Perioperative Temperature Monitoring and Management to Maximize Patient Safety: A Quality Improvement Project

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Notes from the Author

I would like to express my gratitude and appreciation for all who helped shape this project as well as those who have greatly influenced my educational and professional career.

This one is for you B.

Abstract

Appropriate temperature monitoring and management is an important part in optimizing patient success in the operative theatre. Perioperative hypothermia remains a threat to patient morbidity and mortality and consistent measures for thermoregulation are needed. The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and of a newly developed intraoperative temperature monitoring educational tool. Invited participants in this project were Certified Registered Nurse Anesthetists (CRNAs) who took a short pre-intervention questionnaire assessing temperature monitoring knowledge, listened to a recorded educational PowerPoint presenting a newly developed educational tool, and completed a post-intervention questionnaire after the two-week implementation period concluded. Findings suggested that the intervention alerted the CRNAs to the existing AANA national temperature monitoring standard. There was also an improvement in the time required for the CRNAs to locate a reference of evidence-based guidelines to answer any questions they had regarding best practice for perioperative temperature monitoring, as well as an increase in provider confidence in their knowledge. Limitations of this project involved the short project timeline and small sample size. Four participants reflect only a small portion of the anesthesia department at the participating facility. For future projects, more attention could be focused on educating CRNAs on proper temperature monitoring technique and best current practice. Additionally, the organization itself could provide future educational material disbursed to include the current national guidelines.

Keywords: perioperative, hypothermia, nurse anesthetist

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Section I. Introduction

Background

With the incidence of perioperative hypothermia ranging from 20% to 70% among patients receiving general anesthesia in the United States, efforts focusing on improving temperature measurement and management are necessary and ongoing (Ruetzler & Kurz, 2018). Thorough and consistent thermoregulation monitoring in the surgical setting is essential for positive patient experiences and reduced negative outcomes. Advanced monitoring technology and a growing variety of temperature maintenance strategies and resources aid anesthesia providers in maintaining normothermic core body temperature throughout the perioperative period. Currently, many researchers are focusing on the recurring problem of inadvertent perioperative hypothermia (IPH), which is hypothermia that is not induced, planned, or intentional (Ruetzler & Kurz, 2018).

Hypothermia is defined as a core body temperature of less than 36 degrees centigrade. A selective grouping of surgical procedures may require a core body temperature below 36 degrees centigrade, while hypothermia in other cases can be a significant contributing factor to perioperative morbidity and mortality (Ruetzler & Kurz, 2018). In congruence with current clinical guidelines, anesthesia providers must be diligent with patient temperature management, recognize that general anesthesia is one modality that significantly impacts temperature autoregulation, and strive to use all available resources to contribute to the reduction of IPH occurrences. One example of how general anesthesia affects thermoregulation is with the administration of a neuromuscular blocking drug. A neuromuscular blocking drug not only allows for maximizing ventilator synchrony and inhibiting movement for procedures, but also prevents the patient from shivering. Shivering is a response the body produces when

hypothermic to maintain homeostasis within the body. Shivering is largely responsible for increasing the patient's temperature when they are hypothermic, but is associated with increases in heart rate, blood pressure, and overall oxygen demands due to increased consumption (Šunjić, et al., 2015).

The hypothalamus, the thermoregulatory center in the body, is depressed by general anesthesia which contributes to the heat loss experienced during general anesthesia. Heat loss occurs in three phases, with the most rapid occurring during phase one. Within the first hour, 1.6 °Celsius is lost due to vasodilation occurring in the periphery. Phase two is a period of poikilothermia where heat lost to the environment exceeds heat production. For the first 3-4 hours, 0.5 °Celsius is lost per hour until the patient has reached 34.5 °Celsius. A plateau is reached once the patient's temperature falls below 34 °Celsius where phase three ensues. Vasoconstriction resumes at this point and decreases heat loss by 25% (McAuliffe, 2021). Maintaining normothermia is required for essential enzymatic reactions to occur. Altered enzyme activity can significantly impact the pharmacodynamics as well as the pharmacokinetics of many drugs. Volatile agents, for example, have increased solubility with a delayed washout under hypothermic conditions which may contribute to prolonged emergence times from general anesthesia. Minimal alveolar concentration (MAC) also decreases 5% for every 1 °Celsius decrease in temperature which may result in a decreased requirement of volatile agents (McAuliffe, 2021).

Because thermal irregularities have been associated with potentially harmful patient outcomes, the current standard of care is to monitor temperature during all general anesthesia cases, maintaining normothermia unless otherwise indicated (American Association of Nurse Anesthesiology [AANA], 2019; Insler & Sessler, 2006). The most current AANA standards for

nurse anesthesia practice categorize thermoregulation under “Standard 9: Monitoring, Alarms” which states that the reasonably prudent nurse anesthetist is to monitor temperature when significant temperature changes are expected, predicted, or intended and “use active measures to facilitate normothermia” (2019, p. 3). The American Society of Anesthesiologists (ASA) has comparable standards regarding temperature monitoring, also instructing anesthesia providers to monitor temperature in all patients receiving general anesthesia when a significant, anticipated, or predictable alteration in temperature is expected (2020). The importance both anesthesia organizations place on temperature monitoring further confirms the critical role of the anesthesia provider in maintaining normothermia perioperatively.

Compliance with AANA Standard 9 as well as documentation of appropriate patient care also contribute to meeting requirements of hospital Medicare reimbursement for services provided as outlined by the Merit-Based Incentive Payment System (MIPS; Centers for Medicaid and Medicare Services, 2020). Perioperative temperature management under the anesthesiology specialty is currently listed as a high priority patient outcome measure for all patients regardless of age. MIPS reports that IPH occurs in up to 20% of patients undergoing general anesthesia. They also discuss the negative impact IPH has on patient readiness for discharge. Because of the substantial number of Americans receiving healthcare benefits from Medicare, all Medicare accepting healthcare organizations have additional financial motivation for assuring a reduction in the incidence of IPH in patients undergoing surgical procedures at their facilities.

Organizational Needs Statement

Located in a southern state, the partnering organization is a Magnet-recognized, Level 1 designated trauma center with approximately 1,000 beds that serves 29 counties, many of them rural and facing economic challenges. In fiscal year 2019, the facility reported performing over

20,000 surgery cases. The facility's current policy, titled "Prevention of Hypothermia in the Perioperative Setting," states "the patient's temperature will be measured and monitored during all phases of perioperative care." The policy also states that the methodical plan to prevent perioperative hypothermia is a collaborative effort involving all members of the perioperative team.

According to the policy, selection of site and method for temperature monitoring is also a perioperative collaborative effort that considers the type and length of surgery, anesthesia type and delivery method, body site accessibility, and level of invasiveness. The current policy statement does not provide temperature monitoring methods but does include hypothermia prevention specific information, including passive insulation methods and active warming methods.

Problem Statement

IPH increases the risk for poor patient outcomes, patient dissatisfaction, and reimbursement issues in surgical practice. Despite current research identifying the frequency and risks of IPH as well as advances in monitoring techniques, IPH remains a persistent problem for a range of patient populations. Ensuring that anesthesia providers have access to perioperative temperature monitoring educational resources is important for maximizing the effectiveness of current clinical practice.

Purpose Statement

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and of a newly developed intraoperative temperature monitoring educational resource.

Section II. Evidence

Description of Search Strategies

A structured review of scholarly literature addressing the prevention of inadvertent intraoperative hypothermia during the intraoperative period (referred to in this paper primarily as IPH) was undertaken in an effort to identify evidence needed to inform the design and implementation of a CRNA specific educational resource. The executed search was guided by the PICOT question: "How do CRNAs perceive an educational resource designed to review current evidence-based practice recommendations regarding intraoperative temperature monitoring in the operating room." The search was completed using the keywords perioperative, temperature, CRNA, and monitoring. Databases utilized for the search included PubMed and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). The search engine Google Scholar and the online educational resource Access Anesthesiology were also queried. Searches were limited to peer-reviewed publications from 2016 to 2021 when limiting was available.

All keywords and concepts were combined utilizing Boolean operators. The search strategy performed in PubMed was: (Perioperative OR Operating room OR Surgery OR Surgical OR Anesthesia) AND (Hypothermia OR Hyperthermia OR Temperature OR Core Body Temperature OR Thermoregulation) AND (CRNA OR Nurse Anesthetist OR Certified Registered Nurse Anesthetist OR Anesthesia OR Anesthesiologist) AND (Monitoring OR Non-Invasive Device OR Intraoperative Monitoring OR Warming Devices). The same query strategy was used in Google Scholar. Keywords for the concepts perioperative, temperature, CRNA, and monitoring were used to identify pertinent subject headings in CINAHL. Refer to Appendix A for specific keywords, search terms, and additional details pertaining to the query.

Selection of items from the search results was determined by relativity to the concepts addressed in the PICOT question. Specific focus was placed on identification of studies or investigations focused on perioperative temperature monitoring or IPH. Inclusion and exclusion criteria are included in Appendix B.

Melnyk and Fineout-Overholt (2019)'s *Evidence-based practice in nursing and healthcare: A guide to best practice* was utilized to classify the types of evidence identified. Based on this resource, one systematically performed retrospective chart review (Level III), one implementation survey analysis (Level VI), four quality improvement studies (Level VI), two observational studies (Level VI), one qualitative study (Level VI), and one retrospective study (Level VI) were identified as pertinent to this project. Further details on levels of evidence can be found in Appendix C.

Selected Literature Synthesis

Multiple gaps and barriers have been identified as preventing full provider compliance with temperature monitoring and prevention of hypothermia during the perioperative period. There is little research currently available relating compliance in intra- and post-operative monitoring and treatment to patient outcomes.

Identified Issues and Barriers

Multiple researchers have investigated the issues and barriers associated with the continued occurrence of perioperative hypothermia. Steelman et al. (2015) investigated the relationship between existing perioperative temperature documentation and incidence of intra- and post-operative hypothermia. They conducted a chart review of 10,673 records of patients undergoing surgical procedures of longer than 60 minutes and requiring general or neuraxial blocks during the four-year period from 2008 to 2011. They identified a need to place greater

emphasis on adoption of evidence-based practices tailored to properly monitoring individual patients rather than solely on documentation compliance. The authors concluded that a significant gap exists between compliance with quality improvement measures and actual achievement of normothermia among patients undergoing surgical procedures. Efforts placed on adoption of evidence-based practices often emphasize maintaining compliance with quality performance measures rather than the actual desired patient outcomes. This study suggests, however, that reaching ideal patient outcomes rather than simple documentation assessment needs to be the greater focus, and more emphasis should be placed on education regarding the detrimental effects of hypothermia in vulnerable patient populations.

One issue of concern with assessing compliance with documentation of temperature monitoring in the intraoperative period is a potential for manual manipulation of data to better meet quality metrics impacting reimbursement levels. A study by Freundlich et. al (2018) assessed the integrity of provider-entered temperatures in comparison to automatically-recorded computer temperatures in light of perioperative temperature being introduced as a quality metric. To seek an explanation as to why manually-entered patient temperatures varied significantly from those automatically-entered, they reviewed literature on the weaknesses of manually entered data in comparison to those automatically entered. From this review, they found that putting a provider between the patient and the electronic medical record opened opportunity for error. In their review, over 60,000 pre-operative temperatures, over 100,000 intraoperative temperatures, and almost 285,000 PACU temperatures collected over a 5 year span were analyzed. Their statistical analysis revealed a variance in recorded PACU and pre-operative temperatures. Explanations proffered included provider bias, intentional or unintentional rounding, or differences in temperature monitoring tools in the intra-operative and post-operative

settings. The authors concluded that provider-entered temperatures had significantly different distributions than those automatically entered. This study provided evidence to support the need for future qualitative studies to analyze provider awareness and understanding of perioperative temperature metrics.

A similar quality improvement study completed by Munday et al. (2013) addressed the clinical gaps related to provider education that may hinder practice improvement. This quality improvement study involved auditing the perioperative records of 73 patients prior to project implementation (to be used as a baseline), and then of 72 patients after an evidence-based best practices educational intervention delivered using a multifaceted approach. They found a small increase in temperature monitoring on admission or in the pre-operative suite, and a considerable increase in temperature monitoring in the holding area from pre- to post-implementation audit. The results demonstrated there was only a slight increase in the number of normothermic patients from pre-operative to operative time. Although none received pre-warming either pre- or post-intervention, there was an increase in intra-operative warming after implementation of the intervention. These results suggest that, despite educational materials being distributed in multiple different media types, barriers still exist. The barriers, which need to be considered when designing future quality improvement projects, include: large groups of staff requiring education with limited educators, lack of temperature monitoring equipment in the pre-operative area, no area on the pre-operative checklist to include the patient's temperature, and the currency of existing hospital policy addressing patient warming and temperature documentation requirements.

Munday et al. (2019) took the quality improvement study completed by Munday et al. (2013) to elucidate healthcare providers' perceptions. Their quality improvement study was

designed to evaluate the perspectives of healthcare professionals directly involved in surgical areas to determine how to best overcome barriers and capitalize on enablers of the prevention of IPH They included eight nurses, two surgeons, and two anesthetists for a total of 12 participants who completed semi-structured interviews. The aim of the interviews was to gain insight about providers' perceptions of the current temperature management practices in the operative setting. Eleven theoretical domains were identified as relevant for successful implementation of perioperative hypothermia prevention. These theoretical domains were "knowledge; skills; social/professional role and identity; beliefs about capabilities; optimism; beliefs about consequences; reinforcement; goals; memory, attention, and decision processes; environmental context and resources; and social influence" (Munday et al., 2019, p. 398).

According to the authors, findings suggested the importance of effective and continuing education and multi-disciplinary teamwork and that future interventions to prevent IPH should consider utilizing a team-based, multi-modal approach (Munday et al., 2019). Availability of necessary equipment for temperature monitoring also had an influence on providers' perceptions as to whether or not they felt the current practice was adequate. Additionally, the effectiveness, feasibility, availability, acceptability, and cost of the equipment should be prioritized to facilitate the necessary improvement of IPH occurrences. The conceptual framework for interprofessional work by Reeves et al. (2010), which was used in this quality improvement project, seems congruent with the recommendations made by Munday et al. (2019) and could be a useful resource when designing perioperative team training forums and engagements to maximize success.

Gustafsson et. al (2017) found similar results after completing a quality improvement study using a descriptive survey/questionnaire sent to nurse anesthetists and anesthesia

department heads in 48 Swedish hospitals. Two surveys were used to evaluate both accessibility and application of evidence-based recommendations. The surveys were similar in design, and focused on surgery specifics including type, operating room environment, risk for hypothermia, and typical procedural time. The surveys also included items addressing the nurse anesthetists' perceptions and knowledge of existing guideline recommendations. Reasons why current recommendations were not being followed were also evaluated. The researchers found that 40% of surveyed nurse anesthetists did not have knowledge of current guidelines for practice. These findings support providing continued employee education to ensure all practitioners are following the same current, evidence-based recommendations to minimize hypothermic-related patient complications.

The aforementioned studies all support the need for continued education and interdisciplinary communication to help providers keep up-to-date about current evidenced-based clinical recommendations.

Interventions

A variety of interventions aimed at increasing provider compliance in monitoring for and preventing perioperative hypothermia have been trialed in clinical settings. Recognizing that interdisciplinary communication was a weakness in their partnering agency, Guidash et al. (2021) implemented a hand-off script developed by the multidisciplinary team for improvement. Patient tracers were also used to identify opportunities during the perioperative period where heat loss mitigation was most important to improve patient outcomes. Hand-off script compliance was measured utilizing a hand-off audit tool. This tool also recorded team member attendance and the time commitment required for the hand-off process. The involved team

member was given a post-intervention questionnaire to rate their satisfaction with the new hand-off tool and offered an opportunity to provide improvement recommendations.

Guidash et al. (2021) found the rate of anesthesia provider participation in the handoff study increased from 78.8% to 98.4% during the 2014 to 2019 study, while the incidence of hypothermia decreased from 28.6% to 6.3%. The decreased incidence of hypothermia was sustained from 2016 to 2021. Findings from this study suggest that standardization of transfer of care among disciplines is the best approach to optimizing the management of surgical patients during transition from the operating room to the post-operative care unit or intensive care unit.

The concept of a thermal care bundle was introduced using a collaborative implementation by Duff et. al (2018). It provides an example of a study that did not yield the desired effect, but whose results could still be capitalized on for future study design. In this study, 800 randomly sampled patient charts were audited, with 400 being pre-implementation and 400 being post-implementation. This bundle included a risk assessment for hypothermia, contraindications to active warming, recordings of perioperative temperatures, and use of active warming intraoperatively for temperatures below 36°C. An audit tool included patient demographics, surgical characteristics, and compliance with guideline recommendations. Implementation of the thermal care bundle was associated with increased completion of patient risk assessments, documentation of temperature, and utilization of appropriate active warming. It also allowed for early detection of IPH because of the increased frequency in temperature monitoring. Though the incidence of IPH was unchanged, the delivery method and program evaluation technique for the bundle was still successful, as it helped improve clinical practice.

Scott et. al (2015) and Şenkal and Kara (2020) both evaluated the successes of newly implemented provider protocols/guidelines. Scott et. al retrospectively analyzed the Surgical

Care Improvement Project (SCIP), originally introduced in 2003, in an effort to both measure and improve perioperative patient care. Their retrospective analysis of the electronic medical records of 45,304 inpatients documented methods of temperature measurement and recorded patient temperatures during the pre-, post-, and intraoperative periods. SCIP compliant providers were defined as those who selected reasonable temperature measurement devices for the allotted surgical procedure and who appropriately documented and treated patient temperatures. Those compliant with the SCIP guidelines demonstrated improved patient outcomes in comparison to those non-compliant with the SCIP guidelines. This illustrates how set guidelines provide clinicians a basis for patient care decisions and also improve documentation compliance.

Senkal and Kara (2020) created a Prevention of Unintended Perioperative Hypothermia manual that included procedural notes and necessary equipment, methods, and actions to achieve the desired effect, which in this case was normothermia. The study was divided into three periods: 1) Pre-implementation period, 2) Protocol development and implementation strategy period, and 3) Post-implementation period. Period one consisted of gathering data on 349 patients who all received thermal care during perioperative care. The second period included the introduction and inclusion of the newly developed manual. This was accomplished through presentations, on-site training, and distribution of the printed manual. The third period consisted of data collection from 320 surgical patients to assess for the impact of introduction of the manual. The assimilation of this manual into practice was associated with a decreased incidence of IPH, which the researchers referred to as unintended perioperative hypothermia, was observed (Senkal & Kara, 2020). This supports this QI project goal of providing a tangible reference material presented in different ways to accommodate multiple learning styles.

Lakha et. al (2020) provide a potential solution for improving provider compliance in perioperative temperature management, suggesting the adoption of intraoperative electronic alert systems would alert providers of real-time patient temperature trends, prompt temperature measurement, and maintenance of normothermia. Their study considers the financial implications of MIPS 424: Compliance Improvement (Centers for Medicare and Medicaid, 2020) and demonstrates that the effectiveness of a decision support tool for improving temperature monitoring and maintenance. This study also provides evidence for other variables associated with inconsistency in documenting temperature monitoring. For example, a patient may meet the MIPS temperature measurement requirement intraoperatively but may fail to meet this requirement in the PACU due to less capable invasive temperature monitoring equipment. This suggests that results of interventions can be misrepresented when comparing intraoperative to PACU temperatures.

Though most evidence identified in this literature review appears to support the general premise that the implementation of a quality improvement project will improve patient outcomes by reducing IPH, a study by Duff et al. (2018) did not. The authors found the delivery and evaluation of the recently developed bundle successful, however, the incidence of IPH cases identified increased post-implementation, which the authors attributed to increased identification of patients at high risk for developing IPH and improved documentation of pre-operative temperature, rather than an increase in actual rate of occurrence.

Project Framework

Model for Improvement Using the PDSA Quality Improvement Cycle

The model for improvement suggested by the Institute for Healthcare Improvement is intended to be a continuous improvement process that becomes more successful and consistent

with each cycle (IHI, 2022). The plan-do-study-act (PDSA) cycle is useful to apply and assess change (Langley et. al, 2009).

The aim of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and of a newly developed intraoperative temperature monitoring educational resource. Specific objectives were to assess if CRNAs reported increased knowledge and understanding of where to locate policies, greater awareness of how to apply current evidence-based practice knowledge, and awareness of additional temperature monitoring resources available to them after completion of the two-week intervention period.

The *plan* portion of this project was accomplished by using evidence from the literature to define the problem and determine the intervention to be used to address the issue. The *do* step involved developing and sharing the informational resource with project participants, along with pre- and post-implementation surveys to gather data about their perceptions of practice and the provided resource. Analysis of pre- and post-intervention survey responses was accomplished during the *study* step of the cycle, with evaluation focusing on identification of any changes and factors that may or may not have contributed to identified results. The *act* portion of the cycle involved sharing findings and future suggestions with others, including interested participants, but did not include implementation of changes within the project setting.

Conceptual Framework for Interprofessional/Interdisciplinary Work

The conceptual framework for interprofessional work was developed by Reeves et al. (2010). This framework was developed because of the increased attention placed on the improvement of interprofessional relationships, patient care quality, and interdisciplinary collaboration. This framework explores various key elements of interprofessional work, such as

"shared team identity, clear roles/goals, interdependence, integration, and shared responsibility in defining teamwork" (Jayasuriya-Illesinghe, et at., 2016, p. 2). The conceptual framework for interprofessional work is especially applicable in delivery of anesthesia care as all disciplines must come together to work effectively in order to ensure the highest level of healthcare is provided to patients, including anesthetic planning and management.

There are several key assumptions and propositions within this framework. The key assumption is that interdisciplinary collaboration is a "good thing" (Jayasuriya-Illesinghe et al., 2016, p. 1). Another assumption is that interprofessional work or teamwork is a positive, realistic, and functional way to deliver healthcare. The key propositions include the idea that interprofessional teamwork is shaped by four domains: relational, processual, organizational, and contextual (Jayasuriya-Illesinghe et al., 2016). The primary focus of the relational domain is how leadership, management, or power influences the functionality or dysfunction of a team. The processual domain addresses how "time, space, and task complexity affect teamwork" (Reeves et al., 2010, p. 4). The organizational domain focuses on the location of the team, focusing on the structure, support, and commitment of the team. Lastly, the contextual domain addresses the political, cultural, economic, and social landscape where the team is operating. Of note, the authors of this framework attest to their work as being representative of what an ideal heath care team would look like, not necessarily what currently exists in today's world (Reeves et al., 2010).

This framework has been used to increase effective collaborative practice, which has been noted to increase accessibility to care, decrease healthcare costs, and increase overall efficiency of delivery. This is especially relevant today with the increasing changes and expenses in healthcare financing and delivery of care (Smith, 2014). The conceptual framework for

interprofessional work can be easily applied to both the phenomenon of CRNAs managing patients' core temperatures in the operating room and the concept of interdisciplinary collaboration. The approach of this framework allows each member of an interdisciplinary team, including CRNAs, to be matched to their intended purpose, keeping in mind their intentions and abilities to serve in that team role. Effective interdisciplinary collaboration shadows this framework in that the team dynamics are largely situational; depending on the setting and scenario, shifts could occur in leader and team member roles (Jayasuriya-Illesinghe et al., 2016).

Some of the biggest challenges to fully utilizing this framework are conflicting personalities and power differences within the individual disciplines that make up the team. These both, if not addressed, can lead to decreased communication between the individuals and less effective patient care coordination amongst interdisciplinary teams. One of the potential solutions to help mitigate these inevitable challenges is to increase the interprofessional educational opportunities available for staff (Reeves et al., 2010). These opportunities allow team members the opportunity to increase their capacity to listen and appreciate the opinions of others, and therefore help support the successful application of the conceptual framework for interprofessional work. The notion of teamwork could be applied in the perioperative setting when the surgical team is communicating goals and plans for the patient during the case. This would include all aspects of hemodynamic monitoring, including temperature goals.

Ethical Considerations and Protection of Human Subjects

All CRNAs meeting established criteria were invited to participate on a voluntary basis with completion of the electronic surveys serving as consent. Risks were not greater than those encountered during their usual work and no activities were outside of current care standards utilized within the facility. Individual rights were respected and no personal data was gathered.

Additionally, no patients or patient data were part of this project. There was no monetary compensation for participation.

Formal approval process preparation included completion of Collaborative Institutional Training Initiative (CITI modules) by the primary investigator (https://about.citiprogram.org/). The approval process itself began with evaluation of the project in regard to the need for full Institutional Review Board (IRB) approval through a collaborative process between the East Carolina University (ECU) College of Nursing and the ECU University and Medical Center Institutional Review Board (UMCIRB). It was determined the project met requirements for quality improvement and full IRB approval was not required. An additional process through the participating facility and the ECU UMCIRB was also completed, with approval provided. A contact person from the unit where the project was completed also provided acknowledgement through their signature on the approval form (see Appendix D).

Section III. Project Design

Project Setting

The partnering facility was a Level 1 trauma center located in a southern state. This hospital is the flagship medical center of a healthcare system comprised of nine total facilities. The partnering facility has approximately 1,000 beds and is Magnet-recognized. During the 2019 fiscal year, over 20,000 surgeries were performed at this facility. A wide variety of surgical procedures are performed by general surgeons as well as specialists in neurosurgery, orthopedics, gynecology, obstetrics, plastics, urology, surgical oncology, cardiac, transplant, podiatry, and endoscopy. The anesthesia department is comprised of anesthesiologists, CRNAs, and anesthesia assistants (AAs). An existing relationship between the facility and the university facilitated the implementation of this project. Potential barriers included a high volume of surgeries and a fast-paced surgical setting.

Project Population

The project participants were CRNAs providing anesthetic care to patients undergoing surgical procedures in designated orthopedic suites within the partnering organization who voluntarily agreed to participate in this quality improvement project. The organization's partnership with the university facilitated this quality improvement project as many of the CRNAs are familiar with the university's staff and student body. Several CRNAs at this facility also serve as preceptors for new graduates and as mentors for current students. Potential barriers to participation included possible CRNA disinterest in participating.

Project Team

The project team consisted of a SRNA primary team lead, a CRNA faculty project chair, a site contact person from the partnering organization, a CRNA faculty clinical contact person,

the CRNA program director, the course director, and three other SRNA project team members who participated in development of the project. The site contact person signed the letter of acknowledgment that data was to be collected within the surgical suite of the hospital (see Appendix D). The clinical contact person provided necessary contacts within the facility and helped determine those eligible to participate in the study. The program director served as a liaison between the university and the participating facility.

The team lead independently launched this quality improvement project and collected and analyzed data from the selected site. The team lead was responsible for facilitating communication with the project chair, site contact person, and clinical contact as needed. Together, the team lead and project chair established a project timeline. The project team members contributed to the overall project objectives, provided expertise, and contributed to project/tool design. The project chair approved final materials before delivery/presentation, ensured availability of resources, provided expertise, and reinforced the project goals as needed. The course director served as a resource during this quality improvement project and provided suggestions for both organization and display of project findings and statistics.

Methods and Measurement

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and of a newly developed intraoperative temperature monitoring educational resource. A pre-intervention survey was created using Qualtrics survey software and distributed via email to participating CRNAs to assess their current perceptions of temperature monitoring. The survey tool was created to be readily accessible on desktops, tablets, or smartphones. Types of measurement included in the survey tool included nominal, ratio, as well as open-ended

questions. The pre- and post-questionnaires may be viewed in Appendix E. Responses were analyzed using Microsoft Excel.

An informational handout was created to include the most up-to-date, evidence-based practice recommendations involving peri-operative thermal care (see Appendix E). It was shared via email along with the invitation to participate in the project and the pre-implementation survey to the selected CRNAs (see Appendix F and Appendix G).

A follow-up post-implementation survey (see Appendix E), which included follow up questions from the pre-implementation survey as well as a few additional ones, was sent two weeks after the initial survey. Responses were again recorded and analyzed using Microsoft Excel. Data analysis was used to assess for change by comparing pre- and post-intervention surveys.

The *planning* portion of this project included identifying current practice resources, developing the intervention materials, and creating the pre- and post-intervention surveys. The *do* portion involved distribution of the Qualtrics surveys and intervention tool via emails to participants and gathering the data using Microsoft Excel. *Study* activities included analyzing the data using Microsoft Excel and considering the implications of the results. The *act* portion of the project involved delivery of findings and suggestions for future adaptation to other members of the anesthesia program, participants, and representatives of the partnering organization through a poster presentation

Participants were volunteer CRNAs providing anesthetic services to patients undergoing orthopedic procedures. Communication with participants was primarily via electronic mail unless questions arose in the clinical setting and the team lead was approached by one of the participants in person.

Section IV. Results and Findings

Results

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the effectiveness of their current practice for intraoperative temperature monitoring and of a newly developed intraoperative temperature monitoring educational resource. Survey links along with the educational resource were sent via email. Data from the pre-survey was collected over a two-week implementation period with a reminder email being sent out after one week. Data from the post-survey was collected over a one-week period. A follow-up thank you letter was sent following receipt of the final response.

Five participants were invited to participate in this project, with four responses received for both the pre- and post-survey. Data was collected via Qualtrics surveys formatted for both a cellular device and desktop and was analyzed utilizing Microsoft Excel.

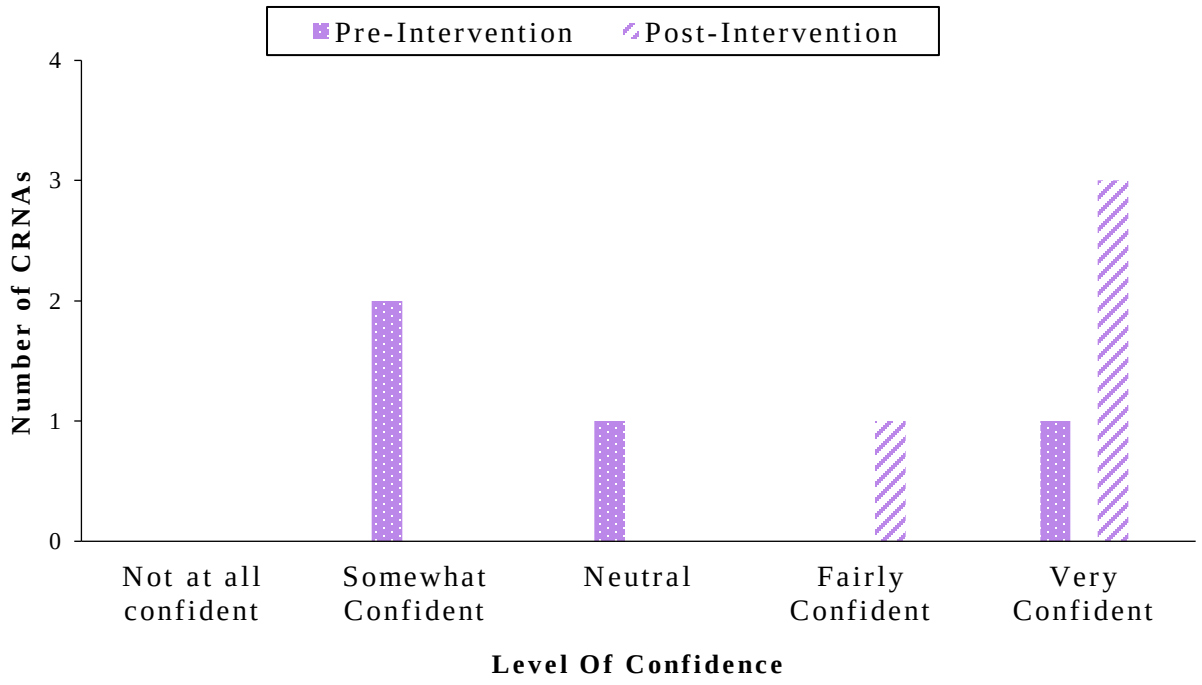
Data Presentation One of the four respondents reported that they had not received education on temperature monitoring policies or standards for their current surgical setting. All respondents reported that they utilized intraoperative temperature monitoring 75-100% of the time during a 40-hour work week. When asked if they were aware of the AANA national standard for temperature monitoring on the pre-survey, three out of four answered *yes* and one out of four answered *no*. The intervention included the current AANA national standard and all CRNAs responded they could access it in the post-survey.

When asked how long it would take to access a reference of evidence-based guidelines about perioperative temperature monitoring, the four responses were evenly split between 1-3 minutes and 4-6 minutes. After the intervention, three out of four responded 1-3 minutes while the fourth participant responded 4-6 minutes.

When asked about their confidence level in identifying core temperature monitoring sites, three of four participants responded *very confident* and one responded *somewhat confident* on the pre-survey. After the intervention, four of four respondents reported *very confident* on the post-survey. There was no change in responses between the pre- and post-surveys when assessing CRNAs' ability to identify patients or procedures at higher risk of intra-operative heat loss, with three participants being *somewhat confident* and one reporting *very confident.*

Figure 1

Self-Reported Confidence Level of Perioperative Temperature Monitoring Knowledge



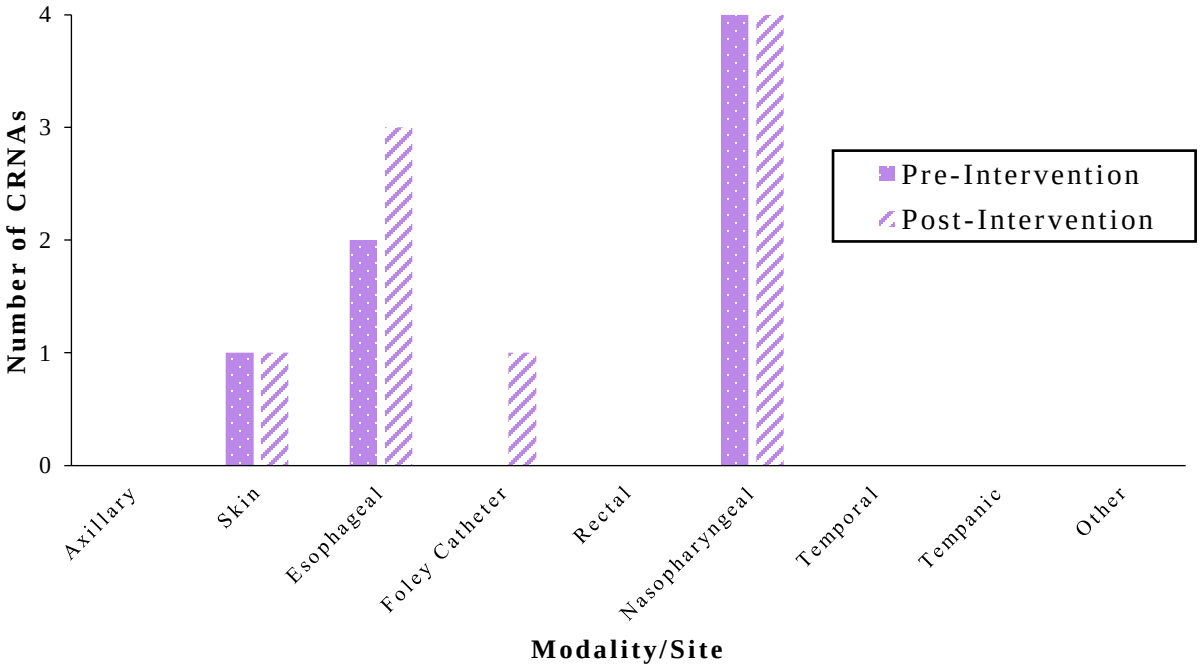
Note. N=4. CRNAs = Certified Registered Nurse Anesthetists.

As noted in Figure 1, responses ranged from *neutral* to *somewhat confident* to *very confident* when CRNAs were queried about their confidence level of their own perioperative temperature monitoring knowledge. All responding CRNAs indicated in the post-intervention survey that they would reference the educated resource again and there were no responses to the

open-ended question asking the input for future improvements/recommendations for the educational resource.

Figure 2

Preferred Modality/Site for Temperature Monitoring



Note. N=4. CRNAs = Certified Registered Nurse Anesthetists. Multiple responses allowed.

As noted in Figure 2, similar temperature monitoring sites were selected when comparing before and after the interventional period, however, there was an additional response for esophageal monitoring and a new response for foley catheter temperature monitoring.

Two respondents reported being *neutral* and two were *somewhat confident* about the accuracy of current temperature monitoring devices available to detect the patient's core body temperature. When asked how often CRNAs find that their last operating room temperature correlates well with the first PACU temperature, one CRNA answered 25-50%, two answered 50-75%, and one answered 75-100 % of cases. When asked about issues that hinder a closer correlation between intra-operative and post-operative temperatures, two respondents reported

lack of education and two respondents reported lack of similar/same equipment for temperature monitoring.

An open-ended question about barriers to preventing intraoperative hypothermia produced several different responses with much commonality. Some of the perceived barriers to preventing intra-operative hypothermia included room temperature, operating room staff preference, and patient warming resource availability. Several respondents commented that cold room temperature is predominately surgeon-controlled. Other factors noted by respondents were hormone imbalances and obese members of the operating room staff. Lastly, it was noted by two respondents that Bair hugger, or patient warming device, availability is an ongoing challenge.

Analysis

Education is important for healthcare workers to work safely and efficiently to provide quality care. Education unavailability was a barrier one person identified in the pre- and post-implementation survey. Further investigation may ascertain what type of education the other three respondents had received since all four participants work at the same facility. Identification of a barrier could help guide future educational projects.

Based on CRNA responses**,** this intervention alerted the CRNAs to the existing AANA national standard. There was also an improvement in the time required for the CRNAs to locate a reference of evidence-based guidelines to answer any questions they had regarding best practice for perioperative temperature monitoring.

There were few differences in the pre- and post-intervention survey about modality/site preference for intraoperative temperature monitoring intraoperatively. However, the small changes seen do indicate that the educational material provided could have changed some perspectives.

CRNAs reported that 25-100% of time they were confident that available temperature monitoring devices accurately detect the patient's core body temperature. The variable correlation between patient temperature in the PACU and OR may be an area for improvement. Lack of standardized education among staff members and the lack of similar/same equipment for temperature measuring were identified as issues that may warrant further attention for organizational improvement. This could be considered a barrier to preventing intraoperative hypothermia because inaccurate data could be collected which ultimately results in incorrect/inappropriate treatment.

Ultimately, some of the most significant factors in preventing intraoperative hypothermia are not under CRNA control. Some of these include ambient room temperature, operating room staff temperature preference, and availability of patient warming resources. More than one respondent reported that operating room temperatures are determined by surgeons. While CRNAs can advocate for the patient, often it is the surgeon who dictates the room temperature because of the multiple layers they are required to wear that cause them to be warm during the surgical procedure.

The availability of Bair huggers is one of the most easily modifiable barriers noted by CRNAs. This is a supply problem that could be addressed by the organization. It must first be determined if there is a shortage. Then a plan for remediation would be put into place. This would be a department-wide initiative.

Section V. Implications

Financial and Nonfinancial Analysis

If this project were to be replicated by CRNAs in the future, it would offer a cost-effective approach to distributing useful, evidence-based information for practice. The simplicity of this quality improvement project allows for a low monetary and time input with the possibility of lasting impactful results. If this project were expanded, more change could be seen in the future, including increased educational opportunities, higher supply availability, and electronic health record changes making documentation easier and allowing for temperature reminders.

This QI project used software and resources to which the organization had existing access. Qualtrics, used for survey creation and data collection, requires a subscription. If the organization does not already have a subscription, however, there is free software available that could be used in a similar fashion. While Microsoft PowerPoint and Adobe Acrobat, used for creation of the educational material, are likewise not free, they are available for use in the organization. Microsoft Excel, used for data analysis, is also available within the organization. The learning tool was distributed as a PDF document that can be viewed on any device with reader capability.

Employee time will not pose any requirements beyond the scheduled work week with the exception of the one or two CRNAs serving as designated advocates. The designated advocates would be responsible for coordinating the dispersal of this material, ensuring all CRNAs receive the material. They would also serve as resources if questions arise from staff. These employees can elect to work on this during scheduled working hours if the charge nurse is able to assign them to operating rooms that end earlier in the day or they can elect to keep track of their time outside of their work schedule and apply for reimbursement. As for all other employees, the brief

presentation could take place at one of the already mandatory staff meetings that occur once a month.

The organization should consider the money that could be saved by preventing hypothermia in the perioperative period. These hypothermia cases could easily result in lawsuits or infections/complications resulting in extended hospital stays. Boet et al. (2017) specifically found that it costs a hospital $2,412 to $6,839 per patient with each case of perioperative unintentional hypothermia. This project will not bring direct income to the organization but does have the potential to contribute to quality and efficiency of care. If the project had been sponsored by the organization, there would not be immediate good return on their investment, however, with the continuation of efforts and increased knowledge gained from this quality improvement project, the organization could see a reduction in morbidity/mortality resulting from hypothermia. Reducing morbidity and mortality could increase the hospital profit margin.

Implications of Project

The most current AANA Standards for Nurse Anesthesia Practice state under Standard 9: Monitoring, Alarms that the nurse anesthetist is to monitor temperature when significant temperature changes are expected, predicted, or intended and "use active measures to facilitate normothermia" (2019, p. 3). The ASA (2020) published comparable standards regarding temperature monitoring that also instruct anesthesia providers to monitor temperature in patients receiving general anesthesia when a significant, anticipated, or predictable alteration in temperature is expected. This quality improvement project increased awareness of these standards and also provided a resource to quickly be able to reference them. CRNA confidence in knowing the standards and how to apply them to practice was increased after delivery of the intervention.

Quality improvement projects are important in enhancing healthcare delivery. These projects can be focused on clinical, financial, and operational aspects and can have a significant impact on total healthcare costs. According to current literature focused on this topic, providing greater staff education can successfully prevent inadvertent perioperative hypothermia. Previously mentioned findings from Munday et al. (2019) suggested the importance of effective and continuing education and multi-disciplinary teamwork, and that future interventions to prevent IPH should consider utilizing a team-based, multi-modal approach. Based on their claims, actively engaging all anesthesia providers at the practice will help produce the greatest impact of change.

Sustainability

One threat to the sustainability of this project might be lack of staff motivation for change/improvement. When assessing the success of quality improvement initiatives in healthcare, Backhouse (2020) found that improvement in healthcare is 20% technical and 80% human. Eager and motivated staff is an essential part in ensuring the success of this project. If there is a large number of locum CRNAs there could be even more disinterest as they may not see the value in putting in extra effort in a department they will only be working in for a short time.

The most appealing part of this project is the low input cost. The organization could afford to continue what was done in this project because it was low budget. Everything used in this project was without significant additional cost, including Qualtrics for the surveys, Microsoft PowerPoint, Microsoft Excel, and Adobe Acrobat PDF Reader for creation. Recommendations for future department discussion engagement, future implementation efforts, and for

sustainability efforts include incentivizing involvement to increase participation and sample size and offering in-person education during already mandatory staff meetings.

One resource that the organization had that truly contributed to the success of this project was willing staff members. The CRNA involvement indicates they are both willing and eager to add to their educational tools. There were no barriers identified that directly impacted the success of this project.

Dissemination Plan

This Quality Improvement Project was disseminated using multiple media types and venues. A poster was created and presented to faculty and students of the nurse anesthesia program. Project participants were invited to attend the poster presentation where the results of this quality improvement project were discussed. Time was also allotted for questions, discussion of findings, and feedback. A copy of the poster was electronically shared with the department for future use. The final version of this paper and the associated poster is posted in The Scholarship, the East Carolina University digital repository, where all will have free access.

Section VI. Conclusion

Limitations

Limitations identified during this project mostly related to time and sample size. A larger sample size could help make the data more meaningful to the department. Allowing the CRNAs more time for survey response also could improve results. While four CRNAs did actively participate in this survey, the fifth CRNA was out of work on medical leave and, therefore, did not participate. If a longer time had been allowed, this CRNA may have been able to participate in the quality improvement project.

Recommendations for Future Implementation and/or Additional Study

Recommendations for future implementation include increasing the sample size which can offer stronger results for a more impactful and meaningful analysis. Those considering future implementation should also consider offering in-person educational opportunities. This can occur during current mandatory staff meetings or could be done as a lunch and learn where lunch is provided in exchange for attendance and active participation. The pre-survey and post-survey questions could also be improved. Several of the questions were essentially assessing the same knowledge.

Another identified issue in this project that could be addressed with additional study is operating room staff members desiring a colder room temperature due to personal reasons. This is an identified barrier that presents as a challenge. One possible solution could be to provide these individuals with something similar to this tool to educate them on the importance of perioperative normothermia for the patient. This could encourage them to re-evaluate their own personal needs and take appropriate action to address them.

Based on some of the open-ended responses in the post-survey, additional investigation could also address staff involvement and teamwork. Cohesivity in the work environment, as previously discussed in Reeves' Conceptual Framework for Interprofessional/Interdisciplinary Work, is important for organizational success (Reeves et al., 2010). This framework addresses the improvement of interprofessional relationships, patient care quality, and interdisciplinary collaboration.

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Appendix A: Concept Chart

	Concept 1 **Perioperative**	**Concept 2** **Temperature**	**Concept 3** **CRNA**	**Concept 4** **Monitoring**
Keywords	Perioperative OR Operating room OR Surgery OR Surgical OR Anesthesia	Hypothermia OR Hyperthermia OR Temperature OR Core Body Temperature OR Thermoregulation	CRNA OR Nurse Anesthetist OR Certified Registered Nurse Anesthetist OR Anesthesia OR Anesthesiologist	Monitoring OR Non-Invasive Device OR Intraoperative Monitoring OR Warming Devices
PubMed MeSH	“operating rooms” [MeSH Terms] "surgical procedures, operative"[MeSH Terms] "anesthesia"[MeSH Terms]	“Hypothermia” [MeSH Terms] “Hyperthermia” [MeSH Terms] “temperature” [MeSH Terms] "monitoring, physiologic" [MeSH Terms] "body temperature"[MeSH Terms] "body temperature regulation"[MeSH Terms]	"nurse anesthetists" [MeSH Terms] "anesthesia" [MeSH Terms] "anesthesiologists" [MeSH Terms]	"monitoring, physiologic"[MeSH Terms] "monitoring, intraoperative"[MeSH Terms]
CINAHL	(MH "Perioperative Care") OR (MH "Operating Rooms") OR (MH "Surgery, Operative") OR (MH "Anesthesia") OR (MH "Anesthesia, General")	(MH "Body Temperature") OR (MH "Core Body Temperature") OR (MH "Body Temperature Regulation") OR (MH "Hypothermia") OR (MH "Hyperthermia")	(MH "Nurse Anesthetists") OR "CRNA" OR (MH "Anesthesia") OR (MH "Anesthesiologists")	(MH "Monitoring, Physiologic") OR (MH "Intraoperative Monitoring") OR (MH "Warming Techniques")
Google Scholar	Perioperative OR Operating room OR Surgery OR Surgical OR Anesthesia	Hypothermia OR Hyperthermia OR Temperature OR Core Body Temperature OR Thermoregulation	CRNA OR Nurse Anesthetist OR Certified Registered Nurse Anesthetist OR Anesthesia OR Anesthesiologist	Monitoring OR Non-Invasive Device OR Intraoperative Monitoring OR Warming Devices

Appendix B: Literature Search Log

Search Date	Database/Search Engine	Search Strategy	Limits Applied	Number of citations found/kept	Rationale for Inclusion/Exclusion of Items
September 24, 2021	PubMed	(((Perioperative OR Operating room OR Surgery OR Surgical OR Anesthesia) AND (Hypothermia OR Hyperthermia OR Temperature OR Core Body Temperature OR Thermoregulation)) AND (CRNA OR Nurse Anesthetist OR Certified Registered Nurse Anesthetist OR Anesthesia OR Anesthesiologist)) AND (Monitoring OR Non-Invasive Device OR Intraoperative Monitoring OR Warming Devices)	5 years	566/22	Inclusion: Perioperative focus, consequences of hypothermia discussed, warming tactics and rationales Exclusion: Unrelated to topic of interest
September 24, 2021	CINAHL	"Perioperative" OR (MH "Perioperative Care (Iowa NIC)") OR (MH "Perioperative Care") OR (MM "Thermoregulation (Iowa NIC)") OR (MM "Anesthesia Administration (Iowa NIC)") AND (MH "Core Body Temperature") OR (MM "Body Temperature/ST/DE") OR (MM "Temperature/ST/EV/MT") OR "Temperature" OR (MH "Body Temperature") AND "CRNA" OR (MH "Nurse Anesthetists")	10 years	99/17	Inclusion: Temperature monitoring devices, body temperature regulation, Temperature response to anesthetics Exclusion: Unrelated to topic of interest
September 24, 2021	Google Scholar	(((Perioperative OR Operating room OR Surgery OR Surgical OR Anesthesia) AND (Hypothermia OR Hyperthermia OR Temperature OR Core Body Temperature OR Thermoregulation)) AND (CRNA OR Nurse Anesthetist OR Certified Registered Nurse Anesthetist	4 years	4240/6 (5 pages/100 items reviewed)	Inclusion: Improved compliance, clinical practice application, CRNA satisfaction, successful temperature indicators Exclusion: Unrelated to topic of interest

		OR Anesthesia OR Anesthesiologist)) AND (Monitoring OR Non-Invasive Device OR Intraoperative Monitoring OR Warming Devices)			
September 24, 2021	Access Anesthesia	“Operating Room Temperature” OR “Perioperative Hypothermia” OR “Temperature Monitoring” OR (MH "Intraoperative Monitoring") OR "Monitoring"	5 years	151/24	Inclusion: Intraoperative focus, hypothermia, anesthesia considerations for drugs, temperature regulation, prevention and management of hypothermia Exclusion: Unrelated to topic of interest

Appendix C: Literature Matrix

Citation	Level of Evidence	Objective	Method	Results/Conclusion
Duff, J., Walker, K., Edward, K., Ralph, N., Giandinoto, J., Alexander, K., Gow, J., & Stephenson, J. (2018). Effect of a thermal care bundle on the prevention, detection, and treatment of perioperative inadvertent hypothermia. *Journal of Clinical Nursing, 27*, 1239-1249. https://doi.org/10.1111/jocn.14171	VI	To reduce the occurrence of perioperative hypothermia after implementation of a new Thermal Care Bundle	A pre- and post-implementation survey was used to determine the effectiveness of the Thermal Care Bundle. Data was collected via audited medical records of 729 patients at four sites from December 2014-January 2016.	The Thermal Care Bundle was introduced by using a collaborative implementation method. This bundle included a risk assessment including risk of hypothermia and contraindications to active warming, temperatures recorded including pre-operative, operative, and post-operative, and active warming used intraoperatively or any time the patient's temperature was below 36 degrees Celsius. Regular feedback was provided to team members and a group discussion board was located on the intranet site to serve as a resource for practitioners. A structured barrier identification and mitigation tool was used to identify potential barriers present hindering the capacity at which the Thermal Care Bundle could be implemented. This bundle did not decrease the incidence rate of IPH, but had several positive effects on clinical practice. The Thermal Care bundle increased completed risk assessments, temperature documentation, and appropriate active warming. It also allowed for early detection of IPH because of the increased frequency in temperature monitoring. This shows that even though the incidence rate of IPH was unchanged, the delivery method and program evaluation technique for the recently developed bundle was still successful and helped improve clinical practice.
Freundlich, R., Nelson, S., Qiu, Y., Ehrenfeld, J., Sandberg, W., & Wanderer, J. (2018). A retrospective evaluation of the risk of bias in perioperative temperature metrics. *Journal of Clinical Monitoring and Computing, 33*, 911-916. https://doi.org/10.1007/s10877-018-0233-1	III	To assess the integrity of provider-entered temperatures in comparison to automatically-recorded computer temperatures in light of perioperative temperature being introduced as a quality metric	Retrospective review that included all perioperative temperatures recorded for surgeries with >60 minutes anesthesia time between January 2012 and 2017. Graphs were utilized to compare and analyze provider-entered temperature to automatically recorded temperatures to assess for normalcy.	A concern of manually entered data is that it allows for manipulation. The analysis determined that provider-entered temperatures illustrated significantly different distributions than those automatically entered. This suggests possible bias or inappropriate rounding in temperature reporting to meet quality metrics for reimbursement purposes. This study recommends future qualitative studies be done to analyze provider awareness and understanding of perioperative temperature metrics.

Guidash, J., Berman, L., Panagos, P., & Sullivan, K. (2021). Engaging frontline providers prevents hypothermia and improves communication in the postoperative neonate. *Advances in Neonatal Care, 21*(5), 379-386. https://doi.org/10.1097/ANC.0000000000000839	VI	To improve the communication between the OR staff, anesthesia, and the NICU by utilizing a handoff tool	Prospective quality improvement study utilizing a newly designed hand-off script that was developed by the multidisciplinary team. 2 patient tracers of the perioperative process were performed in efforts to identify opportunities for heat loss for stages between pre-operative and return to the neonatal intensive care unit.	A two-year implementation period saw a decrease in the mean hypothermia rate. A limitation to the study was the lack of participation and attendance, but this was said to have improved. This quality improvement initiative used patient tracers to identify opportunities during the perioperative period to mitigate the occurrence of heat loss. They found that achieving euthermia before transporting the infants also helped give them more of a buffer to unavoidable heat loss variables.
Gustafsson ,I., Elmqvist, C., From-Attebring, M., Johansson, I., & Rask, M. (2017). The nurse anesthetists' adherence to Swedish national recommendations to maintain normothermia in patients during surgery. *Journal of PeriAnesthesia Nursing, 32*(5), 409-418. https://doi.org/10.1016/j.jopan.2016.03.006	VI	To assess nurse anesthetists' perceptions of current temperature monitoring guidelines and available resources.	Quality improvement study with descriptive survey. A questionnaire was sent out to 56 nurse anesthetists and directly involved heads of the department in the operative setting in Sweden.	Two surveys were utilized to evaluate both accessibility and application of evidence-based recommendations. Reasons for why current recommendations are not being followed were also evaluated. It was surprising to learn that 40% of their surveyed nurse anesthetists did not have knowledge of current guidelines for practice. This article evaluates the importance of providing continued employee education to ensure that all practitioners are following the same current evidence-based recommendations to minimize hypothermic related patient complications and negative patient outcomes.
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 & Analgesia, 130*(5), 1167-1175. https://doi.org/10.1213/ANE.0000000000004546	VI	To determine if a real-time decision support tool could influence/improve intraoperative temperature measurement and management of normothermia	IRB approved retrospective observational study. Completed analysis of cases that utilized the electronic alert system and met requirements for MIPS #424 performance eligibility. A total of 24,755 cases in 2017 that were eligible for reporting were included. 25,274 cases from 2016 were used to provide a baseline.	Improved temperature monitoring and maintenance was shown to be statistically significant with the introduction of an intraoperative electronic alert system. Addressed other variables in inconsistency of temperature monitoring documentation: a patient may meet the MIPS temperature measurement intraoperatively, but may fail to meet this requirement in the PACU due to less invasive temperature monitoring capability. This study also considered the financial implications of MIPS #424 compliance improvement.

Munday, J., Delaforce, A., Forbes, G., & Keogh, S. (2019). Barriers and enablers to the implementation of perioperative hypothermia prevention practices from the perspectives of the multidisciplinary team: A qualitative study using the theoretical domains framework. *Journal of Multidisciplinary Healthcare, 12,* 395–417. https://doi.org/10.2147/JMDH.S209687	VI	To evaluate the perspectives healthcare professionals directly involved in surgical areas to determine how to best overcome barriers and capitalize on enablers of the prevention of IPH	Qualitative study with a purposive sample of key stakeholders in an Australian tertiary hospital's perioperative setting were selected for semi-structured interviews. A total of 12 participants took part of this study with years of experience ranging from 2 to 30 years. The median duration of interviews was 18.3 minutes. Data analysis was completed after all 12 interviews were completed.	This study suggests the importance of effective continued education. A team-based, multi-modal approach should be used for future interventions to prevent IPH. The effectiveness, feasibility, acceptability, and cost should also be heavily weighted to facilitate the necessary improvement of IPH occurrences.
Munday, J., Hines, S., & Chang, A. (2013). Evidence utilisation project: management of inadvertent perioperative hypothermia. The challenges of implementing best practice recommendations in the perioperative environment. *Int J Evid Based* Healthcare, 11(4), 305–311. https://doi.org/10.1111/1744-1609.12035	VI	To assess the current clinical practice for preventing hypothermia and to determine the challenges to implementing a new audit tool outlining best practice recommendations	Quality improvement project study completed from August 2010 to March 2012. This project involved completing baseline chart audits for 73 patients and comparing the data collected to the current guidelines for preventing IPH. Educational materials on perioperative temperature management and appropriate recording were dispersed using various media forms and 72 post-implementation audits were performed to measure improvement in meeting current evidence-based practice guidelines.	A baseline audit was completed before recommendations for practice were dispersed/displayed via email, in-service educational opportunities, and posters. They identified practice gaps present that included minimal temperature documentation in the preoperative/intraoperative period. They also addressed current barriers present that are hindering practice improvement. Some of these included: large groups of staff requiring education with limited educators, lack of temperature monitoring equipment in the pre-operative area, no area on the pre-operative checklist to include the patient's temperature, and an outdated hospital policy on patient warming and temperature documenting requirements. They followed up with a post-implementation audit that showed the number of patient's receiving pre-operative temperature monitoring increased while only small increases were seen intraoperatively.
Scott, A., Stonemetz, J., Wasey, J., Johnson, D., Rivers, R., Koch, C., & Frank, S. (2015). Compliance with surgical care improvement project for body temperature management (SCIP inf-10) is associated with improved clinical outcomes. *Anesthesiology, 123*(1), 116-123. https://doi.org/10.1097/ALN.0000000000000681	VI	To evaluate the effectiveness of previously implemented body temperature management guidelines (SCIP Inf-10)	Retrospective observational study conducted by analyzing 45,304 electronic medical records from inpatients at a single institution to determine if compliance with the SCIP guidelines was associated with decreased patient mortality and morbidity.	Compliance with these previously designed surgical care improvement project (SCIP) guidelines showed improved patient outcomes and has proven itself as a useful quality measure. The SCIP compliant patients were returned to the PACU with higher temperatures than those who were not compliant. SCIP compliance was also associated with a decreased incidence of hospital acquired infections and a decrease in the length of hospital stay.

Şenkal, S. & Umut Kara, U. (2020). Guideline implementation and raising awareness for unintended perioperative hypothermia: Single-group "before and after" study. *Ulus Travma Acil Cerrahi Derg, 26*(5), 719-727. https://doi.org/10.14744/tjtes.2020.55237	VI	To reduce the occurrence of unintended perioperative hypothermia (UPH) after implementation of evidence-based guidelines that established new hospital hypothermia prevention protocol	Prospective quality improvement study that compared the occurrence of hypothermia before (November 24, 2015-January 15, 2016) and after (April 6, 2016-July 21, 2017) the new manual/protocol was implemented to determine effectiveness. This manual included pre-operative, intra-operative, and post-operative tasks/documentation that must be completed to satisfy the hospital's hypothermia prevention protocol.	The manual addresses pre-operative, intra-operative, and post-operative procedures that must be completed and the necessary equipment to do complete these tasks in their respective areas. They found that the overall incidence of UPH was decreased with the implementation of the "Prevention of Unintended Perioperative Hypothermia" manual.
Steelman, V., Perkhounkova, Y., & Lemke, J. (2015). The gap between compliance with the quality performance measure "perioperative temperature management" and normothermia. *Journal for Healthcare Quality, 37*(6), 333-341. https://doi.org/10.1111/jhq.12063	VI	To assess the relationship between compliance in regard to quality performance measures and achieving normothermia, which is the perioperative goal	Retrospective study with a sample including all surgical procedures from 1/2008-12/2011 with a general or neuraxial anesthesia time of >60 minutes where patients were transferred to the post-anesthesia care unit. The analysis then described to what extent these procedures remained compliant with the Perioperative Temperature Management performance measure.	This study concludes that a significant gap exists between compliance with quality improvement measures and actual achievement of normothermia with patients undergoing surgical procedures. Because of reimbursement legalities, the stress to adopt evidence-based practices emphasizes maintaining compliance with the quality performance measures. This study suggests that ideal patient outcomes resulting from normothermia needs to be at the center of all teaching and more emphasis should be made on education regarding the detrimental effects of hypothermia in vulnerable patient populations.

Note: Key to abbreviations used in chart. Unintended perioperative hypothermia (UPH), surgical care improvement project (SCIP), post-operative care unit (PACU), inadvertent perioperative hypothermia (IPH), Merit-Based Incentive Payment System (MIPS).

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. Copyright 2019 by Wolters Kluwer.

Appendix D: Project Approval

Based on your responses, the project appears to constitute QI and/or Program Evaluation and IRB review is not required because, in accordance with federal regulations, your project does not constitute research as defined under 45 CFR 46.102(d). If the project results are disseminated, they should be characterized as QI and/or Program Evaluation findings. Finally, if the project changes in any way that might affect the intent or design, please complete this self-certification again to ensure that IRB review is still not required. Click the button below to view a printable version of this form to save with your files, as it serves as documentation that IRB review is not required for this project. 11/12/2021

Center for Research & Grants

[redacted]

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

[redacted]

Project Title:	Perioperative Temperature Monitoring and Management to Maximize Patient Safety: A Quality Improvement Project		
Funding Source:	None		
Project Leader Name:	Rachel Jones/Dr. Angela Ciuca	☐ Ed.D. ☐ J.D. ☐ M.D. ☐ Ph.D. ☐ Pharm.D. ■ R.N. ☐ Other(specify):	
Job Title:	ECU SRNA/ECU CRNA Faculty	**Phone:**	**Email:** [redacted]
		Primary Contact (If different from Project Leader): Rachel Jones	[redacted]

Key Personnel/ Project Team members:

Name and Degree:	Department: (Affiliation if other than Vidant)	Email:
Rachel Jones, SRNA	ECU Nurse Anesthesia Program	[redacted]
Angela Ciuca, DNAP, CRNA	ECU Nurse Anesthesia Program	
McAuliffe, PhD, CRNA	ECU Nurse Anesthesia Program	

QI/QA Assessment Checklist:

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

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

rev. 03.21

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

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

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

2. **If the Primary purpose of your project/study is for QA/QI, have you obtained approval from the operational leader within your department or health system** [Please specify here whom and obtain their signature in the signature section below]: [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 [redacted]

NHSR vs. HSR Determination:

☒ **Not Human Subject Research:** The [redacted] 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] 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:** 3-7-2022

[redacted] **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, Vidant Health must make reasonable efforts to limit PHI to the minimum necessary to accomplish the purpose of the use, disclosure or request.

Under HIPAA, a Covered Entity ([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] 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] data has been utilized.

Rachel E Jones
Project Leader Signature

February 21, 2022
Date

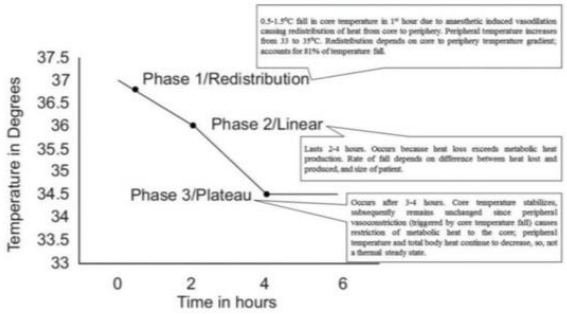
Appendix E: Learning Resource

Causes of Hypothermia Under Anesthesia[1,6]

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

Mechanisms of Heat Loss Under Anesthesia

Conduction, convection, radiation, evaporation, and redistribution



Current Standard of Care

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

AANA Standard IX: Monitoring[2]

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

ASA Standards for Basic Anesthetic Monitoring[3]

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

Potential Negative Outcomes[4]

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

Raising the BRRR On Temperature Management

High risk Populations & Procedures[5]

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

Prevention of hypothermia[6,7]

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

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

Tools available for temperature monitoring[7,8]

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

ECU Nurse Anesthesia Program

References

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6. Warming devices and temperature monitoring. Rose G, & McLarney J(Eds.), (2014). *Anesthesia Equipment Simplified*. Retreived January 12, 2022 from https://accessanesthesiology.mhmedical.com/content.aspx?bookid=871&sectionid=51860184
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Appendix F: Intervention Surveys

Pre-Survey Questions

1) Have you ever received education on temperature monitoring **policies** for your surgical setting?
   a) Yes / No / Unsure
2) Are you aware of the AANA national standard for temperature monitoring?
   a) Yes / No / Unsure
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 educational initiative, can you readily access the AANA national standard on temperature monitoring?
    a. Yes/No/Unsure
2) How likely are you to reference this material in your future practice?
    a. Very likely / likely / neutral / unlikely / very unlikely
3) If you saved this resource 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. 1-3 minutes / 4-6 minutes / 7-9 minutes / 10 or more minutes / Not applicable
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 guide, 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. 100% of the time / 25% of the time / 50% of the time / 75% of the time / 0% of the time
9) If you find the correlation between the operating room temperature and PACU temperature lacking, do you have any recommendations 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	d. Foley catheter	g. Temporal
b. Skin	e. Rectal	h. Tympanic
c. Esophageal	f. Nasopharyngeal	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?

Appendix G: Email Communication

Initial Pre-Survey and Video Email to Participants

Dear CRNAs of [redacted] Orthopedic Operating Rooms,

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 practice 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, viewing a pre-recorded PowerPoint presentation (attached), utilizing a temperature management educational resource in your CRNA practice for two weeks at your discretion (attached), and completing a short post-intervention questionnaire when the two-week implementation period is over.

Each questionnaire should take less than 2-4 minutes to complete. The questionnaires were created and are completed using Qualtrics® survey software. The use of "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, complete the pre-intervention questionnaire here.
Next, please view the "Raising the Brrr on Temperature Management" resource and its accompanying video presentation attached to this email.

Again, thank you so much for your participation in our quality improvement project. I will be at [redacted] through the course of this project if you have any questions. You may also reach out to me, primary team lead, or Dr. Maura McAuliffe, project chair, by email.

Thank you again for your time and participation.

Sincerely,

Rachel Jones, BSN, SRNA
Jonesra20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023

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

Reminder Email to Participants

Dear CRNAs of [redacted] Orthopedic Operating Rooms,

I wanted to send out a reminder of the opportunity present for you to participate in the quality improvement project titled "Raising the Brrr on Temperature Management." Detailed information regarding the project was sent out in a previous email, but is also included below. Please consider participating in this learning opportunity.

Participation is voluntary and will involve completing a short pre-intervention questionnaire, viewing a pre-recorded PowerPoint presentation (attached), utilizing a temperature management educational resource in your CRNA practice for two weeks at your discretion (attached), and completing a short post-intervention questionnaire when the two-week implementation period is over.

Each questionnaire should take less than 2-4 minutes to complete. The questionnaires were created and are completed using Qualtrics® survey software. The use of "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, complete the pre-intervention questionnaire here.
Next, please view the "Raising the Brrr on Temperature Management" resource and its accompanying video presentation attached to this email.

Again, thank you so much for your participation in our quality improvement project. I will be at [redacted] through the course of this project if you have any questions. You may also reach out to me, primary team lead, or Dr. Maura McAuliffe, project chair, by email.

Thank you again for your time and participation.

Sincerely,

Rachel Jones, BSN, SRNA
Jonesra20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023

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

Post-Intervention Survey Email to Participants

Dear CRNAs of [redacted] Orthopedic Operating Rooms,

Thank you to everyone who has already completed my pre-survey and viewed the educational resource! It's now time to complete the brief post-survey linked here. It should take less than two minutes and can be completed on a desktop or mobile device.

If you have not yet completed the pre-survey, it is not too late! I would really appreciate your participation. The pre-survey can be found here.

If anyone has any questions or issues with the links, please let me know. Again, thank you so much for your participation in our quality improvement project.

Sincerely,

Rachel Jones, BSN, SRNA
Jonesra20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023

Post-Intervention Follow-Up Email to Participants

Dear CRNAs of [redacted] Orthopedic Operating Rooms,

Thank you for taking the time to participate in the quality improvement project titled “Raising the Brrr on Temperature Management.” Your participation and shared experiences are highly valued and have greatly aided in the success of this project.

Thank you again for your time and participation.

Sincerely,

Rachel Jones, BSN, SRNA
Jonesra20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023