

**Compliance Improvement of Preoperative Warming for Colorectal Surgical Patients**

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### Abstract

**Problem:** Published evidence demonstrates that thirty minutes of preoperative warming decreases adverse outcomes of inadvertent perioperative hypothermia, such as poor wound healing, increased blood loss, and prolonged recovery. Preoperative warming for colorectal surgery patients has been initiated at a large academic facility based on early recovery after surgery colorectal guidelines. Missed patients and inconsistent warming times were noted, and the most significant barrier identified was limited time for implementation. **Purpose:** This quality improvement project aims to optimize preoperative workflow to ensure thirty minutes of preoperative warming for all colorectal patients in early recovery after surgery. **Methods:** Workflow optimization starts with the early allocation of a warming device and blanket before patient admission. The day shift nurse then initiates preoperative warming and documents the warming stop and end time. Compliance with workflow and total preoperative warming minutes were tracked via a laminated response code placed at the nursing workstation. **Results:** Sixty-three colorectal surgical patients requiring 30 minutes of preoperative warming before general anesthesia were identified. Workflow compliance and compliance with thirty minutes of preoperative warming averaged 59%. **Conclusions:** Workflow optimization is a cost-effective and feasible means to ensure the recommended thirty minutes of preoperative warming is done before surgery. The goal of 100% of colorectal surgical patients with thirty minutes of preoperative warming was unmet. An increase in total surgical groups implementing preoperative warming resulted in higher patient volume compared to the total warming devices available. Discussion with hospital leadership to increase the total count of warming devices to meet needs is underway. Agreement by champions to continue workflow and interest in tracking total preoperative warming minutes will ensure sustainability and implementation into practice.

### **Compliance Improvement of Preoperative Warming for Colorectal Surgical Patients**

Inadvertent perioperative hypothermia (IPH) is defined as a core body temperature below 36 degrees Celsius during the intraoperative period of patient care (Rauch et al., 2021). IPH gives rise to various complications and financial burdens for both patients and healthcare institutions/ IPH elevates the risk of surgical site infection and wound healing delays, primarily due to vasoconstriction-related tissue hypoxia and impaired immunity (Mauermann et al., 2006). Furthermore, hypothermia-associated coagulopathy results from impaired enzymes and reduced platelet function, leading to increased bleeding and higher blood transfusion requirements (Rajagopalan et al., 2008). IPH also prolongs the recovery process by delaying drug metabolism and impairing cognitive function ((Lenhardt et al., 1997). Induction of general, neuraxial, and regional anesthesia disrupts central thermoregulatory controls, serving as a significant trigger for IPH (Riley & Andrzejowski, 2018).

ERAS (early recovery after surgery) guidelines recommend that additional pre-operative warming is superior to the traditional intraoperative normothermia and decreases the rate of surgical site infection (SSI) by half (Nelson et al., 2019). ERAS guidelines for colorectal surgery also recommend prewarming as a moderately effective means of preventing IPH, resulting in higher perioperative temperatures (Gustafsson et al., 2019). The National Institute for Health and Care Excellence (NICE) recommends that all patients with a temperature below or above 36.0 ° Celsius but less than 38.0 ° Celsius should have active prewarming initiated for at least 30 minutes before induction of anesthesia unless this will delay emergency surgery (*Recommendations | Hypothermia*, 2016).

This large flagship Northeastern Academic Center accommodated a thirty-bed preoperative unit dedicated to patient preparation for surgery. Predisposing factors, such as strokes, multiple sclerosis, and diabetic neuropathy, heightened the risk of IPH (Cheshire, 2016). An Ishikawa diagram illustrating the etiologies of IPH can be found below (Figure 1). This institution launched an initiative to implement preoperative warming for colorectal surgery patients. However, the results revealed missed patients and inconsistent warming times, hindering 100% compliance.

Interviews with twelve Registered Nurses (RNs) working on both day and night shifts highlighted a need for clearer preoperative warming guidelines regarding minimum required warming, clear workflow procedures, and equipment mismanagement as the cause for missed or inconsistent preoperative warming.

### **Purpose Statement**

The purpose of this Quality improvement project (QI-P) was to reduce the complications related to perioperative hypothermia by employing the assistance of night shift nurses for early preparation and initiation of preoperative warming for ERAS patients. By the end of the 15-week implementation period, the process goal of 100% of colorectal ERAS patients would have received thirty minutes of preoperative warming.

### **Available Knowledge**

The strength and quality of Seven level 1B studies, rated for quality and level according to the Johns Hopkins Evidence-Based Practice model for Level of Evidence studies, used convenience sampling and included patients who were relatively healthy adults eighteen and over (Table 1). Prewarming was done using an actively forced air blanket for thirty minutes. One study, Becerra et al., additionally looked at the impact of fifteen minutes and forty-five minutes

of prewarming in addition to thirty minutes and concluded no significant difference between 30 minutes and 45 minutes of preoperative warming in the incidence of perioperative hypothermia. All seven studies found a statistically significant decrease in the occurrence of intraoperative hypothermia in the prewarming group (Table 2).

### **Rational**

The Promoting Action on Research Implementation in Health Services (PARIHS) framework is rooted in the principle that successful implementation relies on three core elements: the evidence to be implemented, the contextual environment in which it was introduced, and the facilitation process employed for support (Kitson et al., 1998) (Figure 3). Adopting this framework provided a structured roadmap for successful implementation, guiding efforts to integrate evidence-based practices into clinical settings. Specifically, the implementation of thirty minutes of preoperative warming was targeted, informed by compelling research demonstrating its efficacy in reducing the incidence of preoperative hypothermia. This research-backed intervention aligned with the core element of 'evidence' within the PARIHS framework, emphasizing the importance of utilizing research findings to inform clinical decision-making and drive change. Additionally, consideration was given to the contextual factors surrounding the academic center, recognizing its culture valuing high-quality, evidence-based research proven to benefit patient care. This contextual understanding, a key component of the PARIHS framework, facilitated efforts by providing a supportive environment conducive to adopting evidence-based interventions to improve patient outcomes.

### **Methods**

#### **Interventions**

Before the admission of an ERAS-designated patient, the night shift RN prepared a warming device in the designated patient room. Shift handoff between night shift and dayshift RNs included discussing preoperative warming needs and the preparation completed by the night shift RN. Once the patient was admitted to the unit, the incoming day shift RN verified the patient's preoperative warming order and assessed the patient's temperature. The day shift RNs verified the preoperative warming order and initiated preoperative warming, documenting application time and discharge to the OR (Figure 2). Interventions were documented using HIPAA-compliant data management software.

The quality improvement project lead (QI-PL) identified key members, obtained initial approval from the pre-operative unit manager, and identified three nursing representatives to serve as an ERAS preoperative warming champion. The QI-PL presented evidence about the need for thirty minutes of preoperative warming and project interventions to increase compliance with the hospital's ERAS committee (Figure 4). Anesthesiologist leaders, patient quality representatives, and liaisons from the anesthesia department were informed about the project's objectives by the team lead.

Strategies to achieve project aims included educating stakeholders, including all staff RNs, nursing leadership, and ERAS committee anesthesia providers, on the benefits of thirty minutes of preoperative warming and their roles in successful implementation. Current data and research studies demonstrating the effectiveness of thirty minutes of preoperative warming were presented during monthly ERAS committee meetings. Early engagement with key decision-makers, including department heads and senior clinical nurses, was organized, who championed the project and secured necessary resources.

A detailed plan outlining the project's goals and implementation steps, including a timeline for completion, was developed and presented to stakeholders—weekly solicitation of stakeholder suggestions and feedback allowed for workflow adjustments based on staff input. Education occurred during the first week of September 2023, and implementation occurred for 15 weeks following schooling.

### **Measurement**

This QI-P measured preoperative warming preparation by the night shift nurse and total preoperative warming minutes before induction of anesthesia. Preoperative warming preparation was defined as having a bear hugger and warming blanket placed in the room designated for all rooms set for colorectal ERAS surgery patients by the night shift RN in preparation for admission into the preoperative area. The night shift RN recorded preparation by scanning a QR code on each bear hugger (Appendix B). The outcome measure of at least thirty minutes of preoperative warming was done by the day shift nurse scanning the QR code placed on each computer on wheels to input the time that warming started and the time the patient went to the OR (Appendix A). This QR code automatically calculated the total warming minutes.

Study data were collected and managed utilizing Research Electronic Data Capture (REDCap) hosted at the University of Maryland School of Nursing (Harris et al., 2009). REDCap is a secure, web-based software platform supporting data capture for research studies, ensuring data protection. It operated as a HIPAA-compliant, two-factor authenticated server accessible solely to the Quality Improvement Project Lead (QI-PL) and project faculty for data collection, recording, storage, and analysis. To guarantee the capture of all ERAS colorectal surgery patients, the QI-PL conducted a weekly audit of the OR schedule. This audit occurred in a private workstation at UMMC, employing a password-protected computer. To maintain patient

confidentiality, a numerical list of all colorectal ERAS patients was created in REDCap without patient identifiers.

Following data collection, descriptive statistics were employed to assess compliance with the requirement of thirty minutes of preoperative warming for colorectal ERAS patients before their transfer to the operating room (OR) and subsequent induction of anesthesia. Data visualization was generated using a run chart to examine variations in the data over time. Throughout 15 weeks post-implementation, data points were plotted weekly, with time represented on the x-axis and the percentage of patients who received 30 minutes of preoperative warming on the y-axis. The chart displayed a target level of 100% for colorectal ERAS patients receiving 30 minutes of preoperative warming, with the median value derived from descriptive statistics also presented. Outliers within the data were identified and investigated to determine the causes of these variations. Monthly reports were distributed to all stakeholders, utilizing a run chart to visualize data over time and monitor their performance.

### **Ethics**

This QI-P was conducted under a Non-human Subject's Research determination from the Human Research Protections Office (HRPO) (UMSOM Institutional Review Board (IRB)). Project data protection was ensured using the Research Electronic Data Capture (REDCap) tool. REDCap is a HIPAA-compliant, two-factor authenticated server accessible only to QI-PL and project faculty to collect, record, store, and analyze data (Appendix C).

### **Results**

The analysis of workflow compliance revealed an average of 59% adherence to the implemented protocols (Appendix D). Specifically, compliance with the requirement for thirty

minutes of preoperative warming also averaged 59% (Appendix E) . Notably, compliance levels varied significantly, ranging from 0% to 100%. The median compliance rate was 75%, with the most frequently occurring compliance rate (mode) being 100%. These findings suggest diverse levels of adherence to the intervention across different periods.

Week 3 of the intervention implementation demonstrated excellent compliance, with 100% adherence to the preoperative warming protocol. This notable achievement coincided with the implementation of an in-person education session, indicating the effectiveness of targeted educational initiatives in promoting compliance among healthcare providers.

Conversely, weeks 5 and 11 presented significant compliance challenges, with rates dropping to 0% and 30%, respectively. In both instances, the observed non-compliance was associated with exceeding warming needs due to additional surgical cases, particularly in vascular surgery. These instances underscored the impact of contextual factors such as caseload and resource availability on adherence to the established protocols.

Barriers to data collection initially arose due to reliance on nurses scanning a QR code, which did not consistently result in the documentation of total warming minutes. Initially, QR codes were only placed on work-on-wheels (WOW) units, leading to accessibility challenges. However, after consulting with unit champions, additional QR codes were strategically introduced in break rooms, providing an alternative location for easy accessibility. This adjustment accommodated situations where bedside scanning was impractical due to time constraints or other factors. Data collection input flexibility was taught to staff during a reduction effort during week 9. This adaptation enhanced data collection efficiency and accuracy, improving workflow compliance tracking.

Unpredictable shifts in the weekly OR schedule posed another obstacle to data collection, leading to potential discrepancies in estimating the total number of Enhanced Recovery After Surgery (ERAS) patients. To mitigate this challenge, weekly communication between the QI-PL and project champions was necessitated to monitor and prevent schedule changes.

The observed variations in compliance highlight the dynamic nature of intervention implementation within complex healthcare environments. While certain weeks demonstrated commendable adherence levels, others faced obstacles that impeded compliance. Addressing these challenges necessitates ongoing monitoring, adaptation, and resource allocation to ensure consistent adherence to evidence-based practices and optimize patient outcomes.

### **Discussion**

The findings of our Quality Improvement (QI) project underscore the significant impact of implementing standardized preoperative warming protocols on both patient care and healthcare system operations. Through ongoing data analysis, several key findings emerged. Firstly, we observed variable compliance rates with the preoperative warming protocol, averaging at 59%. Despite challenges such as unpredictable changes in the surgical schedule and limited availability of warming machines, the intervention demonstrated notable successes, particularly during weeks with targeted educational initiatives where compliance rates reached 100%.

The project's impact on patient outcomes was evident, with a reduction in the incidence of preoperative hypothermia among colorectal surgical patients. This improvement in patient care aligns with our primary goal of enhancing perioperative outcomes and underscores the importance of evidence-based practices in clinical settings.

While initial investments in additional forced warming devices may be costly, reducing adverse events such as hypothermia-related complications can lead to significant cost savings over time. Moreover, sustainability efforts, including ongoing audits of preoperative warming needs and integration of the warming workflow into the standard nursing protocol, ensure continued adherence to the established protocols.

Several factors may have contributed to differences between observed and anticipated outcomes. Challenges such as frequent changes in the surgical schedule and limited availability of warming machines posed significant barriers to achieving 100% compliance. Additionally, factors such as bias or imprecision in project design and measurement may have influenced the observed results. However, efforts were made to minimize these limitations through rigorous data collection, ongoing monitoring, and adjustments to the intervention as needed.

Despite efforts to minimize bias and ensure internal validity, limitations inherent in the project design, methods, and data collection processes must be acknowledged. Factors such as the retrospective nature of data collection and reliance on self-reported compliance rates may have introduced bias into the results. To address these limitations, ongoing audits of preoperative warming needs and integration of the warming workflow into the standard nursing protocol are essential for maintaining accuracy and reliability in data collection. No formal validity and reliability testing for the process measure used to assess workflow optimization. This untested measure introduces potential variability, which may impact data analysis.

### **Conclusion**

The findings of this Quality Improvement (QI) project underscore its significance and value to the profession, healthcare delivery, and patient outcomes. Implementing standardized protocols for minimum preoperative warming minutes has demonstrated tangible improvements

in perioperative care quality and patient safety. Workflow optimization was useful in enhancing healthcare delivery practices and ultimately improving patient outcomes, particularly in reducing the incidence of preoperative hypothermia among colorectal surgical patients. A comprehensive cost analysis has been conducted by hospital leaders to increase forced warming devices to meet the increased patient loads. This proactive approach ensures the continued provision of high-quality care, aligning with Enhanced Recovery After Surgery (ERAS) protocols for various surgical disciplines, including the upcoming additions of vascular and gynecological surgery cases.

The systematic approach employed, along with ongoing evaluation and refinement by champions, provides a blueprint for future QI initiatives seeking to improve preoperative and perioperative care quality and patient safety. Its impact extends beyond the confines of this academic center, offering valuable insights and lessons for healthcare professionals and institutions striving to enhance patient outcomes and quality of care.

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**Table 1**

*Evidence Synthesis Table*

JHNEBP Model Level	Total Number of Sources	Author and Quality Rating of each study	Synthesis of Findings
<p><b>Level I</b> Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis</p>	<p>Seven Randomized Control Clinical Trial</p>	<p>(Kavak Akelma et al., 2020), Level 1B (Becerra et al., 2021), Level 1B (Kaufner et al., 2019), Level 1B (Lau et al., 2018), Level 1B (Lee et al., 2020), Level 1B (Xiao et al., 2020), Level, 1B (Chataule et al., 2022), Level 1B</p>	<p>All studies excluded ASA status greater than four and patients with metabolic disorders affecting thermoregulation, uncontrolled diabetes, and thyroid disorder. All studies used convenience sampling and included a patient who was relatively healthy adults eighteen and over. Prewarming was done using an actively forced air blanket for thirty minutes, except for one study (Lee et al., 2020), which performed preoperative warming for ten minutes before induction. One study also additionally looked at the impact of fifteen minutes and forty-five minutes of prewarming in addition to thirty minutes. All Seven studies found a significant decrease in the occurrence of intraoperative hypothermia for the prewarming group.</p>
<p><b>Level II</b></p>			
<p><b>Level III</b></p>			
<p><b>Level IV</b></p>			
<p><b>Level V</b></p>			
<p>Overall Quality Rating w/rational and Recommendation:</p>			
<p>Recommendations Based on Evidence Synthesis</p> <ul style="list-style-type: none"> <li>• Strong, compelling evidence, consistent results: solid indication for a practice change.</li> <li>• Good and consistent evidence – practice change</li> <li>• Good but conflicting evidence: questionable indication for practice change; consider risk/benefit analysis</li> <li>• Little or no evidence: no indication for practice change</li> </ul>			

**Table 2***Evidence Review Table*

Kavak Akelma, F., Ergil, J., Özkan, D., Arik, E., Baran Akkuş, İ., & Aydın, G. B. (2020). The effect of preoperative warming on perioperative hypothermia in transurethral prostatectomies. <i>Gulhane Medical Journal</i> , 62(2), 114–120.					
Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
<p>The primary goal was to assess the effect of preoperative warming on perioperative hypothermia in transurethral prostatectomies. Additionally, this study also assessed thermal comfort, patient satisfaction, postoperative shivering, hemodynamic variable and discharge time.</p>	<p>Research; Single Center, Prospective, randomized single-blinded study</p>	<p><b>Sampling Technique:</b> Convenience  <b>Eligible Participants:</b> American Anesthesiology Association (ASA) I-III patients aged between 50 and 85 years, with a body mass index (BMI) between 15 and 36 kg/m<sup>2</sup>, scheduled for TURP surgery of 30- 90 min under general anesthesia, were enrolled in the study</p> <p><b>Exclusion Criteria:</b> known impaired thermoregulation or thyroid disorders, presence of severe hypertension presence of secondary hypertension (e.g., Cushing’s syndrome, pheochromocytoma, renal artery stenosis), presence of a vascular disease use of an angiotensin-converting enzyme inhibitor/angiotensin II receptor antagonist on the day of surgery, and a baseline temperature <math>\geq 37.5</math> °C.</p> <p><b>Power Analysis:</b> The sample size calculated based on an expected treatment effect of 0.5°C. post-surgery (a-error=0.5 at 80% power) required 16 people in each group.</p>	<p><b>Control protocol:</b> (n=17) Control group received standard of care, no preoperative warming in the pre-op area. Patients received a cotton blanket for comfort. All patients warmed perioperatively.</p> <p><b>Intervention Protocol:</b>            Group P (n=16) = prewarmed group; 30 minutes of full body preoperative warm-up set at 43 degrees Celsius. All patients warmed perioperatively</p> <p><b>Treatment Fidelity:</b>            To ensure blinding, the assessor remained in the surgery room and did not enter the preoperative waiting area. A protocol deviation was defined as a delay of 20 minutes or more between the end of warming and transfer to the surgery room.</p>	<p><b>Dependent Variable:</b>            perioperative hypothermia: defined as a core body temperature less than 36 °C during surgery</p> <p>The secondary variable assessed the shivering scale and PACU discharge time.</p> <p><b>Dependent Variable Measure:</b> Primary measure of intraoperative temperature via 3M SpotOn skin temperature device</p> <p>Shivering scale based on a Likert type scale</p>	<p>Core body temperature was significantly higher in warmed patients than in unwarmed patients after prewarming and at 0th, 15th, 30th, 45th, Core body temperature was also significantly higher in warmed patients at postoperative 0th and 20th min (p=0.039, p=0.01 respectively), PACU discharge time was shorter in warmed than in unwarmed patients (p=0.006)</p>

Becerra, Á., Valencia, L., Saavedra, P., Rodríguez-Pérez, A., & Villar, J. (2021). Effect of prewarming on body temperature in short-term bladder or prostatic transurethral resection under general anesthesia: A randomized, double-blind, controlled trial. *Scientific Reports*, 11, 20762. <https://doi.org/10.1038/s41598-021-00350-2>

Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
<p>Effect of prewarming on body temperature under general anesthesia: This study assessed core temperature differences in patients not prewarmed vs prewarming for 15, 30, or 45 minutes using a forced air blanket preoperatively</p>	<p>Research; Randomized, double-blind, controlled trial in patients scheduled for bladder or prostatic transurethral resection under general anesthesia.</p>	<p><b>Sampling Technique:</b> Convenience  <b>Eligible Participants:</b> . Eligible patients were those scheduled for elective bladder or prostatic transurethral resection under general anesthesia from August 2018 to October 2018  <b>Exclusion Criteria:</b> patients with current infections, those taking antipyretics within 24 h before surgery, patients with neuropathy, thyroid disorders, marked peripheral vascular diseases, skin lesions, or history of hypersensitivity to skin contact devices. Patients expected to have a transurethral resection lasting longer than one hour, and those who declined consent were also excluded.  <b>Power Analysis :</b> The Authors performed a power analysis to detect a temperature difference of 0.15 °C (<math>\pm 0.05</math> °C) at the end of surgery. To detect differences in the esophageal temperature, <u>40 patients</u> in each group were estimated to provide 80% power at an alpha level of 0.05.</p>	<p>All Patients warmed intraoperatively post induction using an upper body warming blanket to 43.0 °C  <b>Control Protocol n=76</b>                      Standard of care; no prewarming blanket    <b>Intervention Protocol</b>                      Prewarming was performed in the pre-anesthesia room using a forced-air covering the entire body. Temperature output of the warmer was set at maximum level (43.0 °C) and was placed for 15 min, 30 or 45 minutes preoperatively depending on each participants group allocation.    <b>15 min Group (n=76)</b>                      15 minutes of prewarming  <b>30 min Group (n=74)</b>                      30 minutes of prewarming  <b>45 min group (n=74)</b>                      45 minutes of prewarming  <b>Treatment Fidelity</b> randomization was performed by an assistant (not involved in enrollment or data collection) using a computer-generated randomization which was done by a statistician not involved in the rest of the trial.</p>	<p><b>Dependent Variable</b>                      To assess the effect of different time-periods of prewarming on perioperative temperature in short-term transurethral resection under general anesthesia.    <b>Dependent Variable measure:</b> temperature was measured using an esophageal thermometer (Mon-a-Therm, Covidien) placed through the drainage tube of the laryngeal mask, and recorded at 15-min intervals from anesthesia induction to the end of surgery. Neither intravascular fluids nor bladder irrigating fluids were warmed. Room temperature, volume of intravenous fluids, and volume of infused glycine were also recorded.</p>	<p>After prewarming, core temperature was significantly higher in 15- and 30-min groups (<math>36.8 \pm 0.5</math> °C, <math>p = 0.004</math>; <math>36.7 \pm 0.5</math> °C, <math>p = 0.041</math>, respectively). Body temperature at the end of surgery was significantly lower in the control group (<math>35.8 \pm 0.6</math> °C) than in the three prewarmed groups (<math>36.3 \pm 0.6</math> °C in 15-min, <math>36.3 \pm 0.5</math> °C in 30-min, and <math>36.3 \pm 0.6</math> °C in 45-min group) (<math>p &lt; 0.001</math>). Prewarming prior to short-term transurethral resection under general anesthesia reduced the body temperature drop during the perioperative period.</p>

Kaufner, L., Niggemann, P., Baum, T., Casu, S., Sehoul, J., Bietenbeck, A., Boschmann, M., Spies, C. D., Henkelmann, A., & von Heymann, C. (2019). Impact of brief prewarming on anesthesia-related core-temperature drop, hemodynamics, microperfusion and postoperative ventilation in cytoreductive surgery of ovarian cancer: A randomized trial. <i>BMC Anesthesiology</i> , 19(1), 161. <a href="https://doi.org/10.1186/s12871-019-0828-1">https://doi.org/10.1186/s12871-019-0828-1</a>					
Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
Authors hypothesized that forced-air prewarming during epidural catheter placement and induction of GA maintains normothermia and improves microperfusion.	Single-center prospective randomized clinical trial	<p><b>Sampling Technique:</b> convenience</p> <p><b>Eligible Participants:</b> Women were enrolled if they were of age (&gt; 18 years), mentally healthy, American Society of Anesthesiologists physical status Class I–III and scheduled to undergo elective major cytoreductive surgery in primary or secondary ovarian cancer under combined epidural and general anesthesia.</p> <p><b>Exclusion Criteria</b> Patients excluded if they have heart failure (left ventricular ejection fraction (LV-EF) &lt;30%), chronic obstructive pulmonary disease (GINA-Classification &gt; 3), renal failure (glomerular filtration rate (GFR) &lt; 50 ml/min) or dialysis, participation in another clinical trial and contraindication of EDA including non-eligibility due to refusal of neuraxial anesthesia.</p> <p><b>Power Analysis:</b> Sample size calculation based on minimal difference of 0.5 °C in body core temperature after prewarming compared to no prewarming (standard) A sample size of totally 48 patients, divided into two groups, was calculated to provide 80% power.</p>	<p><b>Control Protocol (n=24)</b> standard treatment group, patients were covered by a cotton blanket for passive insulation without active warming during the insertion of the epidural catheter.</p> <p><b>Intervention Protocol (n=24)</b> Women in the prewarming group received forced-air warming at 43°C, during the establishment of epidural anesthesia. Prewarming was applied using a forced air warming gown connected to a forced air warmer which warms the front of the body including upper arms</p> <p><b>Treatment Fidelity</b> Patients were prospectively randomized into prewarming and standard group using a computer-generated block randomization (Excel) The randomization was concealed. The researchers were blinded when data evaluation took place</p>	<p><b>Dependent Variable:</b> primary endpoint was defined as body core temperature drop (BCT<sub>drop</sub>) from before epidural catheter placement (T<sub>1</sub>) and after induction of GA (T<sub>2</sub>) in the pre-warming or standard group.</p> <p><b>Dependent Variable measure:</b> Body core temperature was taken by using the SpotOn™ temperature system in both groups and throughout the observation period (The SpotOn provides a non-invasive measurement of core body temperature with a reported accuracy of ± 0.20°C between 31.0-37.0°C )</p>	BCT <sub>drop</sub> was 0.35 °C with prewarming and 0.9 °C without prewarming (p < 0.005) and BCT remained higher over the observation period ( $\Delta T_4 = 0.9$ °C up to $\Delta T_7 = 0.95$ °C, p < 0.001).

Lau, A., Lowlaavar, N., Cooke, E. M., West, N., German, A., Morse, D. J., Gorges, M., & Merchant, R. N. (2018). Effect of preoperative warming on intraoperative hypothermia: A randomized-controlled trial. *Canadian Journal of Anaesthesia = Journal Canadien D'anesthesie*, 65(9), 1029–1040. <https://doi.org/10.1007/s12630-018-1161-8>

Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
<p>To evaluate the effects of preoperative forced-air warming on intraoperative hypothermia.</p>	<p>Randomized-controlled trial</p>	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible Participants</b> ASA physical status I-III adults aged 18 to 85 yr scheduled for elective non-cardiac surgery.</p> <p><b>Exclusion Criteria:</b> Surgical procedures scheduled for &lt; 1 hour or &gt; 6 hours, the need for intraoperative aortic cross-clamping, patients receiving spinal or epidural anesthesia only, known metabolic disorders, pre-existing preoperative hypothermia</p> <p><b>Power Analysis:</b> powered the study to detect hypothermic exposure based on a decrease in the absolute incidence of intraoperative hypothermia for core temperature &lt; 36°C. 100 subjects per treatment group provided 80% power, with an alpha level of 0.05, to detect a relative decrease in the incidence of hypothermia</p>	<p>Both groups received a warmed flannel blanket during admission as per routine institutional practice.</p> <p>Patients were stratified into one of four groups based on scheduled surgery time                      Treatment A → Scheduled to surgical duration <math>\geq</math> to &lt; 2.5 h (n=132)                      Control (n=58) Prewarmed (n=5)                      Treatment B → Scheduled surgery <math>\geq</math> 2.5hr (n=88)                      Control (n=45) Prewarmed (n=43)  <b>Control Protocol:</b> patients standard hospital gowns, received additional warmed flannel blankets on request in the preoperative period for at least 30 min,</p> <p><b>Intervention Protocol</b> Active pre-warming for at least 30 min via the disposable BairPaws full-body forced-air convective warming gowns Study participants were allowed to adjust the temperature output but required to maintain a minimum setting of 41°C with low fan output</p> <p><b>Treatment Fidelity</b> randomization schedule was generated by a statistical software; statistician blinded to the randomization schedule</p>	<p><b>Dependent Variable:</b> Core Body Temperature</p> <p><b>Dependent Variable measure:</b> The SpotOn™ temperature system was utilized throughout the perioperative period to measure core temperatures in both groups.</p>	<p>Results of the study showed that Pre-warmed participants had a lower median [interquartile range] magnitude of hypothermia than controls (0.00 [0.00-0.12] °Chr<sup>-1</sup> vs 0.05 [0.00-0.36] °Chr<sup>-1</sup>, respectively; median difference, -0.01°C□hr<sup>-1</sup>; 95% confidence interval, -0.04 to 0.00°C□hr<sup>-1</sup>; P = 0.005).</p> <p>The Authors concluded minimum of 30 min of preoperative forced-air convective warming decreased the overall intraoperative hypothermic exposure</p>

Lee, S. Y., Kim, S. J., & Jung, J.-Y. (2020). Effects of 10-min prewarming on core body temperature during gynecologic laparoscopic surgery under general anesthesia: A randomized controlled trial. *Anesthesia and Pain Medicine*, 15(3), 349–355. <https://doi.org/10.17085/apm.20006>

Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
<p>To test if 10-min of prewarming could prevent inadvertent perioperative hypothermia (IPH) could be prevented in patients undergoing gynecologic laparoscopic surgery</p>	<p>Randomized Control Clinical Trial</p>	<p><b>Sampling Technique:</b> Convenience  <b>Eligible Participants:</b> Patients between the ages of 19 and 75 years with American Society of Anesthesiologists physical status 1 or 2 who underwent gynecologic laparoscopic surgery under general anesthesia.  <b>Exclusion Criteria:</b> preexisting hypothermia or, hyperthermia, anesthesia lasting for &lt; 1 h or &gt; 2 h, and conversion from laparoscopic surgery to laparotomy Patients with a body mass index (BMI) <math>\geq 31 \text{ kg/m}^2</math> and known thyroid disease  <b>Power Analysis</b>                      Number of patients required for this study was based on a preliminary study of 28 patients undergoing gynecologic laparoscopic surgery. Based on this prior study; the calculated sample size to achieve 80% statistical power with an alpha error rate of 0.05 (two-tailed) and 24 patients per group were required.</p>	<p>All patients received perioperative forced air warming performed over the entire body with a cotton blanket from the time of anesthesia induction until surgery end.  <b>Control Protocol</b> Non-prewarming group (n = 27) = patient was brought into the or and induction was done immediately after measuring the core body temperature using an infrared tympanic thermometer.  <b>Intervention Protocol:</b> prewarming group (n = 27) In the prewarming group, patients were warmed preoperatively with a forced air warming device for 10 min in the operating theater. After 10 min of prewarming, the tympanic body temperature was measured, and anesthesia was induced promptly  <b>Treatment Fidelity:</b> Eligible patients were randomly assigned to one of two groups using a computerized random number generator. An assistant put the patient's allocation into a sealed opaque envelope, which was opened immediately after the patient entering the operating theater</p>	<p><b>Dependent Variable</b>                      Core Body Temperature  <b>Dependent Variable measure:</b>                      Core body temperature was measured using an infrared tympanic thermometer was used for measuring core body temperature.</p>	<p>The incidence of intraoperative hypothermia was higher in the non-prewarming group (73.1%) than in the pre-warming group (24%) (P &lt; 0.001). The core body temperature of the non-prewarming group was lower at the end of the surgery (P &lt; 0.001). There were significant differences in core temperature changes between the non-prewarming and prewarming groups (P &lt; 0.001)                      The Authors concluded that 10 min prewarming beneficial, especially for patients undergoing surgery for about 1 hour according to the present results.</p>

Xiao, Y., Zhang, R., Lv, N., Hou, C., Ren, C., & Xu, H. (2020). Effects of a preoperative forced-air warming system for patients undergoing video-assisted thoracic surgery: A randomized controlled trial. *Medicine*, 99(48), e23424. <https://doi.org/10.1097/MD.00000000000023424>

Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
<p>Evaluate the effects of 30-minute prewarming combined with a forced-air warming system during surgery to prevent intraoperative hypothermia under general anesthesia combined with erector spinae nerve block</p>	<p>Randomized Control Trial</p>	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible Participants:</b> The inclusion criteria were: patients aged 45 to 60 years with American Society of Anesthesiology (ASA) grades I to II; operation time between 1 hour and 3 hours; who underwent elective VATS under general anesthesia combined with ESPB between December 2016 and June 2019.</p> <p><b>Exclusion Criteria</b> Patients with endocrine disorders); patients with peripheral vascular disease impaired respiratory function or vascular disease febrile patients (&gt;37.3°C) or tympanic temperature &lt;36.0°C; delay time longer than 10 minutes; body mass index (BMI) &gt;30 kg/m<sup>2</sup>.</p> <p><b>Power Analysis:</b> Based on a pilot study, 32.4% of patients experienced intraoperative hypothermia in the warming group, assuming a difference of 15% between the 2 groups as clinically significant. A sample size of 42 patients per group (a = 0.05, b = 0.8; PASS 11.0</p>	<p>Both groups received perioperative forced air warming;</p> <p><b>Control Protocol (n=49)</b> Patients received standard care, no preoperative warming, received forced warming post induction of anesthesia during the perioperative period</p> <p><b>Intervention Protocol (n= 49)</b> Patients in the prewarming group were prewarmed for 30minutes before the induction of anesthesia using full body forced-air warming system set to 38.0°C.</p> <p><b>Treatment Fidelity:</b> A computer-generated randomization table was used for participant allocation. On the day before surgery, one nurse who was unaware of the study details performed the preoperative evaluation and educated patients on how to use the patient- controlled intravenous analgesia pump. Another nurse, also unaware of the details of the study, opened the sealed envelope and randomly allocated the patient to the prewarming group (n = 49) or warming group (n=49) when the patient entered the operating room. The anesthesiologist and surgeon were all blinded to the study conditions.</p>	<p><b>Dependent Variable</b> Core Body Temperature arrival at the operating room(T0); preparation room(T1); before anesthesia induction (T2); before incision (T3): at 10 minutes (T4), 20 minutes (T5), 30 minutes (T6), and 60 minutes (T7) after the onset of the operation; at the end of the operation (T8); on arrival at the PACU ( the PACU Severity of hypothermia was graded based on the core temperature as follows: <b>Dependent Variable measure:</b> Patients temperature was measured via infrared tympanic thermometer before induction. An esophageal probe was placed after induction monitorization was recorded.</p>	<p>The incidence of intraoperative hypothermia was significantly lower in the prewarming group than the warming group (12.24% vs 32.65%, P=0.015). Core temperature showed the highest decrease 30minutes after surgery start in both groups; however, the rate was lower in the prewarming than in the warming group (0.31 ± 0.04°C vs 0.42 ± 0.06°C, P &lt; .05). Compared with the warming group, higher core temperatures were recorded for patients in the prewarming group from T1 to T6 (P&lt;.05).</p>

Chataule, S. M., Hazarika, A., Jain, K., Chauhan, R., Luthra, A., Meena, S., Aggarwal, S., & Sethi, S. (2022). Preoperative Forced-Air Warming Strategy: Is It Effective in Averting Intraoperative Hypothermia in Elderly Trauma Surgical Patients? *Cureus*, 14(9), e29305. <https://doi.org/10.7759/cureus.29305>

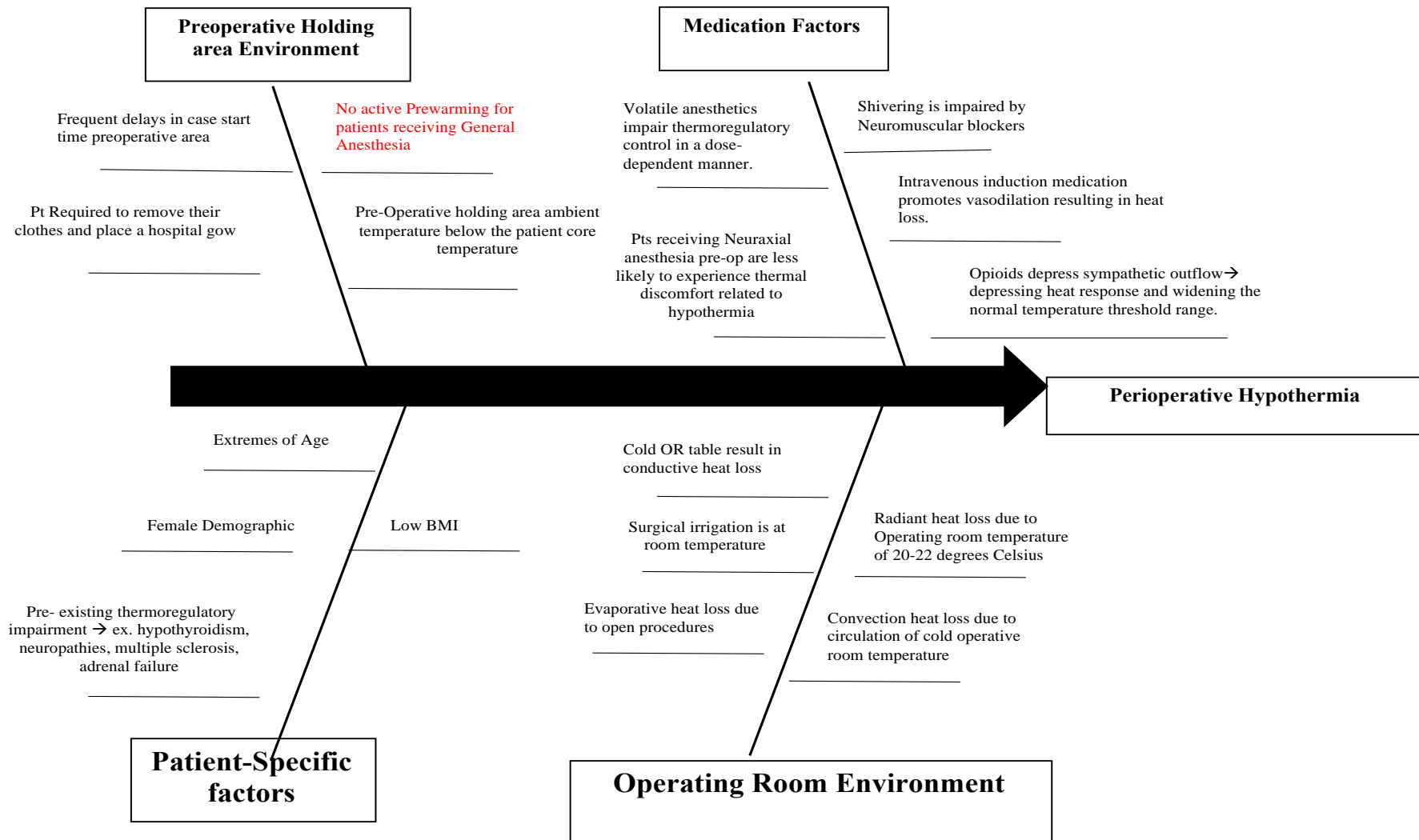
Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
<p>Researchers aim to compare the incidence of intraoperative hypothermia (&lt; 36-degree celsius) between preoperative forced-air warming for 30 minutes vs non prewarming in elderly surgical patients receiving neuraxial anesthesia.</p>	<p>single-blinded, prospective, randomized control trial</p>	<p><b>Sampling Technique</b> Convenience</p> <p><b>Eligible Participants</b> American Society of Anesthesiologists (ASA) I-III (Age &gt; 60 years) patients scheduled to undergo femur fracture surgeries under central neuraxial anesthesia</p> <p><b>Exclusion Criteria</b> Patients having any metabolic disorder affecting thermoregulation, uncontrolled diabetes, thyroid disorder, recent ear infection, ASA physiological status ≥ IV, and contraindications of neuraxial anesthesia were excluded from the study.</p> <p><b>Power Analysis</b> Sample size was calculated based on Horn et al.'s study in which 67% of the subjects developed intraoperative hypothermia and required active warming during surgery (Horn et al., 2017). We hypothesized that in Group A, approximately 50% fewer patients will develop hypothermia during surgery (effect size 33.5%). According to power analysis, at least 50 patients were needed in each group to show a difference in intraoperative hypothermia incidences with a statistical power of 80% and CI of 95% (p&lt;0.05).</p>	<p>All the patients of both groups were hydrated with 500 ml of Ringer's lactate warmed at 38.0°C in the fluid warming cabinet as is standard care for neuraxial anesthesia for this center. Neither group received perioperative warming.</p> <p><b>Control Protocol (n=50)</b>“ Group B” Patients were covered with an insulated blanket prior to neuraxial anesthesia.</p> <p><b>Intervention Protocol(n=50)</b> “Group A” were covered with an insulated blanket and warmed with forced- air warming, which was set at 40.0°C, till patient temperature reached 37.5°C ± 0.5°C. Patients were asked every five minutes about their thermal comfort and tympanic membrane temperature noted.</p> <p><b>Treatment Fidelity</b> All eligible patients were randomized by computer-generated sealed envelope technique, into either Group A (30-minute preoperative warming group) or Group B (non-warming group). The observer involved in the intraoperative and postoperative period was blinded for preoperative warming status.</p>	<p><b>Dependent Variable:</b> perioperative hypothermia</p> <p><b>Dependent Variable measure:</b> An infrared tympanic membrane thermometer measured the core body temperature during the different study points. Hypothermia was defined as temperature &lt;36°C</p>	<p>A statistically significant difference between the two groups in terms of the time to develop hypothermia (p = &lt;0.001) in our study. The mean time for developing hypothermia was 25.88 minutes and 143.08 minutes in Group B and Group A, respectively. We also observed a statistically significant difference between the two groups in terms of mean duration of intraoperative active warming (p = &lt;0.001) (103.60 minutes in Group B and 15.60 minutes in Group A. Patients who have warmed actively (Group A) had a lesser rate of heat loss, and even maintained the euthermia for a longer period as compared to un-intervened patients (Group B).</p>

**Table 3***Role's responsibility and contact of QI team members*

Team Member Name/Credentials/Title	Contact Information	Responsibilities
Linda Goetz, CRNA Director, Faculty Sponsor	<a href="mailto:lgoetz@som.umaryland.edu">lgoetz@som.umaryland.edu</a>	Faculty sponsor, approve and support DNP idea to be implemented at UMMC.
Dr. Bill Howie, Clinical Site Representative	<a href="mailto:bhowie@som.umaryland.edu">bhowie@som.umaryland.edu</a>	Assist in development of project ideas, serve as a site liaison to aid project implementation.
Perry, Mary MC Manager, NursingADMIN PERIOP	<a href="mailto:mperry@umm.edu">mperry@umm.edu</a>	The manager serves as a leader for the nursing staff. Need the approval to perform any project implementations. → preliminary approval of a “warming study”
Noel V. Corpus, BSN, RN, CMSRN SCN I at Ambulatory Surgical Care Unit, UMMC DTC	<a href="mailto:ncorpus@umm.edu">ncorpus@umm.edu</a>	Nursing representative of the ERAS committee. Serves as a SCN I in the ASCU, ERAS Champion.
Sarah Rosenberger Vascular Surgery NP	<a href="mailto:srosenberger@som.umaryland.edu">srosenberger@som.umaryland.edu</a>	Nurse Practitioner that leads the ERAS committee meetings within the hospital system
Dr. Megan Anders, MD Anesthesiology Chief for the Critical Care Division; Vice Chair for Safety and Quality	<a href="mailto:manders@som.umaryland.edu">manders@som.umaryland.edu</a>	She is a leader and representative for the anesthesia department for the ERAS committee.
Elyse Donahue, MS, BSN,CRNA Vice President, Procedural Care Services for the Midtown and Downtown Campuses at the University of Maryland Medical Center	<a href="mailto:elyse.donahue@umm.edu">elyse.donahue@umm.edu</a>	Strategic and operational oversight includes the operating rooms, endoscopy services, cardiac procedural services, preadmission testing, pre and post care units and central sterile reprocessing.
Tamar Pair, Business Operations Manager at University of Maryland Baltimore	<a href="mailto:tpair@som.umaryland.edu">tpair@som.umaryland.edu</a>	IT designee, consulted to help inform database material via REDCap.

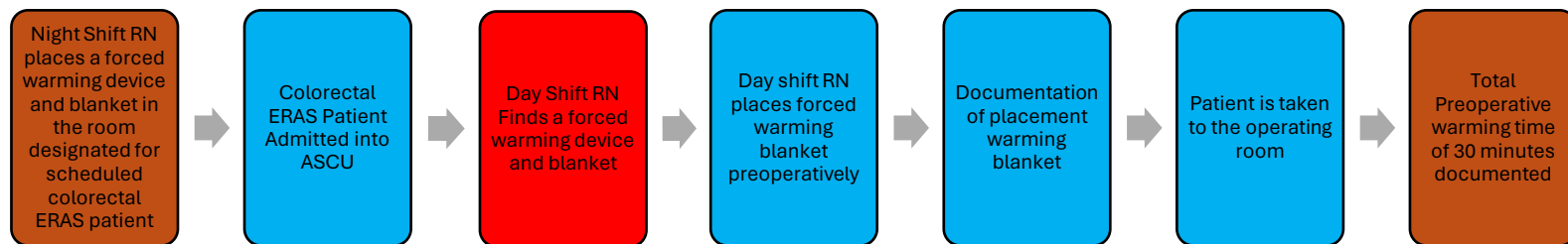
**Figure 1**

*Fishbone of cause*



**Figure 2**

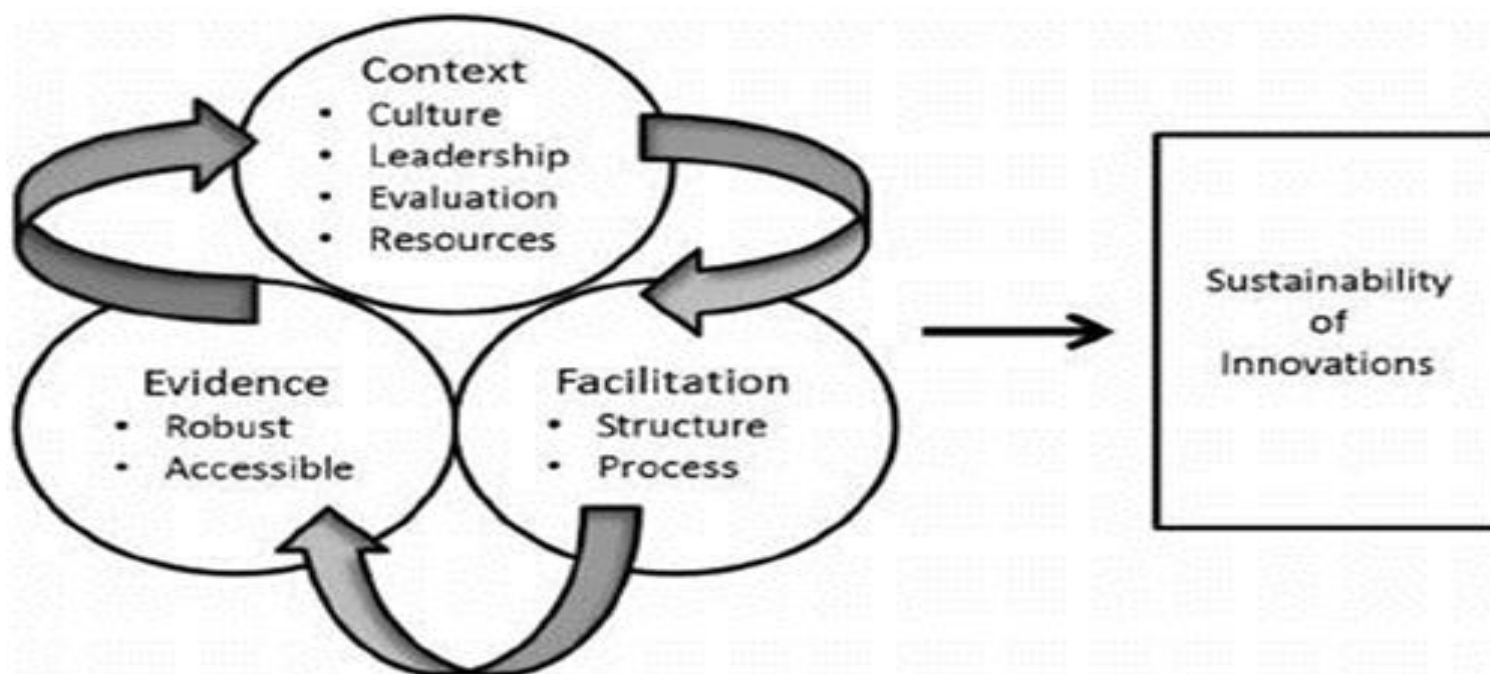
*Desired Process Map for Implementation of Preoperative warming*



*Note.* Orange: additional steps for the desired process, Blue: Current process step that will remain, Red: Current process step that will be eliminated by this QIP

**Figure 3**

*Promoting Action on Research Implementation in Health Services (PARiHS) Framework*



*Note.* From University of Maryland School of Nursing, NDNP 804, Module 8: Theory, Model or Framework Identification. Rycroft-Malone, J. (2010). Promoting on Research Implementation in Health Services (PARISH). In J. Rycroft-Malone & T. Bucknall (Eds.), *Models and frameworks for implementing evidence-based practice: Linking evidence to action* (pp. 109-136). Oxford: Wiley-Blackwell.

**Figure 4**

Presentation for ERAS Committee

**Preoperative Warming to Prevent Inadvertent Perioperative Hypothermia for Early Recovery After Surgery Patients**  
Helen Abraham, SRNA

1

- Increases the risk of surgical site infection and delays wound healing. This is mainly a result of vasoconstriction-related tissue hypoxia and impaired immunity (Maeremans et al., 2006).
- hypothermia-associated coagulopathy results from impaired enzymes and reduced platelet function, resulting in increased bleeding and blood transfusion requirements (Rajagopalan et al., 2008).
- IPH prolongs recovery due to delaying drug metabolism and depression in cognitive functions (Lemarch et al., 1997). Induction of general, neuraxial, and regional anesthesia causes impairment of the central thermoregulatory controls, a significant trigger for IPH (Riley & Andrzegowski, 2018).

2

**Preoperative Warming recommendation**

The National Institute for Health and Care Excellence states all patients whose temperatures are above or below 36.0°C should be preoperatively warmed (Recommendation 1) (epidemiology, 2016)

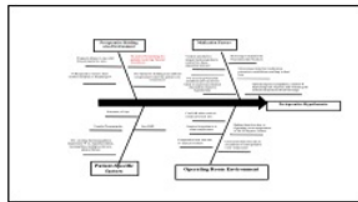
Centers for Medicare & Medicaid Services suggest considering preoperative warming for all patients to reduce the risk of IPH (Quality Incentive Program 2012). (Preoperative Temperature Management – National Quality Strategy (https://www.hhs.gov/nqsa))

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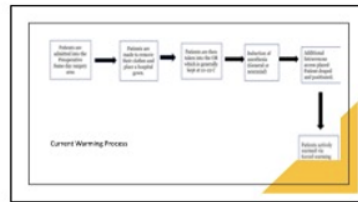
**ERAS Society Preoperative Warming Guidelines**

- Clientship
- Outpatient
- Outpatient
- Heat & Hot
- Cold Storage
- Electrolytic
- Electrolytic/Heat
- Heat/Agency

4



5



6



7

- Kavak et al. (2020), Xiao et al. (2020) Roberts et al., Luo et al. concluded that thirty minutes of preoperative warming significantly decreased the incidence of IPH.
- Kavak et al. also looked at discharge time and found that discharge from post-anesthesia care delivery was shorter in prewarmed patients.
- Roberts et al. also looked at variable preoperative warming times: 15 minutes, 30 minutes, and 45 minutes. They concluded that intraoperative body temperatures were highest in the 30 minutes and 45 minutes but also concluded that 15 minutes of warming resulted in a significantly higher core temperature when compared with the control.
- Kachour et al. and Xiao et al. Level 1 and quality II assessed rates of IPH in patients receiving both general and neuraxial anesthesia and concluded that incidences of IPH were significantly lower in patients receiving thirty minutes of preoperative warming.

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1. Kavak, S., et al. (2020). The effect of preoperative warming on the incidence of intraoperative hypothermia and postoperative shivering. *Journal of Clinical Anesthesia*, 67, 105001.

2. Xiao, Y., et al. (2020). The effect of preoperative warming on the incidence of intraoperative hypothermia and postoperative shivering. *Journal of Clinical Anesthesia*, 67, 105001.

3. Roberts, J., et al. (2020). The effect of preoperative warming on the incidence of intraoperative hypothermia and postoperative shivering. *Journal of Clinical Anesthesia*, 67, 105001.

4. Luo, L., et al. (2020). The effect of preoperative warming on the incidence of intraoperative hypothermia and postoperative shivering. *Journal of Clinical Anesthesia*, 67, 105001.

5. Kachour, A., et al. (2020). The effect of preoperative warming on the incidence of intraoperative hypothermia and postoperative shivering. *Journal of Clinical Anesthesia*, 67, 105001.

6. Xiao, Y., et al. (2020). The effect of preoperative warming on the incidence of intraoperative hypothermia and postoperative shivering. *Journal of Clinical Anesthesia*, 67, 105001.

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Author	Year	Journal	Findings
Kavak et al.	2020	Journal of Clinical Anesthesia	30 min preoperative warming significantly decreased the incidence of IPH.
Xiao et al.	2020	Journal of Clinical Anesthesia	30 min preoperative warming significantly decreased the incidence of IPH.
Roberts et al.	2020	Journal of Clinical Anesthesia	15, 30, and 45 min preoperative warming resulted in higher core temperatures.
Luo et al.	2020	Journal of Clinical Anesthesia	15, 30, and 45 min preoperative warming resulted in higher core temperatures.
Kachour et al.	2020	Journal of Clinical Anesthesia	30 min preoperative warming significantly lowered IPH rates.
Xiao et al.	2020	Journal of Clinical Anesthesia	30 min preoperative warming significantly lowered IPH rates.

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ERAS Society Preoperative Warming Guidelines

1. All patients should be warmed preoperatively.

2. Warming should be initiated before the patient enters the operating room.

3. Warming should be maintained throughout the procedure.

4. Warming should be continued until the patient is discharged from the PACU.

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ERAS Society Preoperative Warming Guidelines

1. All patients should be warmed preoperatively.

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## Appendix A

### *Dayshift warming audit*

#### Day Shift Warming Audit

Page 1

Please complete the survey below.

Thank you!

- 1) Patient Admission Date \_\_\_\_\_
- 2) Was a warming device and warming blanket prepared in the patients room  Yes  No
- 3) Warming device Application Time \_\_\_\_\_
- 4) OR start time \_\_\_\_\_
- 5) Total Preoperative Warming Minutes \_\_\_\_\_
- 6) If preoperative warming was missed, state why  Equipment not prepared in the patient's room  Equipment Malfunction  Patient refusal  Other
- 7) If other Please Explain \_\_\_\_\_

## Appendix B

### *Night Shift Warming workflow*

Page 1

## Night Shift Workflow Audit

Please complete the survey below.

Thank you!

- 
- 1) Patient Admission Date  

---

(M/D/Y)

---

  - 2) Were Preoperative warming placed  Yes  
 No

---

  - 3) Was a warming device and blanket allocated in the room for this patient?  Yes  
 No

---

  - 4) If not explain why?  

---

## Appendix C

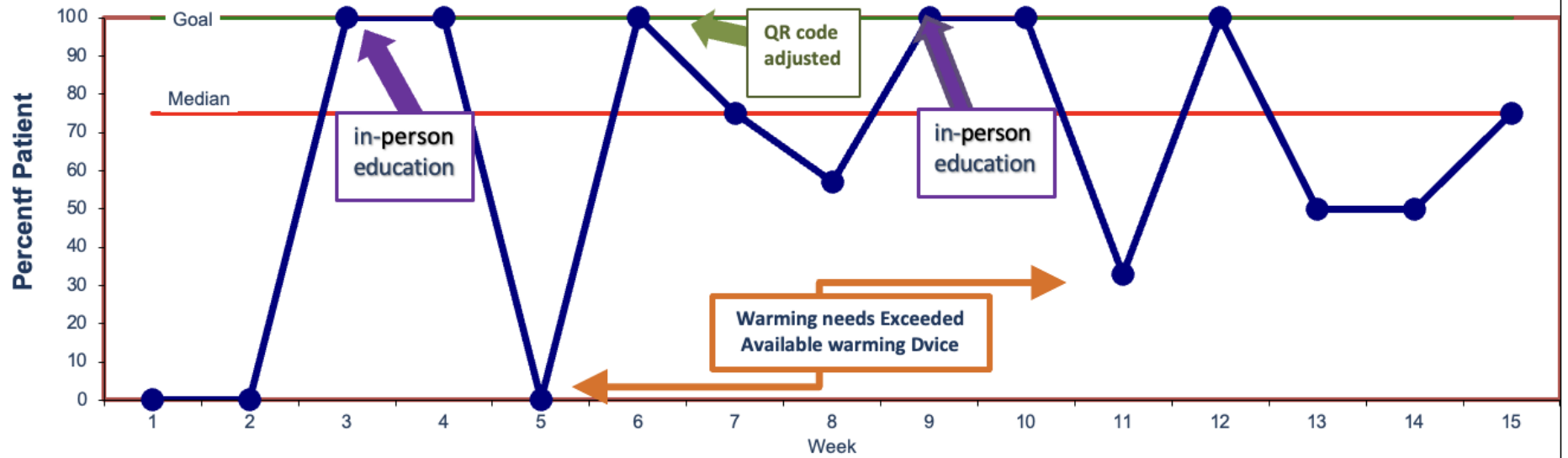
### *Ethics and Procedures Requirements*

- I. Student ensures the site has a current site student affiliate agreement. If not, student works with site representative to obtain one
- II. Student schedules meeting with Clinical Site Representative, DNP Faculty Advisor, and Unit Leader (if applicable), to plan the project
- III. Student submits DNP Project Approval Form
- IV. Clinical Site Representative documents project approval
- V. Administrator/Sponsor documents project approval
- VI. Student submits site Institutional Review Board (IRB) application for Non-Human Subjects Research (NHSR) determination
- VII. Student submits documentation of NHSR determination to site person of contact
- VIII. Student submits to School of Nursing IRB (if applicable)
- IX. Student submits School of Nursing IRB documentation to site person of contact (if applicable)
- X. DNP Project may be Initiated

### Appendix D

#### Workflow Compliance

Compliance with Workflow



Appendix E

Compliance with thirty minutes of preoperative warming

