Preoperative Warming and Improved Postoperative Outcomes in Colorectal Surgical Patients

Elizabeth C. Dikeman

Under Supervision of

Richard Conley

Second Reader

Yanka Campbell

A DNP Project Manuscript
Submitted in Partial Fulfillment of the Requirements for the
Doctor of Nursing Practice Degree

School of Nursing, University of Maryland at Baltimore
May 2023

Author Note

There is no known conflict of interest to disclose. Correspondence regarding this article should be emailed to edikeman@umaryland.edu

Abstract

Problem: The maintenance of normothermia during surgery is a critical component of patient care provided by the anesthesia provider. A root cause analysis revealed this Level II Trauma Center performed preoperative warming for hysterectomy patients, as part of an Enhanced Recovery After Surgery (ERAS) protocol. However, there were no established preoperative warming protocols for patients receiving colorectal surgery. Intraoperative hypothermia is associated with negative postoperative outcomes to include, increased risk of surgical site infection, increased intraoperative blood loss, increased narcotic requirement following surgery and prolonged hospitalization. If this problem was not addressed, patients could experience adverse postoperative outcomes leading to increased hospital costs and waste of resources.
Purpose: To overcome the absence of standardization of preoperative warming for adult surgical patients at this facility, this project implemented a preoperative warming protocol for colorectal ERAS patients prior to surgery. **Methods:** The quality improvement project was implemented over a 15-week period in the fall of 2022. Change in practice occurred with the implementation of a preoperative warming protocol for colorectal surgical patients. The surgical team initiated the ERAS order set and the nurse initiated warming per protocol at least 30 minutes prior to surgery. The patient's postoperative temperature in the post anesthesia care unit was also evaluated. **Results:** If the warming protocol was ordered by the colorectal surgery team 100% of patients received prewarming. Thirty-eight patients were eligible, but only 76% had an order present and received prewarming. All patients who received prewarming were normothermic postoperatively. **Conclusion:** Project findings cannot conclude if protocol implementation had an impact on patient outcomes at this facility. Patients who received prewarming were

normothermic postoperatively. This is associated with improved postoperative outcomes and reduced hospital spending.

Keywords: prewarming, colorectal surgery, hypothermia, enhanced recovery after surgery

Preoperative Warming and Improved Postoperative Outcomes in Colorectal Surgical Patients

The maintenance of normothermia during surgery is a critical component of patient care provided by the anesthesia provider. Intraoperative hypothermia is associated with negative postoperative outcomes to include, increased risk of surgical site infection, increased intraoperative blood loss, increased narcotic requirement following surgery and prolonged hospitalization (Zheng et al., 2020). While intraoperative warming is a widely used practice in the operating suite, preoperative warming is not routinely implemented. This Level II Trauma Center performs preoperative warming for hysterectomy patients, as part of an Enhanced Recovery After Surgery (ERAS) protocol. However, there were no established preoperative warming protocols for patients receiving colorectal surgery. The department of surgery had 16 separate divisions and performed around 20,000 surgeries per year. The colorectal surgery department performs approximately 4 procedures per day, and around 1,500 per year. Implementing a preoperative warming protocol for colorectal surgical patients would improve postoperative outcomes, reducing hospital length of stay, leading to greater patient satisfaction and decreased facility costs. Moreover, colorectal surgery has the highest incidence of surgical site infection rates, compared to other elective surgeries (Paulson et al., 2017). Walters and researchers (2020) performed a retrospective study examining the relationship between hypothermia and surgical site infections in colorectal surgical patients. Out of 7908 adult patients, a 0.5 C decrease in intraoperative core temperature (<35.4C) was associated with increased infection risk complications (Walters et al., 2020). By maintaining normothermia, surgical patients experience fewer complications and faster recovery. Implementing a preoperative warming protocol for colorectal patients at this facility potentially decreased

postoperative adverse events and improved patient outcomes, reducing hospital stays. The purpose of this Doctorate of Nursing Practice (DNP) quality improvement (QI) project was for all ERAS colorectal patients to receive at least 30 minutes of preoperative warming to decrease postoperative hypothermia rates.

Literature Review

A review of the current literature supports the application of a forced air warming device as an effective method to warm surgical patients (Madrid et al., 2016). Initiating preoperative warming at least 30 minutes prior to surgery resulted in a lower incidence of hypothermia postoperatively (Lau et al., 2018). Additionally, preoperative warming decreases the incidence of intraoperative hypothermia, which has been associated with more favorable patient outcomes, including decreased surgical site infection rates (Walters et al., 2020). The complete literature review and synthesis (Appendix A), support the initiation of a preoperative warming protocol within this facility.

Theoretical Framework

Knowledge to Action (KTA) is a conceptual framework used to address the issue of changing the preoperative warming protocol within the organization by identifying barriers, selecting and tailoring interventions, monitoring knowledge use and outcome evaluation (Field et al., 2014). The purpose of the KTA is to help organizations synthesize knowledge, implement interventions and improve outcomes while overcoming barriers and promoting facilitators. The key concepts of the KTA framework are knowledge creation and the action cycle. Knowledge is tailored to address a problem and adapted to the context by selecting implementation strategies that promote sustained change amongst staff. The KTA was utilized to help meet the goals of this project. Structure goals included the integration of the warming protocol into the existing

colorectal ERAS order set in the electronic medical record (EMR). Preoperative nursing staff were then educated on the protocol within the first 2 weeks of implementation with 100% compliance. Process goals included 100% compliance rate among preoperative nursing staff with the use of the preoperative warming protocol for at least 30 minutes for all colorectal ERAS patients. A clinically significant outcome goal was that patients who receive preoperative warming were normothermic on arrival to the post anesthesia care unit (PACU). During the first phase of the action cycle current evidence-based practice research was disseminated to preoperative staff to address the knowledge gap and encourage buy in from key stakeholders. To encourage adaptation of the protocol and overcome barriers unit champions were identified to help garner support for the initiative and serve as a clinical resource for staff. During the implementation phase a new preoperative warming protocol for colorectal surgical patients was initiated. Throughout this phase compliance was monitored to determine if the protocol was being appropriately implemented. Knowledge use was continuously evaluated, making adjustments to promote success. The final phase was sustaining the change where the use of the preoperative warming protocol became the standard of care among preoperative staff within the organization (Figure 2).

Methods

A preoperative warming protocol for ERAS colorectal surgical patients was implemented in the preoperative surgical department at this facility. Team members included, preoperative nursing staff and leadership, members from the colorectal surgery department, anesthesia department and information technology (IT) department. The preoperative nursing leadership served as unit champions to garner support for the protocol as well as served as a clinical resource for staff. Staff education sessions on the preoperative warming protocol were facilitated

by nursing leadership. The IT department aided in incorporating a preoperative warming order into the existing colorectal ERAS order set. Key stakeholders in the preoperative and colorectal surgery departments promoted adoption of the preoperative warming protocol to facilitate change within the organization. The previous process at the facility (Figure 3) was the patient presents for surgery. They are admitted into the preoperative area and issued a standard hospital gown and hat. Warm blankets are provided by the preoperative nursing staff per patient request. Patient warming measures were then initiated intraoperatively by anesthesia staff. There was a forced air warming machine available in each preoperative patient room. The forced air warming device specific disposable gowns were already a supply item being ordered by the preoperative department and were readily available. The new process included when a colorectal ERAS patient presented for surgery, they were issued a forced air warming device disposable gown. They were then connected to the forced air warming device in the preoperative room and placed on high temperature setting for minimum of 30 minutes by the preoperative nursing staff (Figure 4).

The planned intervention was to implement a preoperative warming protocol for colorectal surgery ERAS patients at this facility. The new preoperative warming protocol required that the colorectal surgery team initiate the ERAS order set prior to surgery. At the time of admission, the nurse initiated the order set and provided the patient with a disposable forced air warming device gown. Once the admission process was complete, the patient was connected to the forced air warming device in the room on the high heat setting. The patient received a minimum of 30 minutes of preoperative warming via forced air warming device, titrated to patient comfort. Implementation started on September 4th with an education session conducted by the project lead at the monthly anesthesia department staff meeting. Preoperative nursing

leadership was also educated on the protocol and provided feedback on how to facilitate protocol compliance among staff. Based on this feedback a PowerPoint was developed and disseminated to preoperative nursing staff via email. Staff compliance was continuously evaluated throughout the implementation period. Strategies and tactics to achieve the project aims included conducting ongoing staff education and reminder emails throughout implementation, recruiting, designating and training preoperative nursing change champions and colorectal surgery departments to support and drive protocol implementation (Powell et al., 2015).

The measures used to evaluate process and outcome goals during implementation included evaluating the number of colorectal surgical ERAS patients who had the order set placed. Goal achievement was assessed by evaluating the order set placed by the colorectal surgical team and the preoperative nursing staff implemented the warming protocol for at least 30 minutes prior to surgery. Total warming times documented in the EMR were collected weekly via chart audit. Data points, total number of ERAS colorectal surgical cases, ERAS order set placed by colorectal surgery team, time the order was acknowledged by preoperative nursing staff, time the patient arrived to the operating room and postoperative temperature measurements were collected.

Data collection was performed by the project lead (QI-PL) with weekly chat audits during the implementation period using a data collection tool (Appendix B). Baseline data was collected on the number of patients undergoing colorectal surgery at this facility. Once the preoperative warming protocol was implemented data points collected included, presence of an ERAS order set, protocol compliance, warming time and postoperative patient temperatures. Eligible participants were identified on the operating room schedule the day prior with the surgical procedure comment, “this is an ERAS case”. Confidentiality of patient data was

maintained throughout the data collection process. A secure, password protected computer at the site was used by the QI-PL to protect patient health information. All data collected was stored in REDCap, a HIPPA compliant secure, password protected, data collection tool and only accessed by authorized users. All data used in run charts was deidentified. Quantitative data analysis of the process goal was performed using a run chart to illustrate the percentage of colorectal surgical ERAS patients with a preoperative order set initiated more than 30 minutes prior to surgery. The outcome goal of protocol compliance was also illustrated as a percentage using a run chart (Figure 5). Interventions during the implementation period including staff education sessions and changes to the EMR, were noted to have an effect on protocol compliance. Postoperative patient temperature data was interpreted to assess rates of normothermia following surgery. Data variation of protocol adherence was assessed in run charts looking for shifts, runs, trends and outliers. Changes in equipment, staffing and cooperation of the patients to the protocol were also evaluated when looking at compliance data over time.

Non-human Subject's Research determination from the Human Research Protections Office of the UMSOM Institutional Review Board was obtained prior to implementation of this project. This ensured the project's ethical duty was met.

Results

A total of 38 patients were included in data collection during the 15 weeks of implementation. Out of the 38 eligible patients, only 76% had an ERAS order present and received prewarming. Of these 29 patients, all received at least 30 minutes of prewarming per protocol. Additional data points collected include patient temperatures on arrival to the PACU immediately following surgery. On arrival to the PACU all patients were normothermic, defined as temperatures greater than 36 degrees Celsius. Astronomical data points occurred during week

3 where there was 0% compliance, attributed to the absence of the warming order and weeks 7, 12 and 15 when there were no ERAS colorectal surgical cases scheduled. No shifts or trends were noted as there were no more than 3 consecutive data point above the median. There were no runs noted as the data line was fluctuating around the median. Results show, all patients who received preoperative warming for a minimum 30 minutes prior to surgery were normothermic immediately following surgery.

Discussion

Overall compliance with the warming protocol was high. This was facilitated by integration of the warming order into the existing ERAS order set in the EMR. By using an order set already in use, the workflow of the colorectal surgical team was unaffected. Discussions with preoperative nursing staff and leadership revealed that prewarming was being successfully performed. Contributing factors included, prior staff knowledge of prewarming and easy access to supplies and equipment needed to perform the intervention. Continued protocol compliance was also promoted by nursing leadership during implementation. Chart audits revealed the nursing staff successfully executed the warming protocol when the order was placed in the electronic chart by the surgical team. All patients who received prewarming per protocol were normothermic in the PACU.

Conclusions

This QI project has shown 30 minutes of prewarming via forced air warming device, is an effective method to help prevent hypothermia in colorectal surgical patients. Unfortunately, no conclusions can be made whether prewarming reduced the incidence of postoperative adverse patient events at this facility. Research shows, hypothermia is associated with increased risk of surgical site infections and other serious complications (Walters et a., (2020). Therefore, it is

reasonable to conclude the use of prewarming to maintain normothermia will improve postoperative outcomes, leading to greater patient satisfaction and reduced spending at this facility over time.

To promote long term sustainability of this QI project, protocol reinforcement must continue by unit champions. Education materials will remain readily accessible to staff and be posted in common areas in the preoperative department. Preoperative nursing leadership has also agreed to continue promoting protocol compliance. Favorable results of this QI project have been shared with key stakeholders in the nursing, surgical and anesthesia departments to promote future adoption by staff. Future QI projects should include other surgical patient’s populations. Next steps involve updating the EMR to allow for more streamlined charting of the intervention by the nursing staff.

References

Dang, D., Dearhold, S., Bissett, K., Ascenzi, J., & Whalen, M. (2022). *Johns Hopkins evidence-based practice for nurses and healthcare professionals*: Model and guidelines. 4th ed. Sigma Theta Tau International

Fettes, S., Mulvaine, M., & Van Doren, E. (2013). Effect of preoperative forced-air warming on postoperative temperature and postanesthesia care unit length of stay. *AORN journal*, *97*(3), 323–328. https://doi-org.proxy-hs.researchport.umd.edu/10.1016/j.aorn.2012.12.011

Field, B., Booth, A., Ilott, I., & Gerrish, K. (2014). Using the Knowledge to Action Framework in practice: a citation analysis and systematic review. *Implementation science : IS*, *9*, 172. https://doi.org/10.1186/s13012-014-0172-2

Johns Hopkins Evidence-Based Practice Model for Nursing and Health Care Professionals (2022), Appendix D

Lau, A., Lowlaavar, N., Cooke, E. M., West, N., German, A., Morse, D. J., Görges, M., & Merchant, R. N. (2018). Effect of preoperative warming on intraoperative hypothermia: a randomized-controlled trial. Effet du réchauffement préopératoire sur l'hypothermie peropératoire: essai randomisé contrôlé. *Canadian journal of anaesthesia = Journal canadien d'anesthesie*, *65*(9), 1029–1040. https://doi.org/10.1007/s12630-018-1161-8

Madrid, E., Urrútia, G., Roqué i Figuls, M., Pardo-Hernandez, H., Campos, J. M., Paniagua, P., Maestre, L., & Alonso-Coello, P. (2016). Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *The Cochrane database of systematic reviews*, *4*(4), CD009016. https://doi.org/10.1002/14651858.CD009016.pub2

Paulson, E. C., Thompson, E., & Mahmoud, N. (2017). Surgical Site Infection and Colorectal Surgical Procedures: A Prospective Analysis of Risk Factors. *Surgical infections*, *18*(4), 520–526. https://doi.org/10.1089/sur.2016.

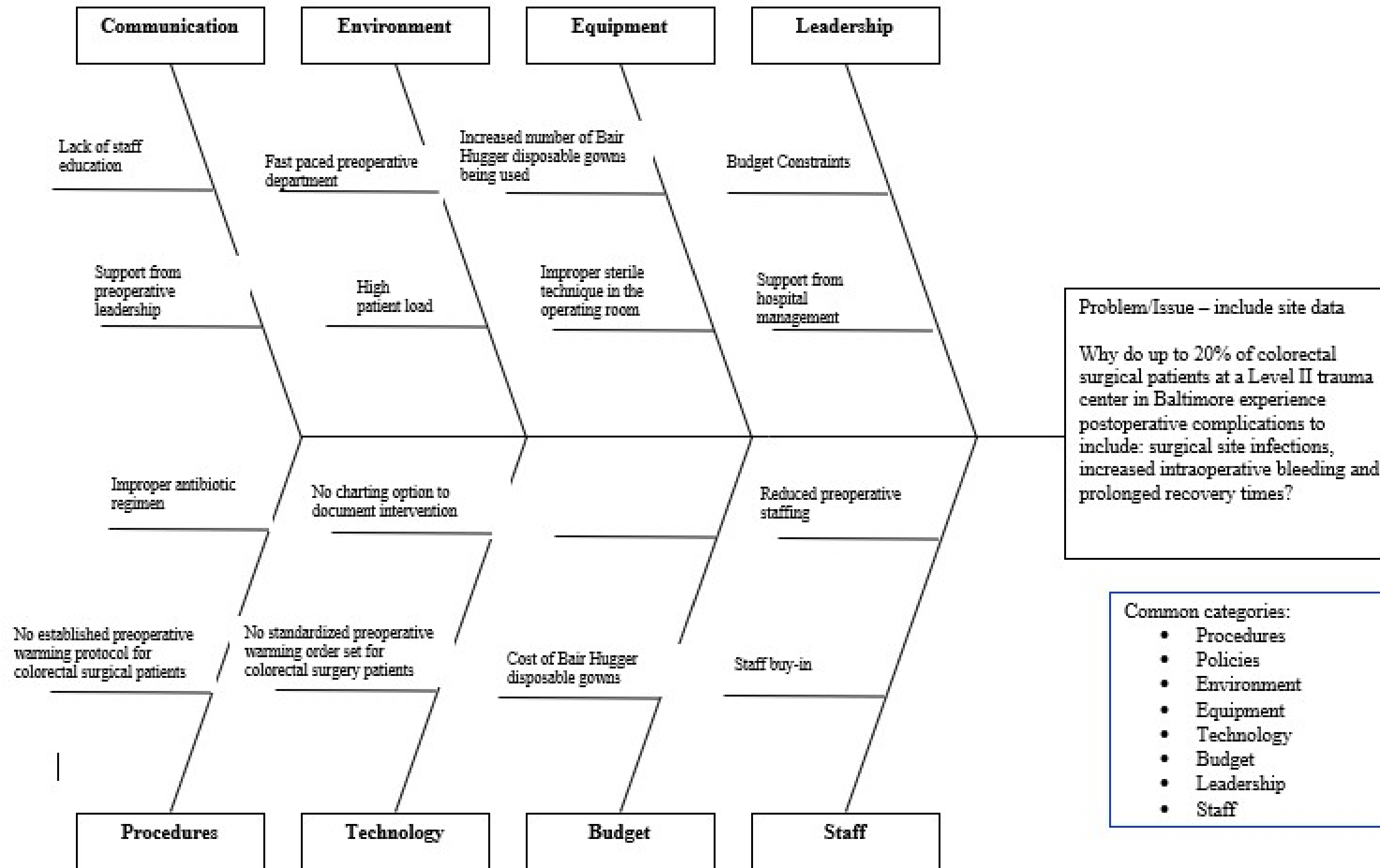
Powell, B. J., Waltz, T. J., Chinman, M. J., Damschroder, L. J., Smith, J. L., Matthieu, M. M., Procter, E.K., & Kirchner, J. E. (2015). A refined compilation of implementation strategies: Results from the Expert Recommendations for Implementing Change (ERIC) project. Implementation Science, 10(1), 21. Retrieved from https://implementationscience.biomedcentral.com/articles/10.1186/s13012-015-0209-1

Walters, M. J., Tanios, M., Koyuncu, O., Mao, G., Valente, M. A., & Sessler, D. I. (2020). Intraoperative core temperature and infectious complications after colorectal surgery: A registry analysis. *Journal of clinical anesthesia*, *63*, 109758. https://doi.org/10.1016/j.jclinane.2020.1097

Zheng, X. Q., Huang, J. F., Lin, J. L., Chen, D., & Wu, A. M. (2020). Effects of preoperative warming on the occurrence of surgical site infection: A systematic review and meta-analysis. *International journal of surgery (London, England)*, *77*, 40–47. https://doi.or

Figure 1

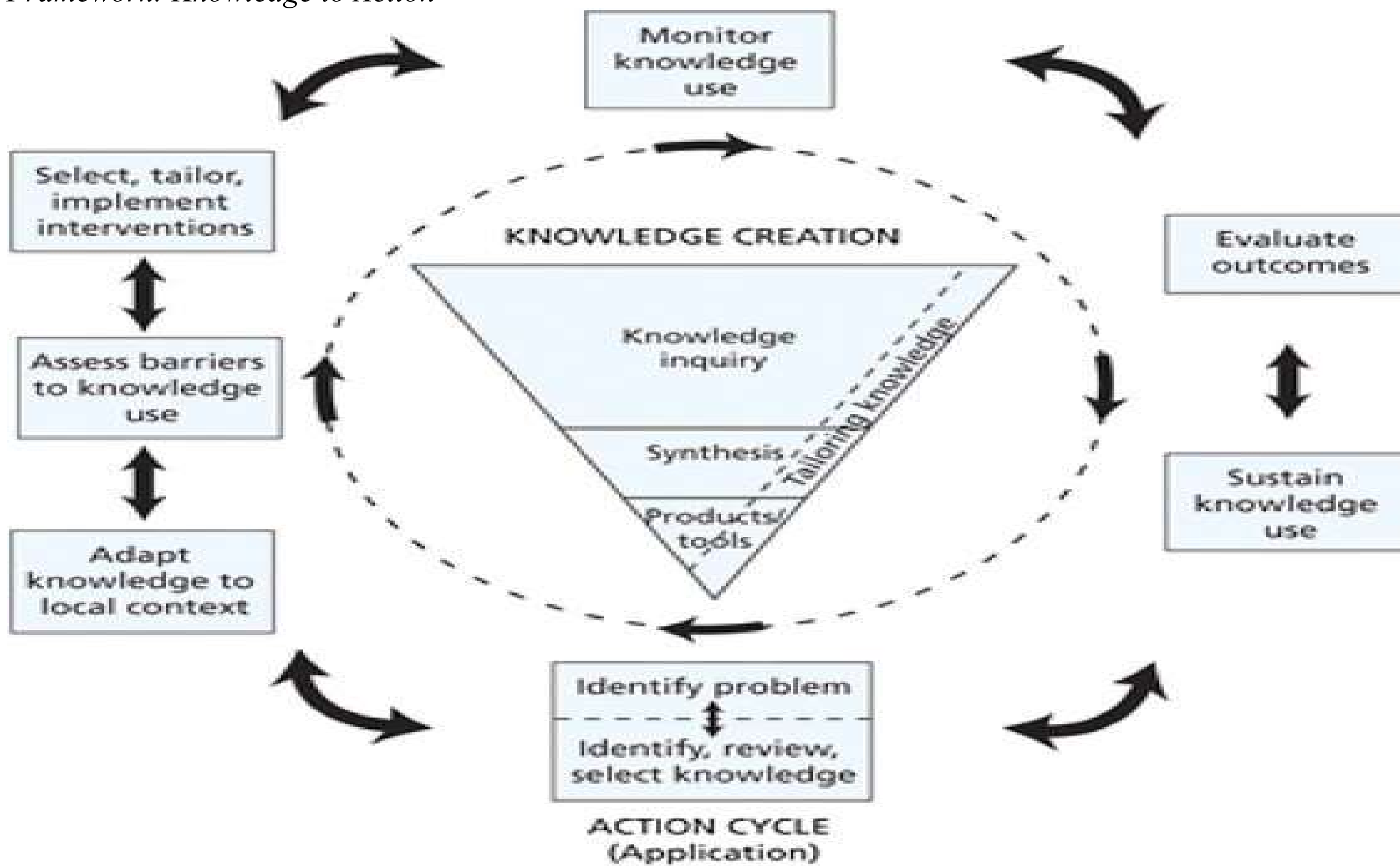
Fishbone Diagram



Note: Root cause analysis of factors contributing to postoperative complications following colorectal surgery

Figure 2

Framework: Knowledge to Action



Note: Image obtained from Field et al., (2014)

Figure 3

Previous Workflow Process Map

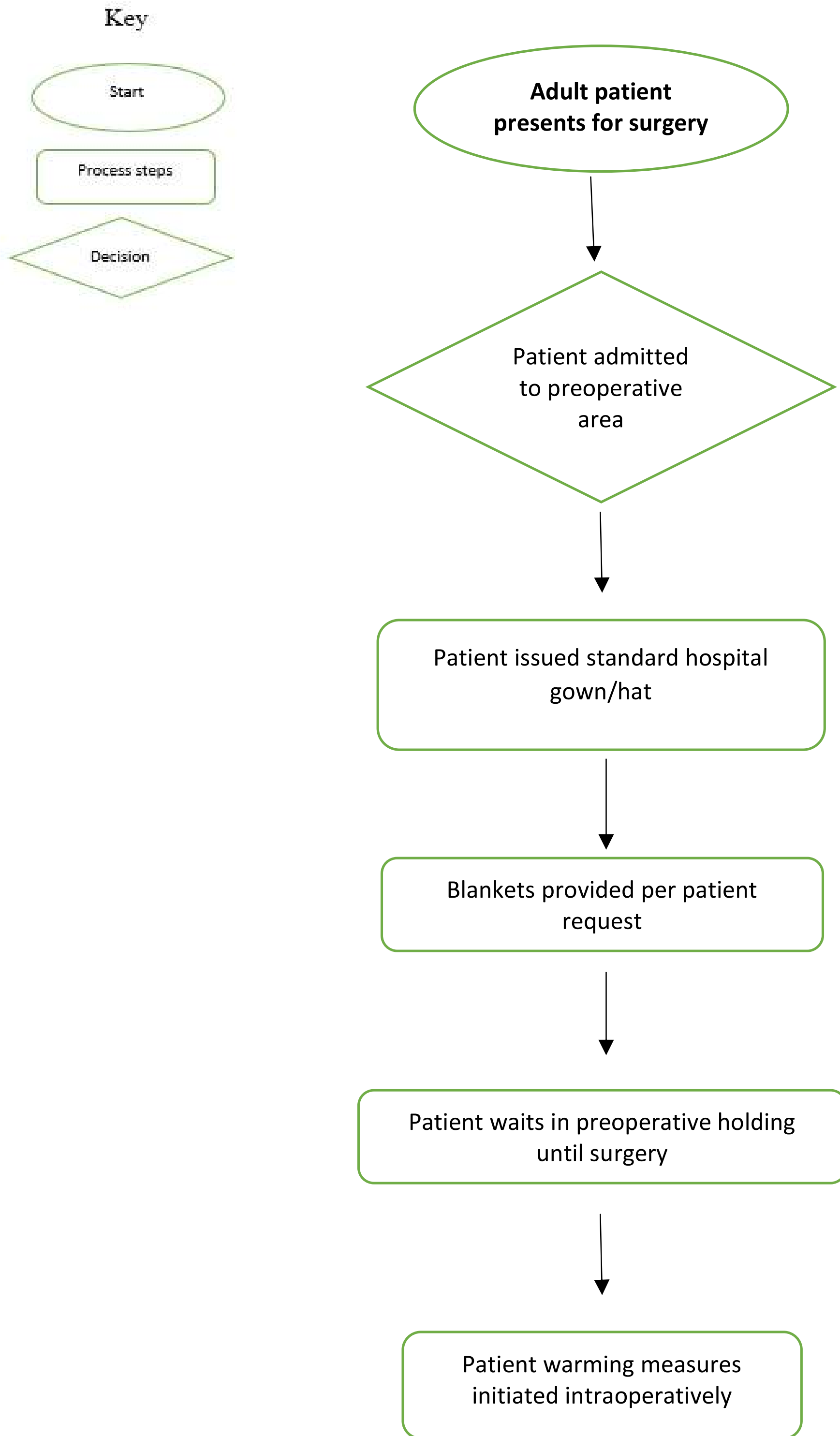


Figure 4

Implemented Process Map

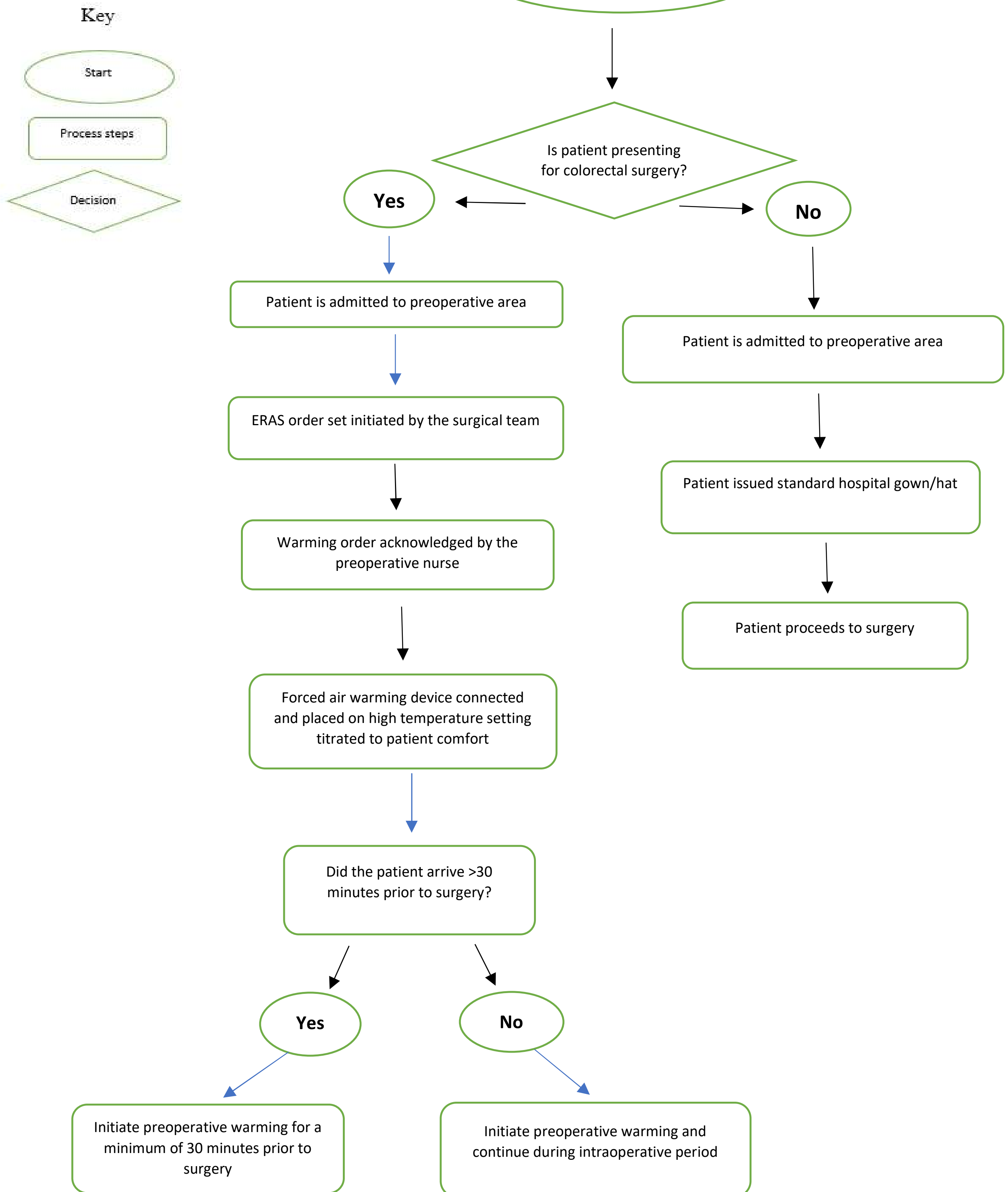
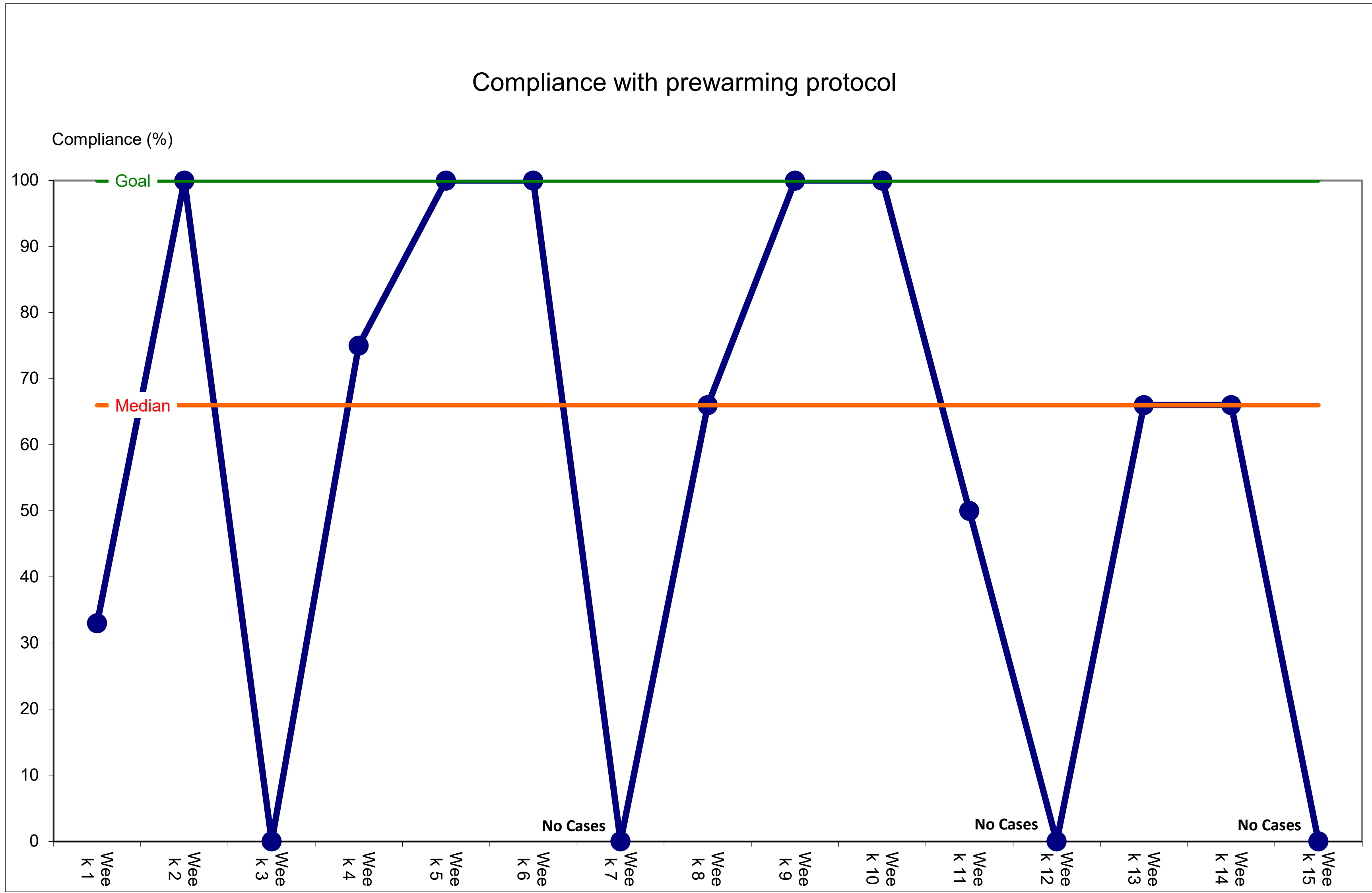


Figure 5

Run Chart of Protocol Compliance



Appendix A

Evidence Review Table

Citation: Fettes, S., Mulvaine, M., & Van Doren, E. (2013). Effect of preoperative forced-air warming on postoperative temperature and postanesthesia care unit length of stay. *AORN journal*, *97*(3), 323–328. https://doi-org.proxy-hs.researchport.umd.edu/10.1016/j.aorn.2012.12.011 Hyperlink: https://pubmed-ncbi-nlm-nih-gov.proxy-hs.researchport.umd.edu/23452697/					**Level and Quality** IB
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
The purpose of this research study was to determine if patients who receive forced air warming before surgery had a decrease in incidence of postoperative hypothermia (<36C) and PACU length of stay.	Research: Randomized controlled trial	Sampling Technique: Convenience # eligible: 146 surgical patients # accepted: 128 # in control: 74 # in intervention: 54 Power analysis: "To detect a moderate effect size of 0.5 with 80% power a sample size of 64 patients was deemed necessary" 128 total study participants-Power Analysis met Group Homogeneity: "There was no significant differences between the two groups based on gender (p=0.407), age (p=0.740), BMI (p=0.406), ASA classification (p=0.392) or hospital admission temperature (p=0.853)". Intervention/control homogeneous based on NS p values on Table 1 for demographic characteristics	Control: Warm cotton blanket provided preoperatively Intervention: One hour before surgery the preoperative nurse placed a forced air warming blanket set at the 100F (medium setting) on the patient. Patient temperatures were taken in the preoperative intraoperative and postoperative period. Intervention fidelity (describe the protocol): A standardized preoperative warming protocol was incorporated into the existing EHR order set for colorectal surgical patients. Protocol: colorectal surgical patients will receive a minimum of 30 minutes of preoperative warming prior to surgery via forced air warming device. Nursing staff educated on protocol. Protocol adherence	DV: Postoperative hypothermia defined as temperature <36C. State the instrument, reliability, and measurement procedure: The DV was measured through temporal artery scanning thermometer by the primary nurse. "The instrument has been documented to be accurate to 0.2F. The thermometers used in the surgical areas are checked for accuracy before the first use. The brand used is designed to stay calibrated permanently, and does not require routine calibration." Nurses followed standard policies and procedures for observing and monitoring the patients throughout the perioperative period.	Statistical Results: T test comparison revealed no statistical difference in patients receiving prewarming and arriving to the PACU in a hypothermic state (p=0.508). No statistical difference in prewarming and decreased length of PACU stay (p=0.545). Conclusions: The researchers concluded prewarming does not significantly affect the patient temperature on arrival to PACU or PACU length of stay.

			evaluated biannually after implementation.		

Citation: Lau, A., Lowlaavar, N., Cooke, E. M., West, N., German, A., Morse, D. J., Görges, M., & Merchant, R. N. (2018). Effect of preoperative warming on intraoperative hypothermia: a randomized-controlled trial. Effet du réchauffement préopératoire sur l'hypothermie peropératoire: essai randomisé contrôlé. *Canadian journal of anaesthesia = Journal canadien d'anesthesie*, *65*(9), 1029–1040. https://doi.org/10.1007/s12630-018-1161-8 Hyperlink: https://pubmed-ncbi-nlm-nih-gov.proxy-hs.researchport.umd.edu/29872966/					**Level and Quality** IB
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
The purpose of this research study was to determine if adult surgical patients who receive 30 minutes of preoperative forced-air warming had a decrease in incidence of intraoperative hypothermia	Research or Practice Randomized controlled trial	**Sampling Technique:** Convenience # eligible: Adult patients ASA I-III, aged 18-85 year scheduled for elective non-cardiac surgery under general anesthesia # accepted: 200 # in control:101 # in intervention: 99 Power analysis: "Preliminary sample size estimate of 100 subjects per treatment group provided 80% power with an Alpha level of 0.05"-Power Analysis met. Group Homogeneity:	Control: Warm blankets provided on request preoperatively Intervention: Bairpaws forced air warming for at least 30 minutes preoperatively Intervention fidelity (describe the protocol): Patients receive active pre-warming for at least 30 minutes prior to surgery via the BairPaws full-body forced air convective warming gowns. Patient temperatures monitored per protocol using SpotOn temperature system by the preoperative nurse and charted in the EHR	DV: Hypothermia defined as core body temperatures of <36C between induction of anesthesia and leaving the operating room. State the instrument, reliability, and measurement procedure: The dependent variable was measured using The SpotOn temperature system during the perioperative period to measure core body temperatures in both groups. "The SpotOn provides a non-invasive measurement of core body temperature with a reported accuracy of 0.20C between 31.0-37.0C." Pre	Statistical Results: The researchers concluded a minimum of 30 minutes of preoperative forced air convective warming decreased the overall incidence of intraoperative hypothermia by 16%. The area under the time-temperature curve (AUC) and %CSH (percentage of the case spent hypothermic) were assessed using the Wilcoxon rank-sum test ($p<0.05$) Conclusions: A minimum 30 minutes period of preoperative forced-air warming can be practically

		Intervention/control homogeneous based on NS p values on Table 1 for demographic and surgical characteristics	throughout the perioperative period following institution nursing protocols. Post intervention data collected on a quarterly basis.	and post operative temperatures were manually recorded; core temps were recorded using the S/5 Collect system. Institutional nursing protocols were followed from admission through PACU discharge.	implemented to effectively decrease intraoperative hypothermia.
Citation: Madrid, E., Urrútia, G., Roqué i Figuls, M., Pardo-Hernandez, H., Campos, J. M., Paniagua, P., Maestre, L., & Alonso-Coello, P. (2016). Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *The Cochrane database of systematic reviews*, *4*(4), CD009016. https://doi.org/10.1002/14651858.CD009016.pub2 Hyperlink: https://pubmed.ncbi.nlm.nih.gov/27098439/					**Level and Quality** IIB
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
The purpose of this research study was to assess the effectiveness of pre or intraoperative active body surface warming systems or both to prevent perioperative complications from hypothermia during surgery in adults.	Research or Practice Systematic review of randomized controlled trials	Sampling Technique: # eligible: 67 RCTs # accepted: 5438 participants # in control: # in intervention: Power analysis: Sufficient power to demonstrate the benefits of preoperative warming in decreasing postoperative complications to include SSIs ($p<0.05$). Group Homogeneity:	Control- No active preoperative warming Intervention-30 minutes of preoperative/intraoperative or both active body surface warming (ABSW) Intervention fidelity (describe the protocol): Adult surgical patients will receive 30 minutes of preoperative warming via ABSW. Warming measures will be implemented by preoperative nursing staff,	DV: Surgical site infection defined as infection that occurs near or at the incision site and or deep underlying tissue spaces and organs within 30 days of a surgical procedure (Borchardt & Tzizik, 2018). -Hypothermia as defined by core body temperature <36C State the instrument, reliability, and measurement procedure:	Statistical Results The comparison of ABSW versus control showed a reduction in SSI rates (risk ratio 0.36, 95% confidence interval 0.20 to 0.66, 3 RCTs, 589 participants). Conclusions: Forced air warming is associated with a lower incidence of surgical site infections and postoperative complications compared to

		Significant heterogeneity (P <0.05)	compliance will be tracked via the EMR. SSI rates evaluated 10-90 days following surgery.	Surgical infection data obtained from surgical registry and billing codes.	not applying any active warming system.
Citation: Walters, M. J., Tanios, M., Koyuncu, O., Mao, G., Valente, M. A., & Sessler, D. I. (2020). Intraoperative core temperature and infectious complications after colorectal surgery: A registry analysis. *Journal of clinical anesthesia*, *63*, 109758. https://doi.org/10.1016/j.jclinane.2020.1097 Hyperlink: https://pubmed-ncbi-nlm-nih-gov.proxy-hs.researchport.umd.edu/32222668/					**Level and Quality** IIIB
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
The purpose of this research study was to evaluate the relationship between intraoperative hypothermia and surgical site infections in adult patients undergoing colorectal surgery.	Research or Practice Retrospective single center study.	Sampling Technique: Adults undergoing colorectal surgery under general anesthesia and were warmed with forced air at the Cleveland Clinic Main Campus between January 2005 and December 2014. Included: age >18 yr, surgery lasting > 1 hour, general anesthesia, esophageal core temperature monitoring and first surgery per hospital visit.	Control-No preoperative warming. Intervention- 30 minutes of preoperative warming, esophageal temperature monitoring during the intraoperative period. Intervention fidelity Patients undergoing colorectal surgery will receive 30 minutes of preoperative warming, to be continued	DV: Surgical site infection defined as infection that occurs near or at the incision site and or deep underlying tissue spaces and organs within 30 days of a surgical procedure. -Hypothermia as defined by core body temperature <36C State the instrument, reliability, and measurement procedure:	Statistical Results: A 0.5 °C decrease in time-weighted average intraoperative core temperature ≤ 35.4 °C was associated with an increased odds of serious infection (OR = 1.38, P = .045); that is, hypothermia below 35.4 °C progressively worsened infection risk. Conclusions:

		# eligible: 10,879 patients # accepted: 7908 patients # in control: # in intervention: Power analysis: 7000 colorectal surgeries required to meet 90% power, with a 0.05 significance level and moderate effect size-Power Analysis met. Group Homogeneity: Homogeneous based on NS p values on Table 3 for baseline characteristics	throughout the intraoperative period to maintain normothermia and reduce the incidence of SSIs postoperatively. Core temperature monitoring will be performed via esophageal temperature probe and recorded in the EMR per institution protocol. The incidence of SSI among colorectal surgical patients will be examined biannually.	Patient temperature measured via esophageal temperature probe. Surgical infection data obtained from surgical registry and billing codes.	Intraoperative core temperatures below 35.5C were associated with serious infectious complications following surgery
Citation: Zheng, X. Q., Huang, J. F., Lin, J. L., Chen, D., & Wu, A. M. (2020). Effects of preoperative warming on the occurrence of surgical site infection: A systematic review and meta-analysis. International journal of surgery (London, England), 77, 40–47. https://doi.org/10.1016/j.ijsu.2020.03.01 Hyperlink: https://pubmed-ncbi-nlm-nih-gov.proxy-hs.researchport.umd.edu/32198100/					**Level and Quality** **IB**
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
The purpose of this review is to determine if preoperative warming can reduce the risk of surgical site infections after surgery.	Research or Practice Systematic review w/ meta-analysis	Sampling Technique: # eligible: 249 studies # accepted: 7 RCT-1086 patients # in control: # in intervention: Power analysis: Sufficient power to demonstrate the benefits of preoperative	Control: No preoperative warming Intervention: Preoperative warming via forced air warming (FAW) blanket with or without fluid warmer (Mixed method). Intervention fidelity (describe the protocol):	DV: Surgical site infection defined as infection that occurs near or at the incision site and or deep underlying tissue spaces and organs within 30 days of a surgical procedure. State the instrument, reliability, and measurement procedure:	Statistical Results: The meta-analysis revealed in the MIX method group, preoperative warming reduced SSI by about 48%, whereas using forced-air warming blanket separately reduced the infection by 32% Conclusions:

		warming in decreasing SSI rates (p<0.05). Group Homogeneity: Significant heterogeneity (P <0.05)	Patients receive preoperative warming via FAW blanket or mixed method for a minimum of 30 minutes prior to induction of anesthesia. Warming protocol incorporated into the existing EMR. Provider adherence monitored on a quarterly basis. SSI rates analyzed during the 90-day postoperative period.	DV measure: The diagnosis of SSI 10-90 days following surgery. Data obtained from institution surgical registry and billing codes.	The use of preoperative warming was associated with a significant decrease in SSI (RR = 0.60, 95% CI 0.42–0.87, P = 0.072)

Note: Evidence was graded using the Johns Hopkins Nursing Evidence-based Practice Level Hierarchy of Evidence Guide (Dang et al., 2022). All articles were retrieved from the Pubmed database.

Appendix A

Evidence Synthesis Table

Category (Level Type)	Total Number of Sources/Level	Overall Quality Rating	Synthesis of Findings
Level 1 - Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis	3	B	All studies concluded some benefit to preoperative warming in adult surgical patients. There was slight variation among studies regarding implementation of prewarming measures. All studies aimed to facilitate positive patient outcomes postoperatively.
Level II · Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis	1	B	All studies concluded some benefit to preoperative warming and reducing the incidence of surgical site infections with some variance due to greater group heterogeneity. Search methods were consistent. Implementation of preoperative warming measures varied among studies. Study aims were consistent.
Level III · Non-experimental study · Systematic review of a combination of RCTs, quasi-experimental, and non-experimental studies, or non-experimental studies only, with or without meta-analysis · Qualitative study or systematic review of qualitative studies with or without meta-synthesis	1	B	No manipulation of an independent variable, no control group. This study was retrospective and look at the temperature of the patient to correlate with rates of infection.
Level IV · Opinion of respected authorities and/or reports of nationally recognized expert committees/consensus panels based on scientific evidence			
Level V · Evidence obtained from literature reviews, quality improvement, program evaluation, financial evaluation, or case reports · Opinion of nationally recognized expert(s) based on experiential evidence			

Recommendations Based on Evidence Synthesis: Evidence shows benefits of active warming methods during the preoperative period. Recommend practice change to incorporate a standardized preoperative warming protocol for colorectal surgical patients.

Note: Evidence was graded using the Johns Hopkins Nursing Evidence-based Practice Level Hierarchy of Evidence Guide (Dang et al., 2022).

Appendix B

Data Collection Tool

Preoperative Warming and Improved Postoperative Outcomes in Colorectal Surgical Patients
Page 1

Data Collection Form

Record ID	______________________
Medical Record Number	______________________
Protocol Ordered	◯ Yes ◯ No
Protocol Compliance	◯ Yes ◯ No
Warming Time >30 minutes	◯ Yes ◯ No
PACU Patient Temperature >36C	◯ Yes ◯ No

Appendix B. Data collection form used for data collection using REDCap