthesiologists (ASA, 2020) practice standards, nurse anesthetists and anesthesiologists are required to actively monitor the body temperature of every patient receiving anesthesia when changes in body temperature are anticipated. AANA also calls for using active measures to facilitate normothermia. The clinical practice guidelines proposed by the National Institute for Health and Care Excellence (NICE) state that each patient should be preoperatively assessed for their risk of developing inadvertent perioperative hypothermia (IPH), anesthesia should only be induced if the patient's core temperature is at least 36 °C, the patient's temperature should be measured before induction of anesthesia and then every 30 minutes until the end of surgery, and forced air warming devices should be used intraoperatively to prevent and treat hypothermia (NICE, 2016). These guidelines were set for every patient over the age of eighteen years old having surgery. Despite these guidelines and decades' worth of research findings, there is a continued prevalence of unintended perioperative and intraoperative hypothermia, revealing a need to further explore its contributing factors and how it might be prevented, especially in relation to care delivered by anesthesia providers (Giuliano & Hendricks, 2017; Sari et al., 2020).

**Organizational Needs Statement**

Within the partnering medical center, Certified Registered Nurse Anesthetists (CRNAs) and anesthesiologists are the professionals responsible for administering anesthesia and providing patient care during surgery and medical procedures, including temperature monitoring and management. Because IPH is an inevitable risk for every patient undergoing a surgical

procedure, this is a relevant issue for any facility that performs surgeries and procedures using anesthesia, including this hospital (Giuliano & Hendricks, 2017).

Nurse anesthetists and anesthesiologists at this facility are required to uphold the standards set for them by their professional associations, the AANA and the ASA, respectively. These standards, however, are nonspecific in addressing only that temperature monitoring is required when the anesthesia provider anticipates changes in body temperature. This allows for anesthesia providers to utilize a variety of different temperature monitoring and management techniques. Understanding the factors that contribute to their decision making could inform interventions aimed at improving practice.

Healthy People 2030 aims to improve hospital care by creating safe practice environments (Office of Disease Prevention and Health Promotion, 2020). This objective closely aligns with nurse anesthetists' goals of improving patient safety with more accurate temperature monitoring and effective temperature management strategies. The goals of the Institute of Healthcare Improvement (IHI) Triple Aim are to improve the population health, enhance patient outcomes and experience, and reduce per capita cost of care for the benefit of the communities (Berwick et al., 2008). Assuring more accurate maintenance of normothermia among surgical patients addresses each of these goals.

In addition to patient safety and professional responsibility, decreases in financial reimbursement for delivered services is another potential motivator for anesthesia providers to maintain normothermia in their patients. Avoiding hypothermia has been recognized by the Merit-Based Incentive Payment System (MIPS) as a relevant measure in assessing patient safety and preventing healthcare harm (Centers for Medicare & Medicaid Services [CMS], 2020). The specific measure used to determine Medicare payment adjustments in regard to maintenance of

optimal body temperature is "the percentage of patients undergoing surgical or therapeutic procedures under general or neuraxial anesthesia of 60 minutes or longer with at least one body temperature greater than or equal to 35.5ºC within the 30 minutes immediately before or the 15 minutes immediately after anesthesia end time (CMS, 2020, Description section)." This goal of preventing patient harm and promoting patient safety coincides with the goals of the AANA and ASA that the anesthesia providers of the partnering organization look to for guiding their practice.

**Problem Statement**

Despite the availability of rigorously developed, evidence-based guidelines and recommendations to guide anesthesia providers in preventing perioperative hypothermia, a high incidence of this adverse event still persists. Without understanding and addressing the reasons behind its continued prevalence, healthcare organizations will continue to experience unnecessary costs and a potential lack of reimbursement for services provided and many surgical patients will continue to experience preventable discomfort and adverse health events.

**Purpose Statement**

The purpose of this quality improvement project is to assess anesthesia providers' perceptions regarding current practice for perioperative temperature monitoring and the usefulness of a newly developed intraoperative temperature monitoring and management educational resource.

## Section II. Evidence

### *Description of Search Strategies*

A literature search for current evidence addressing the prevention of IIH was performed to guide the development and implementation of an intervention at the partnering facility. A PICOT question was written to guide the search strategy: "How do CRNAs perceive an educational intervention designed to review evidence-based practice guidelines and recommendations for intraoperative temperature monitoring in the operating room." A search of current literature was conducted using the databases PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL) as well as the search engine Google Scholar. The key concepts used to develop search strategies included *temperature monitoring, anesthesia,* and *education.* The primary keywords used to guide the searches of all three databases included, but were not limited to, *intraoperative, perioperative, anesthesia, nurse anesthetist, temperature monitoring, temperature management, hypothermia, education, and prevention.* See Appendix A for a list of keywords, MeSH terms, and subject terms utilized in searches. Boolean operators were used to combine keywords and concepts.

The first search strategy used to query PubMed was (((intraoperative) OR (surgery) OR (perioperative)) AND ((temperature monitoring) OR (temperature management) OR (hypothermia)) AND ((anesthesia) OR (nurse anesthetist) OR (anesthesiologist)) AND (education)). The second search strategy used to query PubMed was ((intraoperative hypothermia) OR (perioperative hypothermia)) AND (prevention). These search strategies pulled in the MeSH terms anesthesia, nurse anesthetists, anesthesiologists, temperature, physiologic monitoring, organization and administration, disease management, hypothermia, education, educational status, and teaching. CINAHL was searched using a combination of keywords and

subject headings identified using the keywords. The search strategy used with Google Scholar was (nurse anesthetist OR anesthesiologist) AND (education) AND (hypothermia prevention).

Limits applied to these searches included publication within the last five years (2016-2021), English language, full text, and peer-review. This initial search of all three sources yielded a total of 710 articles that were reviewed by title and abstract. Inclusion criteria for full text review included articles related to factors influencing hypothermia relevant to anesthesia providers and studies with the purpose of assessing and/or improving temperature management practices in the perioperative setting. Articles exploring the phenomenon of IIH or IPH that were not studies or a review of studies that could be used to help guide an intervention were excluded. Research studies comparing specific thermometers or warming devices are applicable to guiding future practice but were excluded for not focusing on the specific goal of this project. Articles unrelated to temperature management in the surgical setting as well as articles related to veterinary medicine were also excluded. After review and deduplication at the title and abstract level, 56 articles were chosen for full text review. See Appendix B for the search strategies and numbers of articles found and kept.

After full text review, eight articles were identified as pertinent to this project. One additional article was discovered through review of the references of initially selected articles, bringing the total to nine. The evidence and information they contained was synthesized and used to design this quality improvement project. Based on the Melnyk and Fineout-Overholt (2019) levels of evidence, these selected items included one randomized controlled trial (Level II) and eight qualitative studies (Level VI). See Appendix C for a literature matrix containing information from the selected sources.

**Selected Literature Synthesis**

The prevailing theme and underlying assumption of the evidence reviewed is that IPH is a serious yet preventable problem that still widely occurs in surgical patients all over the world (Boet et al., 2017; Boet et al., 2018; Munday et al., 2019; Senkal & Kara, 2021. For this reason, multiple studies and projects have been conducted to better understand what factors contribute to the incidence of this preventable complication and investigate methods to prevent it – from research studies that identify the most effective monitoring and warming devices to quality improvement projects to increase evidence-based practice among the perioperative team. Because the aim of this project was to implement and assess the perception of current practices and of a quality improvement strategy, qualitative studies with similar goals were reviewed in order to support and inform the design of this project.

There have been several studies conducted on how CRNAs can prevent perioperative hypothermia, which have led to the creation of guidelines to maintain normal body temperature during the perioperative period. In order to assess if CRNAs have access to and knowledge of such guidelines, and to determine if they adhere to them, Gustafsson et al. (2020) conducted a study in which they utilized the results of 1,169 questionnaires completed by CRNAs inquiring about temperature management for a specific surgical patient as well as the CRNA's knowledge about guideline recommendations. They found that the level of access to evidence-based recommendations was high, but that knowledge about these guidelines and the adherence to them was low. Based on these findings, they highlighted the need for CRNA education on the physiology of heat loss as well as continued education on the current recommendations, including utilizing a designated advocate for the implementation of current guidelines and any subsequent revisions.

Both Boet et al. (2017) and Munday et al. (2019) performed qualitative studies in order to better inform the development of targeted evidence-based interventions to optimize perioperative temperature management and prevent IPH, such as education, as recommended by Gustafsson et al. (2020). These studies used semi-structured interviews based on the theoretical domains framework that revealed the behavioral factors, barriers, and facilitators that contribute to temperature management practices among anesthesia providers and other perioperative team members. Boet et al. conducted semi-structured interviews with 89 anesthesiologists while Munday et al. interviewed a total of 10 anesthesia providers. The need for further education on the etiology and physiology of the condition as well as the recommended preventive practices was widely cited across the perioperative team. Similar to the findings of Gustafsson et al., the majority of the anesthesia providers in these studies reported awareness of evidence-based temperature guidelines for their practice but were unable to identify them or demonstrate knowledge of these best practice recommendations. Participants who were able to confidently express knowledge of the condition and strategies to prevent it attributed this knowledge to attendance at conference workshops and/or continued education methods.

The other key factor to ensuring optimal temperature monitoring and management practices emphasized by both studies was feedback (Boet et al., 2017; Munday et al., 2019). The majority of the anesthesia providers reported that in their practice they typically felt uncertain of the effectiveness of their temperature management practices and unsure of how it affected their patients. They placed heavy emphasis on the role that being notified of the patient's temperature on arrival to the PACU has on their temperature management practices. They identified feedback from colleagues and patients about how the patients felt when they woke up as their greatest

incentive for their temperature management practices. These studies both recommended considering a formal audit and feedback system as a means to improve temperature management.

Several quality improvement initiatives have investigated the effectiveness of these potential strategies aimed at increasing anesthesia providers' knowledge of and adherence to evidence-based practice and minimizing the event of IPH. McCormick et al. (2019) gave educational presentations to anesthesia providers on anesthesia quality practice and outcome measures for quality improvement, delivered regular staff training, and provided monthly personal and electronic feedback on individual compliance with these measures. This program implementation resulted in significant improvements in anesthesia quality measure compliance for several process measures, with the biggest improvement being the intraoperative measurement of core temperature during surgery. Upon review of over 40,000 anesthesia care records, the authors determined compliance with temperature monitoring improved from 69.5% to 85.7%, providing evidence that supports the use of education and formal feedback as mentioned in the previous studies.

Also, using in-person education as a foundational implementation strategy over the course of one month in a Turkish military hospital, Senkal and Kara (2021) provided PowerPoint presentations on their country's anesthesiology society guidelines for prevention of IPH to all members of the perioperative team, on-site training regarding the proper use of different thermometers and warming devices, and a clinical checklist manual based on these guidelines. The utilization of checklists and the implementation of guidelines were also described by the perioperative team in Munday et al.'s (2019) study as strategies that would facilitate the implementation of hypothermia prevention practices. As a result of Senkal and Kara's (2021)

implementation strategy, a review of over 650 patient records revealed the incidence of IPH at this hospital declined from 35% to 23.8%.

Similar to Senkal and Kara (2021), Duff et al. (2018) also implemented a tool to be used as a clinical practice guide, including a checklist that was based on clinical practice guidelines for perioperative thermoregulation in four Australian hospitals. Utilizing a different approach to protocol implementation, each hospital nominated a four-member team, and all members underwent extensive training to prepare them to implement the Thermal Care Bundle at their site. Site-specific barriers and implementation strategies were created but were not elaborated upon. Through analysis of over 700 patient records, the investigators in this study identified an increase in hypothermia risk assessments, temperature monitoring, and active warming. Contrary to their expectations, the incidence of IPH increased, which the authors believed to be a result of an increase in detection related to higher rates of temperature monitoring rather than a true increase in incidence.

Similar to these investigations, Munday et al.'s (2013) work demonstrated that the combination of education and formal feedback is associated with decreasing the incidence of IPH through analysis of almost 150 perioperative patient charts pre- and post-implementation of a program to improve perioperative temperature monitoring. While this study was focused on perioperative nurses rather than anesthesia providers, its implementation strategies resulted in improved practice and might be applicable to use in a project targeting CRNAs. Strategies included assessing for site-specific barriers, audits performed based on clinical practice guidelines, an experienced PACU nurse designated to promote project awareness and direct change, and in-service education with staff to share audit results and provide feedback to direct change. This work emphasized the significant role that the intraoperative period and anesthesia

providers have in preventing perioperative hypothermia. Because their audits revealed low compliance with intraoperative monitoring, the authors strongly recommended implementing interventions targeted at preventing intraoperative IPH.

To further examine the impact that audits and feedback have on anesthesiologists' intraoperative temperature management and patient outcomes, and to determine the most effective type of formal feedback, Boet et al. (2018) conducted a randomized controlled trial assessing the intraoperative temperature management of almost 50 anesthesiologists before and after they received no feedback (control), benchmarked feedback, or ranked feedback. No evidence was found to suggest that using audits and benchmarked or ranked feedback is more effective than no feedback at all in the effort to impact anesthesiologists' intraoperative temperature management performance. Unlike these other implementation studies, this intervention did not utilize education or a guideline-based temperature management tool for the clinicians. It was noted by the authors that feedback may need to be coupled with a care bundle to produce the desired effect.

An additional factor that anesthesia providers recognize as a facilitator to effective temperature monitoring and management is a gentle reminder when an important step in this process is forgotten (Boet et al., 2017). This concept was further explored in an observational study that incorporated a decision-support alert system into the anesthesia providers' electronic documentation program (Lakha et al., 2020). A total of 24,755 cases from 2017 were assessed and compared to 25,274 cases in 2016. If a patient undergoing general or neuraxial anesthesia had no temperature recorded within the first 60 minutes after the procedure started, an alert would display on the workstation to notify the anesthesia provider of this missing documentation. If the patient did not have a documented temperature greater than or equal to

35.5ºC within the 15 minutes before the procedure ended, another alert would display to notify them of the issue and to prompt them to initiate actions to achieve normothermia. Implementation of this tool was associated with an improvement in the maintenance of normothermia and an increase in intraoperative compliance with the perioperative temperature management MIPS measure from 26.8% to 71.0%.

Overall, these nine papers supported this quality improvement project as a clinically relevant and important endeavor. The findings and conclusions of these studies were used to guide the elements of a newly developed intervention with nurse anesthetists as the target population.

**Project Framework**

The Institute for Healthcare Improvement's (2021) model for improvement is the framework followed in creation of this quality improvement project. Included in this framework is the plan-do-study-act (PDSA) cycle, a four-stage problem-solving tool that was used to guide the systematic process of this project. First, a *plan* was developed to set the goals and direction of the project. This included deciding what was going to be done, when it was going to be done, and with what target population. After providing the educational intervention to the target population and disseminating a pre- and post-intervention survey (*do*), the results of these surveys were reviewed and analyzed (*study*). Finally, conclusions from these results were drawn and recommendations for the next cycle were made (*act*). The goal of this project was to enhance the understanding of CRNAs' perception of perioperative temperature monitoring and of an educational tool on this topic, which could inform a subsequent project's intervention to address this clinical issue. The steps of the PDSA model appropriately supported the design of this project as the goal involved a cycle of providing a small change (e.g., providing education),

surveying CRNAs to test the outcomes of the change, acquiring insight to their perceptions on the issue, and summarizing what was learned so that it could be applied in the next cycle in another quality improvement project.

**Ethical Considerations and Protection of Human Subjects**

The potential benefits of this intervention apply equitably to all CRNAs and patients in the target population. No risks have been identified. There is no potential harm to the target population beyond that of their normal work activities or any potential that they would be taken advantage of during this project implementation. Participation of the CRNAs was voluntary and consent was through their active participation, with no formal documentation of consent completed. To prepare for the formal approval processes, the primary investigator of this project completed the Collaborative Institutional Training Initiative (CITI) training program on research ethics and compliance (https://about.citiprogram.org/courses/?reset=true).

Upon completion of an internal review process for student projects with the investigator's College of Nursing and University and Medical Center Institutional Review Board (UMCIRB), this project was deemed quality improvement and thus exempt from full review. This project also received complete facility approval through the research office of the partnering facility in conjunction with the UMCIRB. Approval from the partnering facility to collect data was granted and documented. See Appendix D for documentation of this formal approval process.

## Section III. Project Design

### Project Setting

The partnering facility for this project was a small, critical access hospital in northeastern North Carolina. It is a community hospital, part of a larger health system that includes nine hospitals. It has fewer than 50 inpatient beds with surgical services supported by three shared inpatient/ambulatory surgery operating rooms and one endoscopy room. A wide range of inpatient and outpatient surgical procedures are performed at this facility, including endoscopic, gastrointestinal, general surgical, gynecologic, ophthalmologic, orthopedic, podiatric, and urologic. An anesthesia care team comprised of CRNAs and an anesthesiologist provides anesthetic services and patient care during procedures requiring anesthesia. An existing relationship between this facility and the university facilitated the implementation of this project.

### Project Population

The population of focus for this quality improvement project included the CRNAs practicing in the partnering community hospital. All anesthesia providers practicing in the facility are proficient in the management of anesthesia, patient monitoring, and ventilatory and hemodynamic management of patients undergoing a variety of medical and surgical procedures requiring anesthesia. The anesthesia providers vary in experience and age, and work autonomously. Within this group of providers, experienced leaders familiar with the facility's perioperative practices and workflow helped facilitate the onboarding of this quality improvement project.

CRNAs work in a fast paced, high acuity, and stressful environment. Their work is physically and mentally demanding; therefore, reluctance to spend extra time participating in this project was a potential barrier to successful implementation. On the other hand, because these

CRNAs work in a teaching hospital and are accustomed to working relationships with students, it was reasonable to anticipate that some might be inclined to help support the success of a student-led quality improvement project.

**Project Team**

The quality improvement project team consisted of a nurse anesthesia student team lead, three additional nurse anesthesia students, a project chair, a site contact, a CRNA faculty clinical contact, the course director, and the nurse anesthesia program director. Together, the author and three other student registered nurse anesthetists (SRNAs) developed the project, and each student implemented it in a different setting and population. The project chair was a doctorally prepared, practicing CRNA and faculty member of the program who met regularly with the students to support and guide the development of the project.

The primary SRNA and author led the implementation of this project at the community hospital previously described. A team member of the partnering facility provided a letter of acknowledgement of data collection being performed at that site. The clinical contact member was a doctorally prepared CRNA who led student clinical learning experiences and provided mentoring and clinical expertise during this project. The DNP project course director was a non-CRNA, doctorally prepared faculty member who provided direction and feedback on each step of this project's development and completion. The program director facilitated coordination between the team and the partnering facility and provided leadership and oversight to all project team members for all aspects of the project.

**Methods and Measurement**

The purpose of this project was to better understand CRNAs' perceptions of perioperative temperature monitoring knowledge and practices by providing continuing education on

perioperative temperature monitoring and management best practices (Appendix E) and to assess participants' perceptions of the usefulness a newly created temperature monitoring and management resource (Appendix E). These perceptions were assessed using a pre-test/post-test methodology. Changes in perceptions served as the outcome measures for this project, with the results considered valuable for informing future studies and initiatives aimed at promoting optimum perioperative temperature management. The educational intervention (Appendix F) as well as the links to the pre- and post-intervention Qualtrics surveys (Appendix H) were delivered to participating CRNAs via email. See Appendix G to review all emails sent to participants. This project completed a single PDSA cycle.

*Plan*

After identifying IPH as a relevant problem deserving further exploration, a literature search and a subsequent review were performed. Nurse anesthetists and their temperature monitoring practices were identified as exerting a significant role in the incidence of IIH, and therefore IPH. Being involved in all phases and settings of perioperative care, the perceptions of CRNAs are valuable in providing insight into current perioperative practices in regard to patient temperature monitoring and management. In order to inform future interventions aimed at preventing IPH, the project team determined their goal was to produce a better understanding of CRNAs' perceptions of temperature monitoring and the usefulness of an educational intervention on temperature monitoring. It was determined that these perceptions would be gathered by having the participating CRNAs complete a survey before and after receiving continuing education provided by the project team.

The SRNAs and project chair developed these surveys in the planning phase. The pre-intervention questions inquired about the CRNAs' current temperature monitoring practices,

their perception of the accuracy of their available temperature monitoring devices, and their perception of their current confidence level in their knowledge of perioperative temperature monitoring and their efficiency in accessing evidence-based guidelines to inform temperature monitoring decision-making (see Appendix H). Many of the post-intervention questions were intentionally aligned with the pre-intervention questions in order to compare if and how certain perceptions changed after receiving the educational intervention. The post-intervention survey also asked how CRNAs perceived the effectiveness of previous temperature monitoring practices based upon the standards included in the educational content, explored their opinion on the correlation between the last operating room temperature and the temperature recorded by the nurse on arrival to the PACU, inquired about perceived barriers to preventing perioperative hypothermia, and sought feedback on the educational tool including its usefulness in their practice. The questionnaire primarily included Likert-type questions as well as some open-ended questions. The data collected from these survey responses included nominal, ordinal, and ratio levels of measurement.

The SRNAs, with feedback from the project chair, developed an evidence-based educational resource to be provided to the CRNAs at the partnering facilities. The resource, created as a single page handout to be shared electronically and in print, provided a summary of the physiologic mechanisms of heat loss under anesthesia. It highlighted the importance of temperature monitoring, including the potential negative consequences of unintended hypothermia. The handout identified specific procedures and patient populations associated with a higher risk of intraoperative heat loss. Currently accepted national standards and guidelines as well as recommendations based on current literature regarding best practices for perioperative temperature management were reviewed by the SRNAs and summarized in the handout. The

handout was designed to be an evidence-based resource utilized to support practice. Using PowerPoint and the voiceover tool, the SRNAs recorded an educational presentation in which the content of the handout was presented in detail. The plan was for participating CRNAs to view the presentation and download the handout so that it could be quickly accessed and referenced in their practice.

Based on the overarching goal of this project, the team identified change in CRNAs' perceptions after receiving the educational intervention as the general outcome measure. The aim of this project was not to produce specific pre-determined changes in perceptions, but rather to gain more insight into the many factors that contribute to effective temperature management in surgical patients as observed by the CRNA. The outcome intended by the project team was an enhanced and comprehensive understanding of current perioperative temperature monitoring practices, perceptions of these practices, baseline knowledge on this topic, and how these are all affected by incorporating an educational presentation and accessible resource into CRNAs' practice.

Before the implementation phase, this project was granted approval by the university and the partnering facility. Upon providing a description of the purpose and process of this project and answering a series of questions, the university determined this project to be quality improvement and therefore exempt from IRB approval. The partnering facility also provided permission to implement this project and presented a letter of acknowledgement of data collection at that site (see Appendix D). The recruitment of participants was accomplished through communication between the clinical contact team member and the CRNAs working in the partnering facility. After receiving a brief description of project and agreeing to participate in

the pre-survey, receiving educational content, and the post-survey, a list of participant names and emails were provided to the project team lead by the clinical contact CRNA.

*Do*

Upon launch of the "do" phase of the PDSA cycle, the project team lead sent emails to the participating CRNAs that included an anonymous link to the Qualtrics pre-intervention survey. They were asked to complete the survey, watch the educational video provided in the email, and then download the educational resource to have as a reference to be used in practice. After reviewing these educational resources, the CRNAs were asked to resume their practice using the handout as a resource. Two weeks later, the participants received an email requesting they complete the post-intervention questionnaire via the provided Qualtrics link. Responses to the Qualtrics questionnaires remained confidential, with results gathered electronically then analyzed and reported in aggregate format.

*Study*

All survey responses were collected from Qualtrics and analyzed using Microsoft Excel. Pre-survey responses were studied to capture an insight into the baseline temperature monitoring practices at the partnering hospital through the perspective of the participating CRNAs. These were also reviewed to inquire as to how the CRNAs perceived the effectiveness of current practice as well as their baseline confidence in their knowledge of effective temperature monitoring. These results were compared to post-survey responses to observe if the educational intervention had any impact on their perceived knowledge, confidence in the efficacy of their practices, and efficiency in accessing evidence-based resources on this topic. Results were also assessed in relation to any changes in practice as reported by the CRNAs. Acquiring these results and conclusions satisfied the goal of this project.

*Act*

After studying the results, the project team discussed what was learned and what could be concluded from this cycle. Findings, as well as responses to the post-survey open-ended question regarding how the educational intervention could be improved, were used to inform the next PDSA cycle. How the process and results of this project might be applied to subsequent cycles and future endeavors to prevent perioperative hypothermia were considered. These conclusions and recommendations were presented to the university through a poster presentation.

## Section IV. Results and Findings

### Results

The purpose of this quality improvement project was to assess anesthesia providers' perceptions regarding current practice for perioperative temperature monitoring and the usefulness of a newly developed perioperative temperature monitoring and management educational resource. This quality improvement project utilized a pre-test/post-test methodology and completed a single PDSA cycle. Prior to any intervention, the participants completed a survey that included nine questions aimed at gathering insight into the CRNAs' current temperature monitoring practices, their perception of the accuracy of their available temperature monitoring devices, and their perception of their current confidence level in their knowledge of perioperative temperature monitoring and their efficiency in accessing evidence-based guidelines to inform temperature monitoring decision-making (see Appendix H).

Four CRNAs at the partnering facility completed the pre-intervention survey. These responses were collected over nine days. After completing the first survey, the CRNAs were asked to view a PowerPoint presentation with audio, providing information on perioperative temperature monitoring and management. They were provided an electronic, printable, one-page resource summarizing the information presented in the PowerPoint presentation. They were invited to keep the resource readily available to them and utilize it as an evidence-based resource to support their clinical practice over the course of two weeks. After this two-week implementation period, the CRNAs were asked to complete a post-intervention survey that addressed participants' post-implementation perceptions of the effectiveness of previous temperature monitoring practices based upon the standards included in the educational content, explored their opinion regarding the correlation between the last operating room temperature and

the temperature recorded by the nurse on arrival to the PACU, inquired about perceived barriers to preventing perioperative hypothermia, and sought feedback on the educational tool, including its usefulness in their practice. Three CRNAs completed the post-intervention survey. These responses were collected over nine days. The data collected from the pre- and post-intervention surveys were analyzed using Microsoft Excel.

***Data Presentation***

In the pre-survey, the CRNAs were first asked if they had ever received education on temperature monitoring policies or standards for their current workplace prior to this quality improvement project. Of the four survey respondents, half of them answered "yes" and the other half answered "no." The other pre-survey question that was not duplicated in the post-survey asked for the CRNAs' perceived confidence level that the temperature monitoring devices currently available to them accurately detect the patient's core body temperature. Two CRNAs reported they were "somewhat confident" in the monitoring devices' accuracy, one reported they were "somewhat not confident," and one reported they were "not confident at all."

The post-survey questions that were not duplicates from the pre-survey for comparison aimed at better understanding barriers to optimal temperature monitoring and management practices as well as assessing their perceptions of the newly developed temperature monitoring and management resource provided by this project. Of the three post-survey respondents, two CRNAs reported that, in their practice, they find that their last operating room temperature correlates well with the first temperature obtained in PACU 50% of the time. A third respondent reported that they observe these temperatures to correlate well 75% of the time. The CRNAs were asked to offer recommendations for improving the correlation between patients' temperatures recorded in the operating room and their temperature recorded upon arrival to

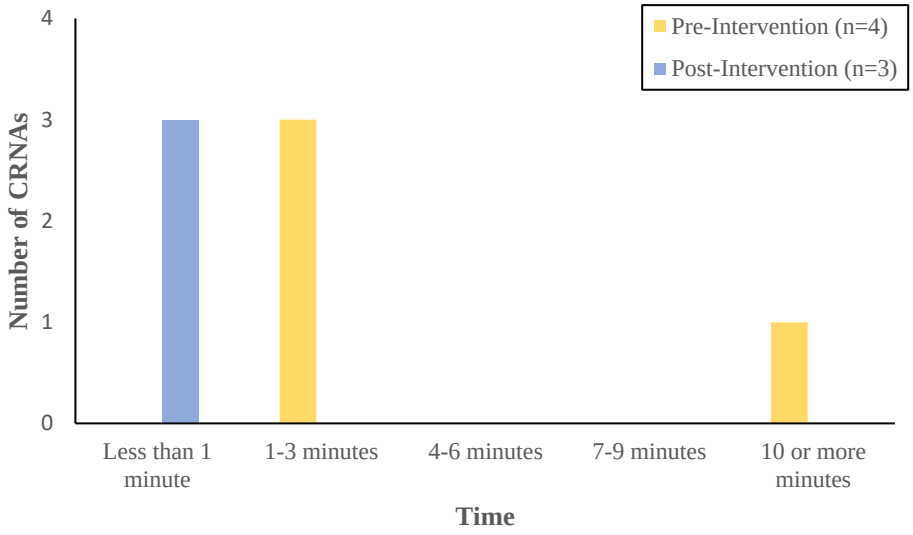
PACU, if they perceived this to be an issue. All survey participants responded with a recommendation. One respondent recommended improving temperature monitors in the OR and another respondent recommended improving temperature monitors in the postoperative areas. A third CRNA used this open-ended question to explain that in the operating room at the end of the procedure the surgical drapes and blankets are removed and replaced with new blankets, and that there is often a delay in the time between uncovering and re-covering the patient with blankets. Another post-survey open-ended question inquired about the CRNAs' perceived barriers to preventing intraoperative hypothermia. The perceived barriers to preventing intraoperative hypothermia as reported by the post-intervention survey participants included "every department not working to the same effect to warm the patient," a lack of warm fluids in the preoperative area, and "the surgeon." When asked how likely they are in their future practice to reference the temperature monitoring and management resources provided to them through this project, one of the three participants was neutral and the other two participants answered that they were likely to do so. No post-intervention survey participants provided any suggestions on what could be added to strengthen the educational tools provided.

The majority of the pre- and post-survey questions were designed similarly so responses could be compared to assess comparisons in perceptions after the implementation phase. Prior to the implementation of this project, the majority of survey participants reported that they were aware of the AANA national standard for temperature monitoring. After the implementation period, all of the post-survey participants answered that they could easily access the AANA national standard on temperature monitoring. Prior to participating in this quality improvement project, the majority of survey participants reported that it would take them one to three minutes to access a reference of evidence-based guidelines to address a question they might have in

practice, and a fourth participant reported it would take then 10 or more minutes. All of the post-intervention survey participants reported that it would take them less than one minute to access the evidence-based resources provided in this project to address a question they may have regarding temperature monitoring. See Figure 1.

**Figure 1**

*Estimated Time to Access a Reference of Evidence-Based Guidelines to Address a Question Regarding Perioperative Temperature Monitoring*

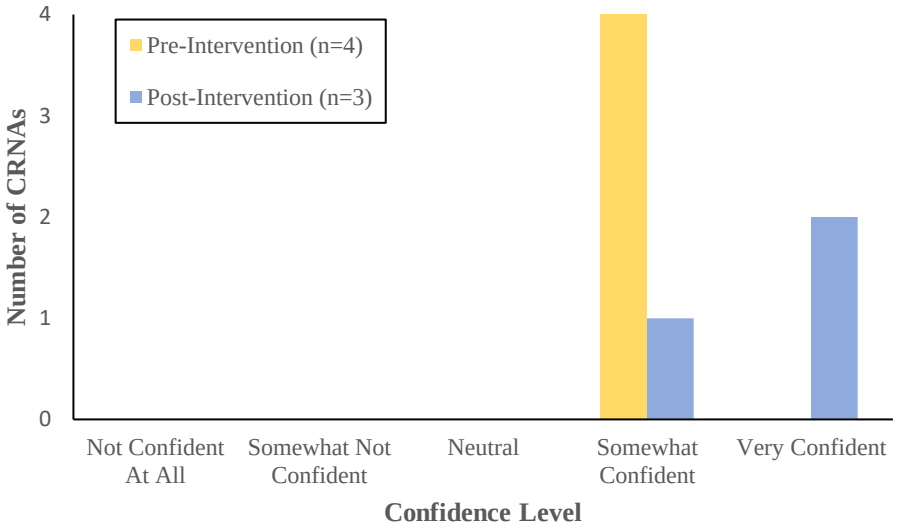



*Note.* Pre-survey responses reflect estimated time CRNAs report that it takes to access an evidence-based reference. Post-survey responses reflect estimated time CRNAs report it takes to access the evidence-based educational resource supplied in the project intervention

Prior to implementation of this project, all pre-survey participants reported they were "somewhat confident" in their knowledge about perioperative temperature monitoring. After reviewing the educational resources, all post-intervention survey participants reported being "somewhat confident" or "very confident" in their knowledge regarding perioperative temperature monitoring. See Figure 2.

**Figure 2**

*Perceived Confidence Level Regarding Knowledge of Perioperative Temperature Monitoring*




Prior to the implementation of this project, when asked to report their confidence level in their ability to identify core temperature sites, one CRNA reported they were "somewhat not confident," one reported they were "neutral," one reported they were "somewhat confident," and one reported they were "very confident." After reviewing the educational resources, all post-intervention survey participants reported they were "very confident" in their ability to identify core temperature sites. Prior to the implementation of this project, three out of four CRNAs stated that they intraoperatively utilize temperature monitoring for 50-75% of their cases in a typical work week. An additional CRNA reported utilizing temperature monitoring intraoperatively for 75-100% of their cases. Following the implementation phase, all post-intervention survey participants reported that they would now utilize intraoperative temperature monitoring 75-100% of the time.

Prior to the implementation phase, when listing their preferred modality/site for temperature monitoring in the intraoperative setting, all participants listed esophageal, foley, and nasopharyngeal. One respondent also listed skin as a fourth preferred modality/site for monitoring. After the intervention, one CRNA reported nasopharyngeal as the site they would most likely use in their practice for temperature monitoring. Another CRNA reported skin and esophageal were the sites they would most likely use for temperature monitoring in their practice. A third CRNA listed esophageal, rectal, nasopharyngeal, and bladder via a foley catheter thermometer as the temperature monitoring sites they were most likely to use in their practice.

**Analysis**

These data present several inferences for the effects of an educational intervention on perioperative temperature monitoring and management. Half of the pre-survey participants answered that they had not received education on temperature monitoring policies or standards for their current workplace prior to this intervention. After participating in the viewing of the evidence-based resource and its accompanying presentation that served as continuing education on the current standards of care as presented by the AANA and ASA and evidence-based recommendations for preventing perioperative hypothermia, it can be inferred that now all of the participating CRNAs have received education on temperature monitoring policies and standards for their surgical setting. Additionally, one of the four pre-survey participants answered that they were unaware of the AANA national standard for temperature monitoring. All three post-survey participants answered that they can readily access the AANA national standard on temperature monitoring. If the CRNA that answered "no" to the pre-survey question was one of the post-

survey respondents, this suggests that following the project intervention, there was an increase in awareness of the AANA national standard on temperature monitoring.

The project data also suggests a decrease in the amount of time it takes for CRNAs to access a reference of evidence-based guidelines to address clinical questions regarding perioperative temperature monitoring and management. Refer back to Figure 1. Prior to the implementation of this project, none of the CRNAs answered that they could access such materials in less than one minute. With the "Raising the Brrr on Temperature Management" resource immediately available to them on their devices, all of the post-survey participants reported being able to access this resource, which is a reference of evidence-based guidelines, in less than one minute. This suggests an improvement in efficiency in accessing evidence-based guidelines and recommendations to support and help guide the CRNAs' clinical practice. Two out of three CRNAs reported that they were likely to reference the materials provided by the project in their future practice, which could indicate that CRNAs perceive these resources to be valuable in supporting their practice. However, one CRNA answered that they were neutral in their likelihood in using these materials and none answered that they were "very likely" to use them. In an open-ended question, all CRNAs reported that they had "no recommendations" for strengthening the educational resources. Further consideration about how these educational resources could be made more useful to CRNAs appears to be an area to be addressed in subsequent phases of this quality improvement project.

Responses to survey questions that were asked both before and after the implementation period were compared in order to assess for any change in the CRNAs' perceptions. See Figure 2. The analysis of the results shows an improvement in the participating CRNAs' confidence levels regarding perioperative temperature monitoring and management. Responses after the

intervention demonstrated an increased reported confidence level in the CRNAs' perceived knowledge about perioperative temperature monitoring, their perceived ability to identify a patient or procedure at higher risk of intraoperative heat loss, and in their perceived ability to identify core temperature sites. The analysis also demonstrates that, following the implementation period, the CRNAs plan to utilize intraoperative temperature monitoring more frequently.

Findings from the project also suggest potential target areas for future interventions aimed at better understanding the phenomenon of IPH and ways it may be prevented. The results suggest that there is not a high level of confidence in the accuracy of the available temperature monitoring devices by the CRNAs at the partnering facility. The perception that temperature measurements are inaccurate could be a major factor affecting CRNAs' temperature management practices and could be a potential barrier to preventing IPH that warrants more attention in future quality improvement interventions. The time between the last recorded temperature in the operating room and the first recorded temperature in PACU is typically a short period of time that, ideally, should not produce any major changes in the patient's temperature; however, this project's results suggest these two temperature measurements are not always well-correlated. With two out of three CRNAs reporting that their last operating room temperature correlates well with the first PACU temperature only 50% of the time, these results reveal an area for further investigation. The participating CRNAs suggest that this issue could be due to inaccurate measurements either in the operating room or the PACU, or that there could be heat loss occurring from the time the patient is undraped and uncovered to the time they are recovered with new blankets.

These results also reveal barriers to achieving optimal temperature management and the prevention of perioperative hypothermia as perceived by CRNAs at a rural hospital. One of the CRNAs answered that the surgeons are a barrier to preventing intraoperative hypothermia. This CRNA could be referring to the cold room temperature as set by the surgeon. The intraoperative forced air warming devices used at this facility are not activated until the patient is prepped and draped, so the CRNA could also be referring to the surgeon being a limiting factor to how soon intraoperative warming is begun. This survey response demonstrates another area for further investigation in future quality improvement projects. Another CRNA perceives the lack of warm fluids in the preop area as a barrier to preventing intraoperative hypothermia. The educational resource identified preoperative warming as the most effective strategy for preventing intraoperative hypothermia. This suggests preoperative warming practices as a potential target area for future quality improvement projects aimed at preventing IPH. While we cannot infer this from the data analyzed, there is a possibility that the continued education regarding preoperative warming may have helped this CRNA recognize the importance of a lack of materials available for preoperative warming. Another CRNA acknowledges the need for the departments involved in all phases of the patients' perioperative care to equally contribute to keeping the patient warm. This CRNA may also be suggesting that there is room for improvement in warming strategies utilized in the preoperative department as a means to prevent IPH.

The data assessing the CRNAs' preferred modality/site for temperature monitoring in the intraoperative setting before and after the implementation period are more difficult to analyze and draw meaningful inferences from. The nasopharyngeal route, which is not considered a core temperature site as presented in the educational resources, was preferred less often in the post-survey. The rectal route for temperature monitoring was preferred by one CRNA in the post-

survey, while this was not chosen as a preferred route in the pre-survey. This may suggest a change in the knowledge regarding core temperature monitoring sites and a motivation to implement evidence-based intraoperative temperature monitoring strategies in practice.

## Section V. Implications

### Financial and Nonfinancial Analysis

If this project were to be replicated by the partnering organization, it would be a cost-effective endeavor. There would be no monetary costs other than employee time required to carry out this project. At least one anesthesia provider would need to be assigned to serve as the designated advocate for project implementation. This project leader would devote time spent on disseminating, collecting, and analyzing data. These responsibilities, however, would not require a significant amount of time outside of normal work hours. The students that completed this project were still able to complete a typical 40-plus hour clinical week without taking any time away from patient care. This suggests it is feasible for the project leader to use on-call hours between cases in addition to approximately two hours a week outside of these normal work hours to complete the tasks required to carry out this project. It would cost the hospital twice a CRNA's approximate hourly wage every week to carry out this project.

Qualtrics, the survey software used for this project, is available by subscription without additional costs added for quantity of use. If the hospital does not have a subscription to this software the surveys could be created and shared via any of several free options. It took less than thirty minutes to create both the pre- and post-surveys used for data collection. By using email, there were no financial requirements for communication outside of internet access, which is already available at this hospital. Microsoft products PowerPoint and Excel were used to create the interventions and analyze data. These programs are already available in the facility and use would entail no additional costs. The mobile-friendly Qualtrics surveys and the educational resources that served as the project intervention were disseminated and made accessible electronically; therefore, there were no costs required for printing materials. Because this

project's implementation phase does not ask the CRNAs to change their practice, it would not produce any changes in workflow or necessitate the organization to purchase any new equipment or supplies. The organization already has temperature monitoring devices available in the preoperative, intraoperative, and postoperative patient care areas. This hospital also has equipment for patient-warming, including fluid warmers, blanket warmers, conduction warming devices, and forced-air warming devices. These devices have already been deemed clinically necessary and cost-effective by this organization.

The results from this project illustrate an increase in access to education on temperature monitoring standards for the surgical setting; increased awareness of the AANA national standard for temperature monitoring; increased efficiency in accessing an evidence-based reference of clinical guidelines to support clinical temperature monitoring and management practices; and an increased level of confidence in knowledge about perioperative temperature monitoring, ability to identify a patient or procedure at higher risk of intraoperative heat loss, and ability to identify core temperature sites as perceived by the participating CRNAs. The results from this project also suggest that, as compared to practice before the implementation period, the CRNAs plan to more frequently utilize intraoperative temperature monitoring. These project outcomes have potential to serve as facilitators to decreasing the rate of IIH and IPH at this organization. The excess morbidity and mortality related to inadvertent hypothermia in the perioperative period is costly for healthcare organizations, with a monetary cost of $2,412 to $6,839 per patient (Boet et al., 2017). IPH also prevents potential hospital reimbursement. If the education provided by this project indirectly produces an increase in the use of disposable warming devices, such as the forced-air warming blankets and fluid warmer tubing, this could potentially increase the patient supply costs for the hospital. However, when considering the

potential costs associated with IPH, the organization would be preventing costs that outweigh what would be spent on these supplies if the increase in patient warming practices prevents even one incident of IIH or IPH.

Overall, when comparing the costs if the organization were to repeat this quality improvement project with the potential it has to prevent the hospital from spending thousands of dollars on IPH-related sequelae, the hospital would have a positive return on their investment. Furthermore, if this project proves to be sustainable at this organization, the inferences made from the first PDSA cycle of this project would be valuable in informing subsequent cycles or future quality improvement projects aimed at further decreasing the rate of IPH and the financial burden of its consequences.

**Implications of Project**

Practice standards for CRNAs as set by the AANA require nurse anesthetists to actively monitor the body temperature of every patient receiving anesthesia when changes in body temperature are anticipated, and to utilize active measures to facilitate normothermia. The results of this project suggest an increased awareness of this standard, thereby supporting the delivery of patient-centered, consistent, high-quality, and safe anesthesia care as intended by the AANA. Similarly, the clinical practice guidelines proposed by NICE state that each patient should be preoperatively assessed for their risk of developing inadvertent perioperative hypothermia (IPH), anesthesia should only be induced if the patient's core temperature is at least 36 °C, the patient's temperature should be measured before induction of anesthesia and then every 30 minutes until the end of surgery, and forced air warming devices should be used intraoperatively to prevent and treat hypothermia (NICE, 2016). The results of this project suggest an increased confidence level in identifying patients and procedures at an increased risk for intraoperative heat loss,

thereby supporting a preoperative risk assessment as advised by NICE. The results also suggest that there will be an increase in frequency with which the CRNAs intraoperatively monitor their patients' temperature, suggesting an increase in observance of the NICE guidelines.

Multiple studies cited in the literature link improvement in knowledge to adherence to evidence-based recommendations on temperature management for the surgical patient as a method of preventing the incidence of IPH (Boet et al., 2017; Gustafsson et al., 2020; Munday et al., 2019). These studies recommend achieving this by utilizing continuing education for anesthesia providers on the physiology of perioperative hypothermia and on the current recommended practices for preventing hypothermia. Their recommendations were used to guide the design of this quality improvement project as both of these topics were included in the educational resources provided to the participating CRNAs.

As predicted by the literature, our findings suggest a positive relationship between providing continuing education on the physiology of and recommended practices for preventing IPH and with the adherence to such recommendations. Our findings are consistent with previous studies that have illustrated utilizing CRNA education on guidelines to prevent IPH as a project intervention can produce positive outcomes. These studies noted their educational interventions to produce positive change, including improvements in compliance with intraoperative measurement of core temperature and a reduction in the incidence of IPH (McCormick et al., 2019; Senkal & Kara, 2021).

If the education provided by our project intervention improves CRNAs' knowledge of IPH, confidence in preventing IPH, and the frequency at which they utilize intraoperative temperature monitoring as reflected by the survey responses we received, this project has served as a means to promoting safe and quality patient care at this partnering organization. An increase

in evidence-based perioperative temperature monitoring and management practices as a result of continued education may reduce the incidence of IPH at this hospital. This would mean a reduction in potential healthcare harm including prolonged time spent on mechanical ventilation, prolonged recovery times and hospital stay, increased blood loss and transfusion requirements, infection, morbidity related to cardiac events, and patient discomfort. For the organization, this could result in avoidance of unnecessary healthcare costs of $2,412 to $6,839 per patient and having a patient care delivery model that more closely aligns with the IHI Triple Aim goals of improving population health, enhancing patient outcomes and experience, and reducing per capita cost of care for the benefit of the communities (Berwick et al., 2008; Boet et al., 2017).

**Sustainability**

If the partnering organization chose to use the strategies of this pilot study to implement a larger quality improvement project, there is not a financial constraint foreseen that would limit the sustainability of the project. If, however, the interventions were altered to include materials with a monetary cost, such as assessing the effects of a new temperature monitoring or warming device or hiring a staff member to provide in-person training, for example, these costs may potentially affect long term sustainability of project interventions.

While our project did not require any financial support, the resource that would be essential to this project's sustainability is a motivated project advocate willing to offer time and effort to the success and longevity of the project and its results. This could conceivably prove to be a challenge for this hospital based on its size and nature of staffing. Currently, the anesthesia team only includes one anesthesiologist and locum CRNAs, who are contracted to work at the facility on a temporary basis. During the implementation period of this pilot project, there were four locum CRNAs on the anesthesia care team. A small anesthesia team that changes over time

with the rotation of temporary CRNAs may significantly limit the likelihood of securing an anesthesia provider who is both motivated to produce a positive impact in that healthcare organization and who will be either present long term or able to secure a replacement when their contract is finished.

Without a secure project leader motivated and willing to dedicate time and effort for the cause of preventing unnecessary harm to their patients in the form of IPH, the sustainability of a quality improvement project at this facility is uncertain. The hospital would need to employ strategies to address this potential issue in order to reap the benefits of providing safe quality care while reducing healthcare costs. The anesthesiologist who is a permanent employee as well as an individual who is personally and professionally invested in ensuring the safest and highest quality anesthesia care for the patients of this facility may consider spearheading the next phase of this quality improvement project. They may prove to be a positive influence on the sustainability of the project and the life span of the positive effects it produces. If they are unable to take on more responsibilities, future students in the nurse anesthesia program may elect to continue this line of quality improvement.

**Dissemination Plan**

The design, results and findings, and implications of this quality improvement project were summarized in a poster and presented to the students and faculty of the East Carolina University Nurse Anesthesia program. The project participants were invited to attend and were offered an electronic copy of the final version of this paper. The final version of this paper and poster were posted in The Scholarship, the East Carolina University digital repository.

## Section VI. Conclusion

### Limitations

The major limitations to this quality improvement project were the small sample size and short implementation period. With four participants in the pre-survey and three participants in the post-survey, this limits the generalizability of the implications of the findings to similar healthcare organizations. This project was implemented among a small anesthesia team that changes over time with the rotation of temporary CRNAs. Collecting responses over a short period of time limited the amount of potential data. Additionally, knowing that the responses gathered in the post-survey were from the same CRNAs that participated in the pre-survey would have allowed for a clearer, more meaningful interpretation of the results.

### Recommendations for Future Implementation and/or Additional Study

If this project were to be repeated, partnering with an organization that has a larger sample size is recommended. Continuing to foster the strong rapport with the CRNAs at the participating facility in order to promote the likelihood of participation is encouraged. The continued use of cost-effective methods such as electronically disseminated educational interventions, Qualtrics surveys for data collection, and Microsoft Excel for data analysis is recommended. Using similar questions for comparison in the pre- and post-surveys is a useful strategy and continued use is recommended to assist in the analysis of data.

Considering the positive results that an educational intervention produced in this project and other studies noted in the literature, continuing to use education as part of future project interventions aimed at reducing the rates of IPH is recommended. After noting the success of these methods in the literature, some recommendations might include adding implementation strategies such as in-person education and training, creating a checklist based on clinical practice

guidelines to be used as a tool, and designating an individual person or team to be "Thermal Care Quality Champions." Future projects may consider incorporating education and/or training in pre-established department meetings in order to increase project participation. The use of checklists based on clinical practice guidelines has been recommended as an implementation strategy to facilitate optimal hypothermia prevention practices and reduce the incidence of IPH (Duff et al., 2018; Munday et al., 2019; Senkal & Kara, 2021).

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## Appendix A

## Literature Concepts Table

| Concepts | Concept 1:<br>Intraoperative | Concept 2:<br>Anesthesia | Concept 3:<br>Temperature monitoring | Concept 4:<br>Education |
|---|---|---|---|---|
| Keywords | Intraoperative, perioperative | Anesthesia, nurse anesthetist, anesthesiologist, anesthesiology | Temperature monitoring, temperature management, hypothermia | Education, training |
| PubMed MeSH | Intraoperative, perioperative | Anesthesia, nurse anesthetists, anesthesiologists | Temperature, physiologic monitoring, organization and administration, disease management, hypothermia, intraoperative hypothermia | Education, educational status, teaching, prevention |
| CINAHL Subject Terms | Intraoperative monitoring, intraoperative complications, intraoperative period, intraoperative care, perioperative nursing, intraoperative, perioperative care | Nurse anesthetists, anesthetists, anesthesia nursing, American Association of Nurse Anesthetists, Perianesthesia nursing, Nurse anesthesia education, anesthesia nursing | Temperature | (Did not use this concept for this search strategy) |
| Google Scholar | Intraoperative, perioperative | Nurse anesthetists | Hypothermia prevention | Educating |

## 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 |
|---|---|---|---|---|---|
| 9/20/2021 | PubMed | (((intraoperative) OR (surgery) OR (perioperative)) AND ((temperature monitoring) OR (temperature management) OR (hypothermia)) AND ((anesthesia) OR (nurse anesthetist) OR (anesthesiologist)) AND (education)) | Five years (2016-2021),<br>English language | 75 found/5 kept | **Inclusion:** quality improvement interventions done in the surgical setting in order to increase use of evidence-based practice; studies that explore anesthesia providers' perceptions on temperature management<br>**Excluded:** general articles about intraoperative hypothermia and its consequences; studies that explore/compare effectiveness of specific warming methods/monitoring devices; veterinary anesthesia; duplicate articles from other databases |

| | | | | | |
|---|---|---|---|---|---|
| 9/20/2021 | PubMed | ((intraoperative hypothermia) OR (perioperative hypothermia)) AND (prevention) | Five years (2016-2021),<br><br>English language | 382 found/20 kept | **Inclusion:** quality improvement interventions performed in the surgical setting in order to increase use of evidence-based practice; studies that explore anesthesia providers' perceptions on temperature management<br><br>**Excluded:** general articles about intraoperative hypothermia and its consequences; studies that explore/compare effectiveness of specific warming methods/monitoring devices; veterinary anesthesia; duplicate articles from other databases |

| | | | | | |
|---|---|---|---|---|---|
| 9/22/2021 | CINAHL | ((MH "Nurse Anesthetists") OR (MH "Anesthetists") OR (MH "Anesthesia") OR (MH "Anesthesia, General") OR (MH "Anesthesiologists")) AND ((MH "Temperature") OR (MH "Body Temperature Changes") OR (MH "Core Body Temperature") OR (MH "Body Temperature")) | Five years (2016-2021),<br>English language,<br>Peer-reviewed,<br>Full text | 53 found/8 kept | **Included:** articles related to factors influencing hypothermia relevant to anesthesia providers<br>**Excluded:** articles about risks factors/consequences of hypothermia as opposed to preventing it; articles about specific warming/pharmacological methods to prevent hypothermia; not related to temperature management |
| 9/21/2021 | Google Scholar | (nurse anesthetist OR anesthesiologist) AND (education) AND (hypothermia prevention) | Five years (2016-2021) | 9,120 found/23 kept<br>(reviewed 20 pages of results) | **Included:** Quality improvement projects to prevent perioperative hypothermia. **Excluded:** specific warming methods; interventions not applicable to the nurse anesthetist; not applicable to hypothermia in the perioperative setting; duplicate articles from other databases |

## Appendix C

## Literature Matrix

| Citation | Level of Evidence & Theory/Conceptual Framework | Objective | Method | Results/Conclusions |
|---|---|---|---|---|
| Boet, S., Bryson, G. L., Taljaard, M., Pigford, A.-A., McIsaac, D. I., Brehaut, J., Forster, A., Mohamed, K., Clavel, N., Pysyk, C., & Grimshaw, J. M. (2018). Effect of audit and feedback on Physicians' intraoperative temperature management and patient outcomes: A three-arm cluster randomized-controlled trial comparing benchmarked and ranked feedback. *Canadian Journal of Anesthesia, 65*(11), 1196–1209. | II (randomized controlled trial)<br><br>Theoretical domains framework | Measure the impact of targeted audits and feedback on anesthesiologists' intraoperative temperature management and patient outcomes and to determine the most effective type of feedback | Setting: large Canadian academic tertiary care hospital<br><br>Sample: 45 anesthesiologists<br><br>Three-arm cluster randomized controlled trial that analyzed anesthesiologists' intraoperative temperature management performance before and after they received no feedback (control), benchmarked feedback, or ranked feedback | No evidence was found to suggest that audit and feedback using benchmarked or ranked feedback is more effective than no feedback at all to change anesthesiologists' intraoperative temperature management performance. Feedback may need to be included in a bundle to produce the desired effect. |

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| Boet, S., Patey, A. M., Baron, J. S., Mohamed, K., Pigford, A.-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. | VI (qualitative study)<br><br>Theoretical domains framework | Identify what anesthesiologists perceive as factors that influence perioperative temperature management in order to reveal target areas for future interventions to close the evidence-practice gap in perioperative temperature management | Setting: large Canadian academic tertiary care hospital<br>Sample: 89 anesthesiologists<br><br>Qualitative study using semi-structured interviews based on the theoretical domains framework. Data saturation was reached after 15 interviews. | After identifying theoretical domains relevant to designing an intervention, potential target areas to improve temperature management practices include feedback, increasing awareness of temperature management strategies and guidelines, improving access to standardized temperature management strategies and monitoring equipment, and increasing communication and teamwork among the perioperative team. |
| Duff, J., Walker, K. Edward, K.-L., Ralph, N., Giandinoto, J.-A., Alexander, K., Gow, J., & Stephenson, J. (2018). Effect of a thermal care bundle on the prevention, detection and treatment of perioperative | VI (Implementation project)<br><br>Breakthrough series collaborative model | Implement a Thermal Care Bundle in order to improve the prevention, detection, and treatment of perioperative inadvertent hypothermia in | Setting: four leading metropolitan Australian hospitals<br>Sample: 729 patients<br><br>Pre and post implementation study.<br>After being trained on quality improvement methods and developing site-specific strategies based on the site-specific barriers, | Implementation of the care bundle increased the amount of hypothermia risk assessments, temperature monitoring, and active warming measures. There was an increase in recorded hypothermia, but the study attributes this to an increase in detection |

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| inadvertent hypothermia. *Journal of Clinical Nursing, 27*(5-6), 1239–1249. | | adult surgical patients | each hospital had a team of four leaders to implement the "Thermal Care Bundle," a tool previously developed by a panel of expert clinicians and researchers. The bundle included elements from the NICE guideline on the management of IPH in adults, including assessing risk, temperature monitoring, and active warming. Each element was to be delivered to every patient, every time. Who provided the care, when, and with what equipment was left to the discretion of the clinicians. Patient charts were audited before and after implementation. | related to increased temperature monitoring rather than a true increase in incidence. |
| 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* | VI (descriptive survey)<br><br>N/A | Determine if nurse anesthetists have access to and knowledge of the recommended guidelines for maintaining perioperative normothermia and if they adhere to such guidelines. | Setting: 56 hospitals in Sweden<br><br>Sample: Operating department heads and nurse anesthetists provided data from 1,169 patients<br><br>Descriptive survey design with literature review.<br><br>Questionnaires were developed based on Swedish evidence-based recommendations to maintain normothermia. Questionnaires to | The level of access to recommendations was high, but only 1/3 of operating departments had them included in their guidelines. Knowledge about the guidelines was 57-60% and adherence to them was low. Revealed a need for education on recommendations and the physiology of heat loss. All members of the |

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| *Nursing*, *32*(5), 409–418. | | | department heads covered number of operations per year, clinics they provide services to, access to recommended heat conservation measures, lowest accepted temperature, and implementations of national recommendations in their guidelines. Questionnaires to nurse anesthetists asked about the clinical setting, the OR set temperature, surgery time, recommended heat conservation measures that were used, when the forced-air cover was placed on the patient, and the anesthetist's knowledge about the guideline recommendations. | perioperative team should be made aware of the existing guideline recommendations and provided with repeated education, including the use of a designated advocate for the implementation of current guidelines and any subsequent revisions. |
| Lakha, S., Levin, M., Leibowitz, A., Lin, H., Gal, J. (2020). Intraoperative electronic alerts improve compliance with national quality program measure for perioperative temperature management. *Anesthesia &* | VI (implementation project)<br><br>N/A | Investigate if an electronic decision-support tool can improve compliance with the intraoperative temperature measurement and normothermia required by the | Setting: Single academic medical center in the United States<br><br>Sample: Patients undergoing general or neuraxial anesthesia; Assessed 24,755 cases in 2017 eligible for reporting and used a baseline of 25,274 cases from 2016<br><br>Retrospective observational study that collected perioperative | Increase in overall compliance from 84.4% to 92.4% and an increase in intraoperative compliance from 26.8% to 71%.<br><br>The implementation of an intraoperative decision-support tool led to improved compliance with the CMS-MIPS measure for maintaining |

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| *Analgesia, 130*(5), 1167-1175. | | CMS-MIPS measure | temperature data from cases that were eligible for reporting to CMS.<br><br>Electronic decision-support tool consisted of an alert system incorporated into electronic documentation that generated an alert on the screen if no temperature was recorded in the first 60 minutes and a separate alert if normothermic temperature is not recorded within 15 minutes before documentation of procedure finish | perioperative normothermia, suggesting that utilizing electronic alerts can help organizations improve their performance and thereby increase their eligibility for payment bonuses from CMS. |
| McCormick, P., Yeoh, C., Vicario-Feliciano, R., Ervin, K., See Tan, K., Yang, G., Mehta, M., & Tollinche, L. (2019). Improved compliance with anesthesia quality measures after implementation of automated monthly feedback. *Journal of Oncology Practice, 15*(6), 583-592. | VI (implementation project)<br><br>Plan-do-study-act cycles | Use staff education reinforced with automated monthly feedback to improve compliance with anesthesiology quality measures in order to reduce postoperative complications | Setting: tertiary academic cancer hospital in the United States<br><br>Sample: 40,228 patients receiving anesthesia care<br><br>Audited patient records to compare anesthesiologists' and nurse anesthetists' compliance with Anesthesiology Performance Improvement and Reporting Exchange quality measures before and after implementing a program that combined staff education and monthly email reports of their individual compliance rates with each measure. | There were significant improvements in anesthesia quality measure compliance for several process measures, with core temperature measurement being the most improved measure with a statistically significant improvement in number of patients who ended anesthesia at a temperature greater than 35.5 °C. Compliance with temperature monitoring improved from 69.5% to 85.7%. |

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| 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. | VI (qualitative study)<br><br>Theoretical domains framework | Identify and examine the domains that serve as barriers and facilitators to successfully adopting perioperative hypothermia prevention practices in order to target areas for future interventions to close the evidence-practice gap | Setting: metropolitan, tertiary hospital in Brisbane, Australia<br><br>Sample: 8 nurses, 2 surgeons, two anesthetists<br><br>Qualitative study using semi-structured interviews based on the theoretical domains framework. Using direct content analysis, interview responses were categorized into domains, classified into specific beliefs, and mapped to the components of the behavior change wheel | Based on the interviews, the recommended intervention strategies included training, reminder systems, checklists, guidelines, audit and feedback, support from the organization to control ambient temperature, and access of accurate temperature measurement devices. |
| Munday, J., Hines, S. J., & Chang, A. M. (2013). Evidence utilization project: Management of Inadvertent perioperative hypothermia. The challenges of implementing best practice recommendations in | VI (implementation project)<br><br>N/A | Assess current clinical practice regarding management of perioperative hypothermia among adult surgical patients and to promote evidence-based practice among | Setting: large public teaching hospital in Queensland, Australia<br><br>Sample: 145 perioperative patient records<br><br>Performed pre- and post-implementation documentation audits to assess practice in admissions, pre-op, OR, and PACU to identify practice gaps, barriers to | Preoperative temperature monitoring increased from 0 to 38% of patients. Intraoperative warming increased from 55% to 60%. Warming in the PACU increased by 8%. This project was not focused on changing practice among anesthesia providers in the |

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| the perioperative environment. *International Journal of Evidence-Based Healthcare*, *11*(4), 305–311. | | perioperative nurses in the management of IPH | improving practice, and strategies to overcome such barriers and improve practice. Multifaceted interventions aimed at perioperative nurses included emails to communicate audit results and project aims, poster updates, assigning staff members to increase awareness and direct change, in-service education to feedback audit results and direct change, the purchase of a new thermometer to be used in preop, identifying a section on the perioperative checklist to be used for temperature documentation, and an update to the hospital warming policy to reflect EBP recommendations. | intraoperative period. With intraoperative monitoring being suboptimal, a project to improve anesthetic management of IPH is recommended. Variability in temperature values between different thermometers was observed. |
| Senkal, S., & Kara, U. (2021). Guideline implementation and creating awareness for unintended perioperative hypothermia: Single-group "before and after" study. *Turkish Journal of Trauma and Emergency* | VI (implementation project)<br><br>N/A | Determine if implementing a hospital protocol based on evidence-based guidelines, specifically the Turkish Anesthesiology and Reanimation Society Guidelines for prevention of | Setting: single military medical academy hospital in Turkey<br>Sample: 669 adult surgical patients<br><br>Prospective quality improvement study performed in hospital central operating rooms<br>Developed a protocol based on the IPH guideline and used an implementation strategy that lasted | IPH incidence in adult surgical patients declined from 35% to 23.8%. The incidence of IPH and its complications can be significantly reduced by implementing evidence-based recommendations while increasing awareness and encouraging behavioral changes |

| | | | | |
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| *Surgery*, *27*(5), 719–727. | | IPH reduces the incidence of IPH | one month including 1. PowerPoint presentations r/t prevention of IPH 2. Presentation of guideline content briefed to all occupations on perioperative team 3. On-site training regarding proper use of different thermometers and warming equipment 4. Distribution of a clinical checklist manual to prevent IPH based on the IPH guideline<br><br>Measured and compared the incidence of IPH pre and post implementation | |

*Note.* NICE = National Institute for Health and Care Excellence; CMS = Center for Medicare Services; CMS-MIPS = Center for Medicare Services-Merit Based Incentive Payment System; Pre-op = Pre-operative; OR = operating room; PACU = Postoperative Anesthesia Care Unit; IPH = Inadvertent Perioperative Hypothermia. Key to Levels of Evidence: I: Systematic review/meta-analysis of randomized controlled trials (RCTs); II: RCTs; III: Nonrandomized controlled trials; IV: Controlled cohort studies; V: Uncontrolled cohort studies; VI: Descriptive or qualitative study, case studies, EBP implementation and QI ; VII: Expert opinion from individuals or groups. 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

## Research Department Project Approval Form

Center for Research & Grants

[redacted]

### 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] 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]

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:** Nurse anesthetists' perceptions of perioperative temperature monitoring and management: A quality improvement project | | |
| **Funding Source:** None | | |
| **Project Leader Name:** Miranda Daniels/Angela Ciuca | ☐ Ed.D. ☐ J.D. ☐ M.D. ☐ Ph.D. ☐ Pharm.D. ■ R.N. ☐ Other(specify): | |
| **Job Title:** ECU SRNA/ECU CRNA Faculty | **Phone:** [redacted] | **Email:** ciucaa18@ecu.edu |
| | **Primary Contact (If different from Project Leader):** Miranda Daniels | |
| | **Phone:** [redacted] | **Email:** danielsmi19@students.ecu.edu |

**Key Personnel/ Project Team members:**

| Name and Degree: | Department: (Affiliation if other than Vidant) | Email: |
|---|---|---|
| Miranda Daniels, SRNA | ECU Nurse Anesthesia Program | danielsmi19@students.ecu.ed |
| Angela Ciuca, DNAP, CRNA | ECU Nurse Anesthesia Program | ciucaa18@ecu.edu |
| Maura McAuliffe, PhD, CRNA | ECU Nurse Anesthesia Program | mcauliffem@ecu.edu |
| | | |

## QI/QA Assessment Checklist:

| Consideration | Question | Yes | No |
|---|---|---|---|
| PURPOSE | Is the PRIMARY purpose of the project/study to:<br>• IMPROVE care right now for the next patient?<br>OR<br>• 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:<br>• literature<br>• 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?<br>• An outside organization with an interest in the results<br>• A manufacturer with an interest in the outcome of the project relevant to its products<br>• 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 Vidant Chowan 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]: [redacted]

   ☐ **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] 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 [redacted] and the following will be completed and returned to you for your records.

**NHSR vs. HSR Determination:**

☒ **Not Human Subject Research:** The [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:** [redacted] **Date:** 2/28/22

[redacted] **CRG Reviewer:** [redacted] **Date:** 3/14/22

**UMCIRB Office Staff Reviewer:** [redacted] **Date:** 3/15/22

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

Miranda Davis

**Project Leader Signature**

2/21/2022

**Date**

# Appendix E

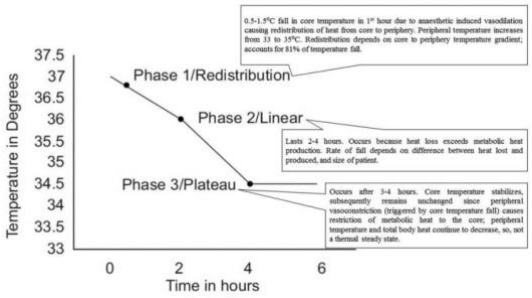
## Newly Developed Evidence-Based Resource

### Causes of Hypothermia Under Anesthesia

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.

### AANA Standard IX: Monitoring

*"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

*"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

- 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

| | |
|---|---|
| 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

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=e00049b1_20

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

Bindu, B., Bindra, A., & Rath, G. (2017). Temperature management under general anesthesia: Compulsion or option. *Journal of Anaethesiology Clinical Pharmacology, 33*(3), 306-316. https://doi.org/10.4103/joacp.joacp_334_16

McAuliffe, M. (2021). *Physics for Nurse Anesthesia: Thermoregulation* [PowerPoint Slides].

### Prevention of hypothermia

- #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 | Other monitoring sites |
|---|---|
| Esophageal | Axillary |
| Bladder | Skin |
| Rectal | Nasopharyngeal |
| Right Atrium | Temporal |
| | Tympanic |

### Tools available for temperature monitoring

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

ECU Nurse Anesthesia Program

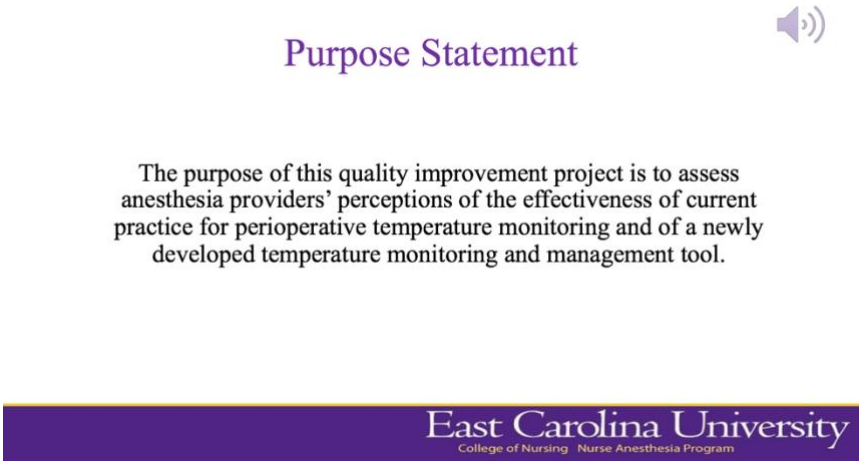
## Appendix F

## Educational Presentation with Script

**Title slide**


Script: Hello and thank you for your participation in this quality improvement project titled "Perioperative temperature monitoring and management"

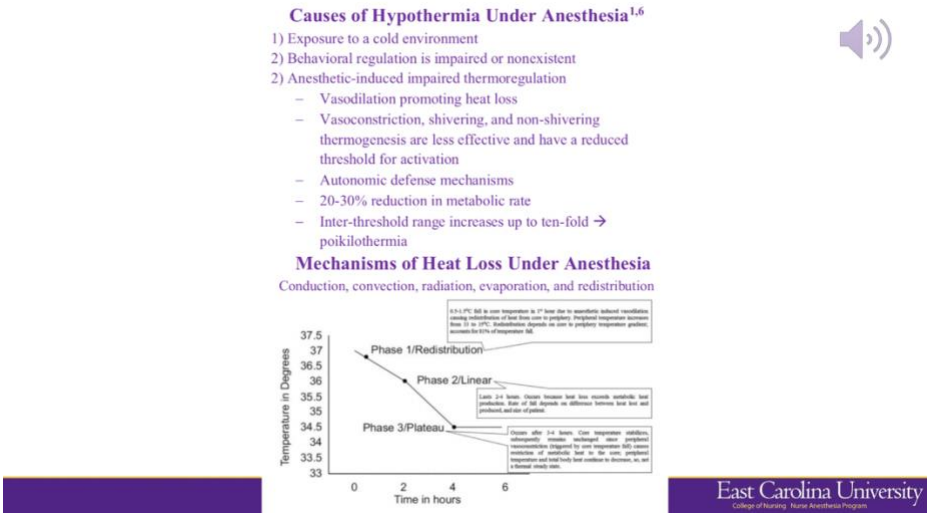
**Slide Two**




Script: Temperature monitoring and management practices to maintain normothermia is a very important aspect of providing safe and quality patient care during the perioperative period. The purpose of this quality improvement project is to assess anesthesia providers' perceptions of the

effectiveness of current practice for perioperative temperature monitoring and of a newly developed temperature monitoring and management tool. First, we will have the participating CRNAs at varying locations complete a pre-intervention survey. After that, we ask the CRNAs to review the newly developed handout to be used as an evidence-based resource regarding temperature monitoring and management and to continue viewing this presentation that will expound upon this handout to serve as continuing education on this topic. The participating CRNAs will then return to their practice with this resource available to them to reference if they choose. After two weeks, we will ask the CRNAs to complete a post-intervention survey.

**Slide Three**

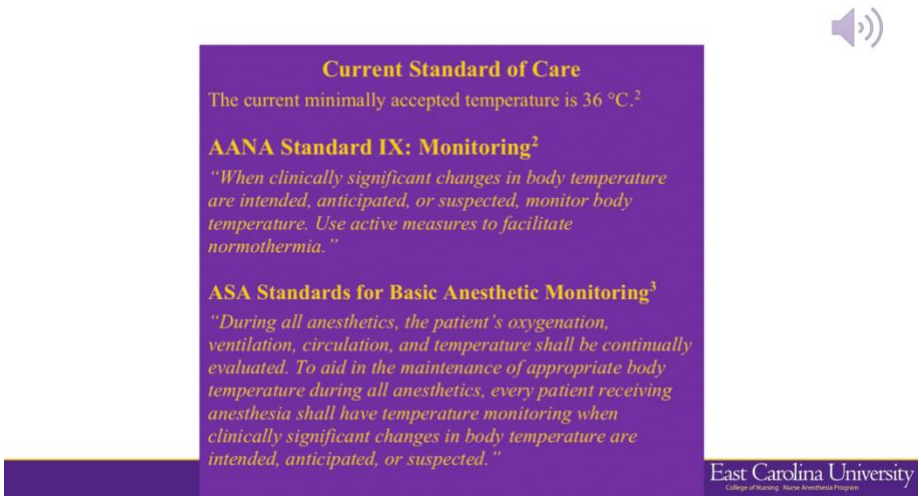



Script: The most common thermal abnormality in the perioperative period and the main cause of inadvertent perioperative hypothermia is inadvertent intraoperative hypothermia. Understanding the physiology behind how anesthesia contributes to heat loss helps us understand our role in preventing hypothermia during the perioperative period and its negative consequences for our patients. Under normal circumstances, without regional, IV, or volatile anesthetics on board, the hypothalamus receives thermal input from almost every type of body tissue, integrates that

thermal input, then activates effector mechanisms that alter metabolic heat production and environmental heat loss in order to normalize the temperature. These include behavioral regulation, which is the most powerful mechanism the human body has at adjusting its temperature, and autonomic responses, which include mechanisms such as cutaneous vasoconstriction, shivering, nonshivering thermogenesis, vasodilation, and sweating. Normally, there is a 2-4 degrees Celsius temperature gradient between the core and the periphery that is maintained by tonic thermoregulatory vasoconstriction. Under general anesthesia, however, the body's mechanisms at maintaining normothermia are significantly compromised. Behavioral regulation is nonexistent and autonomic responses are markedly impaired. For example, the normal threshold to trigger vasoconstriction and shivering are 36.5 and 36.0 degrees Celsius respectively, but general anesthesia markedly reduces the vasoconstriction threshold by 2-3 degrees Celsius and diminishes the effectiveness of these responses when activated. The interthreshold range, or the range of temperatures over which thermoregulatory autonomic responses are *not* activated increases up to ten-fold. Temperatures within this range do not trigger thermoregulatory defense mechanisms and patients are poikilothermic. This anesthetic-induced state of impaired thermoregulation caused by vasodilation, inhibition of vasoconstriction, and a 20-30% reduction in metabolic rate coupled with exposure to a cold environment and fluids are the major contributors to inadvertent intraoperative hypothermia and therefore perioperative hypothermia. Heat transfer from the human body typically occurs in four ways: conduction, convection, radiation, and evaporation. However, due to the effects of IV anesthetics, volatile anesthetics, and regional anesthesia there is a fifth factor, redistribution. Hypothermia under general anesthesia occurs in three phases

During phase 1, or the redistribution phase, there is a 0.5-1.5 degrees Celsius decrease in core temperature over the 1st hour. Anesthetic induced vasodilation causes a redistribution of heat from the core to the periphery as blood from the body's warm internal core temperature reaches the peripheral cold skin, becoming chilled, and then returning to the core and decreasing the core temperature. This phase accounts for 81% of the temperature decrease. Phase 2 involves a linear decrease in temperature over 2-4 hours that occurs because heat loss is exceeding metabolic heat production. After 3-4 hours, the drop in core temperature is finally low enough to trigger peripheral vasoconstriction, allowing metabolic heat to be restricted to the core, and a plateau phase occurs where the core temperature stabilize. As with general anesthesia, under neuraxial anesthesia, behavioral and autonomic cold defenses are also difficult to trigger and are less effective. Core temperature decreases by 0.5-1 degrees Celsius and a similar pattern of heat loss occurs except there may not be a plateau phase due to the prolonged inhibition of peripheral vasoconstriction.

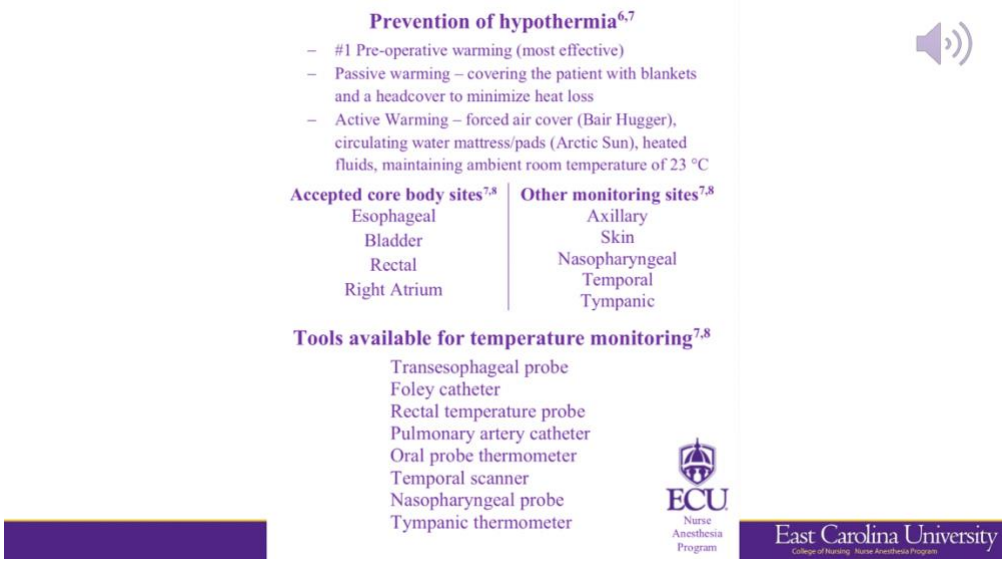
**Slide Four**




Script: Why do we care about maintaining normothermia during the perioperative period? We care because normothermia is not only good for the patient and their outcome, but it is also a

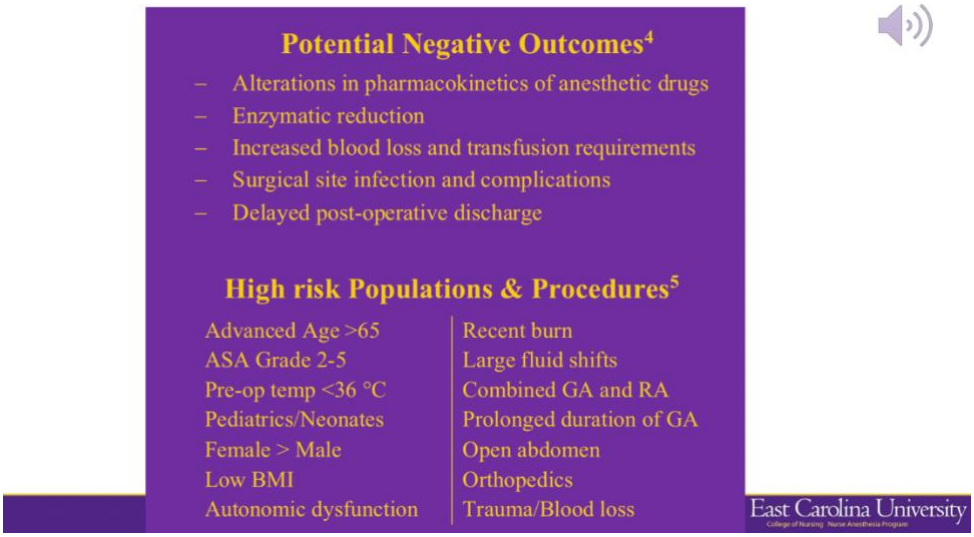
standard per the AANA and the ASA. Not only is it a standard but we must achieve a minimum body temperature at the end of surgery to receive reimbursement via the U.S. Centers for Medicare & Medicaid Services Quality Payment Program. The current minimally accepted standard of care is a temperature of 36° Celsius during the perioperative period. As you all know, the AANA has 14 Standards & Standard 9 includes monitoring & alarms required during anesthetic care. Standard 9 states "When clinically significant changes in body temperature are intended, anticipated, or suspected, monitor body temperature. Use active measures to facilitate normothermia." We also practice in accordance with the ASA standards, Standard 2.4 says "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." Lastly, the CMS Quality Payment Program Merit-based Incentive Payment System or MIPS #424 states " Patients undergoing surgical or therapeutic procedures under general or neuraxial anesthesia for 60 minutes or longer must achieve a temperature of at least 35.5° Celsius 30 minutes immediately before or 15 minutes immediately after anesthesia end time." Not meeting this benchmark puts your facility at risk for missing out on reimbursement for services provided.

**Slide Five**




Script: The most effective way to prevent peri-operative hypothermia is to initiate pre-warming. Passive warming may also be done using blankets and headcovers to prevent heat loss from patient. Active warming, which is what we see done the most intraoperatively, can be accomplished by using a forced air cover such as a bair hugger, a circulating water mattress or pads such as an Arctic Sun, heating fluids or blood before administration, or keeping the ambient room temperature at or above 23 degrees Celsius. Core body temperature most accurately reflects homeostatic and physiologic processes occurring. Sites used to obtain core body temperature include the following: Esophageal, bladder, rectal, and right atrium.
Other temperature monitoring sites include axillary, skin, nasopharyngeal, temporal, and tympanic. Tools currently available for temperature monitoring include the following: Transesophageal temperature probe, foley catheter with temperature monitoring feature, thermometer with rectal probe, rectal temperature probe (used solely, with rectal tube, or with Arctic Sun), pulmonary artery catheter, thermometer with oral probe, temporal scanner, nasopharyngeal temperature probe, and tympanic thermometer.

**Slide Six**



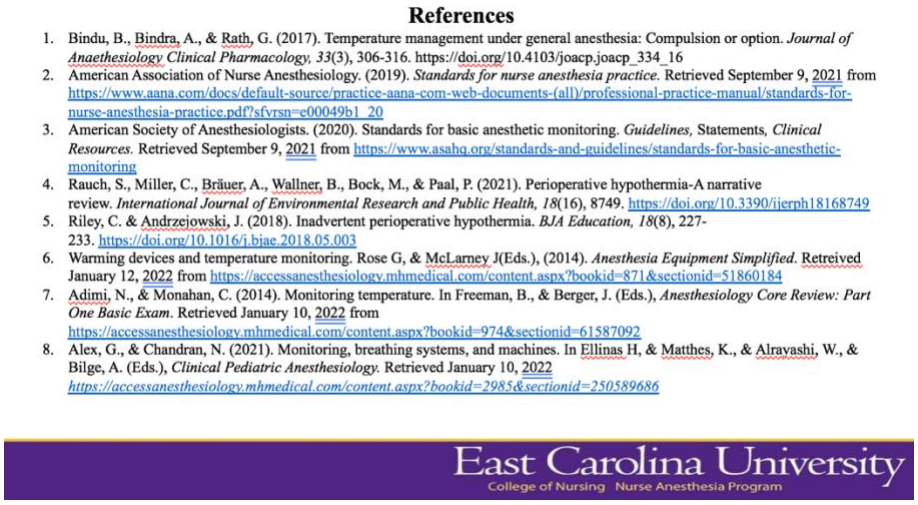

Script: As the body is no longer in homeostasis, many processes can be disrupted during hypothermic states that present in various negative patient outcomes such as alterations in pharmacokinetics of commonly used anesthetic drugs or volatile gases, coagulopathies, increased blood loss and transfusion requirements, surgical site infections and complications, and delayed post-operative discharge. Hypothermia can alter the distribution, metabolism, and clearance of anesthetic drugs through the reduction of enzymatic capacity, diversion of blood away from organs essential for metabolism such as the liver or kidney, and can even increase lipid solubility and alter ionization of common anesthetics. A frequently used anesthetic, Propofol, relies on hepatic metabolism and can increase in plasma concentrations during times of hypothermia due to reduced hepatic blood flow. Volatile gases such as Sevoflurane and Isoflurane will have an increase in potency with the Minimum alveolar concentration being reduced 5% for every 1 degree C drop in core body temperature. And all volatiles will see an increased lipid solubility with a decrease in core body temperature that can delay off-loading thus delaying emergence.

Hypothermia-related coagulopathies can be attributed to the reduced enzymatic activity and capacity within the clotting cascade. Furthermore, hypothermia reduces the release of thromboxane A2, reducing platelet aggregation. These associated coagulopathies attribute to both the increased intraoperative blood loss and increased transfusion requirements seen with just 1 degree C reduction in core body temperature. Hypothermia has proven to be a significant and independent risk factor for surgical site infection. Persistent peripheral vasoconstriction associated with hypothermia can lead to decreased tissue oxygenation and impaired protein metabolism at the surgical site. This can lead to poor wound healing, infection, and even wound dehiscence. The consequences of perioperative hypothermia can delay discharge, increasing cost for both the patient and hospital. High risk Populations & Procedures include advanced Age >65, ASA grade 2-5, preoperative Temperature <36.0, pediatrics/Neonates, female > Male, low BMI, autonomic dysfunction (i.e. Diabetes), recent burn, large fluid shifts, receiving combined general and regional anesthesia, prolonged duration under general anesthesia, open abdomen, orthopedics, trauma/Blood loss.

**Slide Seven**


Script: Thank you so much for your time and dedication to helping us further our education. We thoroughly enjoy working with and learning from each of you. We hope that you take some of the information in this presentation and apply it to your practice. Thank you again!

**Slide Eight**



# Appendix G

## Emails to Participants

### Initial Email to Participants

Dear CRNAs of [redacted],

Thank you for you considering participating in a quality improvement project titled "Raising the Brrr on Temperature Management." The purpose of this project is to assess CRNAs' perceptions of the effectiveness of current perioperative temperature monitoring and management practices and of a newly developed temperature management evidence-based resource at [redacted].

Participation is voluntary and will involve completing a short pre-intervention questionnaire of nine questions, viewing a brief PowerPoint with an audio voiceover presentation, utilizing a temperature management educational resource 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 and the video should take less than 2-4 minutes to complete. The questionnaires were created and are completed using Qualtrics® survey software. The use of "Raising the Brrr on Temperature Management" resource 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, please complete the pre-intervention questionnaire here.

Next, please view the "Raising the Brrr on Temperature Management" resource and its accompanying PowerPoint presentation. These materials are attached to this email. Again, thank you so much for your participation in our quality improvement project. I, Miranda Daniels, will be at [redacted] on June 6-9 and June 13-16 if you have any questions, but you may also reach out to me or Dr. Maura McAuliffe by email. Thank you again for your time and participation.

Sincerely,

Miranda Daniels BSN, SRNA
danielsmi19@students.ecu.edu

Maura McAuliffe CRNA, PhD, FAAN
mcauliffem@ecu.edu

**Pre-Intervention Survey Reminder Email to Participants**

Good morning CRNAs of [redacted],

I just wanted to send a quick reminder about the ongoing DNP Project on temperature monitoring and management. If you've already filled out the pre-survey and viewed the video, thank you so much! If you haven't had a chance to yet, it is not too late and it would be very helpful and appreciated. Please complete the pre-survey here. I have attached the "Raising the Brrr on Temperature Management" resource and its accompanying PowerPoint presentation for you to use at your discretion. After this week, I will begin sending out the post-surveys.

Pre-survey link

Please let me know if you have any questions and thank you again for your participation.

Sincerely,
Miranda Daniels, SRNA
ECU Nurse Anesthesia Program
Class of 2023

**Post-Intervention Survey Email to Participants**

Dear CRNAs of [redacted],

Thank you so much to everyone who has already completed my pre-survey and viewed the attached resources! It's now time to complete the brief post-survey here.

*If you have not filled out a pre-survey*, I would really appreciate your participation. The link to the pre-intervention survey is here If you would like, you can follow it up by viewing the attached temperature monitoring and management resource and its accompanying PowerPoint presentation.

If you've already completed the first survey, here is the link to the post-survey It should take less than 3 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 coming back to [redacted] in the future.

Sincerely,
Miranda Daniels, SRNA
ECU Nurse Anesthesia Program
Class of 2023

**Post-Intervention Survey Reminder Email to Participants**

Good morning,

I hope you all are doing well and that your weeks are off to a great start! I wanted to thank you again for participating in the pre-intervention survey for my DNP project and ask if you would please consider filling out the post-intervention survey. If you have time, I would be extremely grateful for your responses.

Click here to access the post-survey

Thank you so much,

Miranda Daniels, SRNA
ECU Nurse Anesthesia Program
Class of 2023

**Final Thank You Email to Participants**

Dear CRNAs of [redacted],

I just wanted to say thank you so much to everyone for helping me out with my DNP Project! [redacted] was my only assigned site of implementation for this project, so your participation truly helped me tremendously. I now have enough data to perform data analysis and finish my paper. I am very grateful for your participation and everything each of you taught me as preceptors during my rotation in [redacted]. I hope to work with you again in the future!

Take care,
Miranda Daniels, SRNA
ECU Nurse Anesthesia Program
Class of 2023

## Appendix H

## Survey Questions

### 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?

_____