2016

Patient Normothermia as it Relates to Surgical Site Infections in General Surgical Cases

Helen M. Claudon
Bethel University

PATIENT NORMOTHERMIA AS IT RELATES TO SURGICAL SITE INFECTIONS IN GENERAL SURGICAL CASES

A MASTER'S PROJECT

SUBMITTED TO THE GRADUATE FACULTY

OF THE GRADUATE SCHOOL

BETHEL UNIVERSITY

BY

HELEN M. CLAUDON

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE IN NURSING

AUGUST 2016

BETHEL UNIVERSITY

PATIENT NORMOTHERMIA AS IT RELATES TO SURGICAL SITE INFECTIONS IN GENERAL SURGICAL CASES

HELEN MARY CLAUDON

AUGUST 2016

Approved: Kristin E. Sandau Advisor

Signature

APPROVED

Diane Dahl PhD RN

Acting Associate Dean of Nursing

Paula K. Fries PhD RN

Program Director

Abstract

Background: Approximately 54.4 million inpatient surgical procedures are performed annually in the United States (CDC, 2016). Unfortunately, 500,000-750,000 surgical site infections (SSI) are reported annually (Roesler et al., 2010). A legacy study completed by Kurz et al. (1996) suggested maintaining normothermia during surgery may help decrease SSI. However, few recent studies have been conducted confirming these findings.

Purpose: To review current literature for association between normothermia and SSI in adult patients undergoing general surgery.

Results: Studies were identified (n = 21) examining association between body temperature normothermia control and SSI in general surgical cases. These studies were analyzed using Betty Neuman's Systems model which proposes homeostasis helps individuals attain optimum health.

Conclusions: Findings from contemporary studies (2011-Feb. 2016) support the premise that maintaining intraoperative normothermia may help decrease SSIs in general surgical cases. However, many studies used interventions bundled within a protocol; thus, it is difficult to determine whether any single individual intervention was responsible for a decrease in SSIs.

Implications for Research and Practice: Standard definitions are still needed for normothermia and hypothermia. Bundled care interventions make it difficult to determine if individual interventions are connected to results. However, normothermia can contribute to a decrease in SSI incidence and the following measures have been shown to contribute toward perioperative normothermia: raising operating room

temperatures, covering non-operative body parts, forced air warming blankets, and fluid and blood warmers. These interventions support what Neuman refers to as "reconstitution" or the reestablishment of system homeostasis following an intervention and may reduce SSI.

Keywords: surgical normothermia, surgical hypothermia, surgical infections

Table of Contents

Chapter One: Introduction

Each year in the United States there are approximately 54.4 million inpatient surgical procedures performed (CDC, 2016). The vast majority of these surgical procedures are successful and do not result in a postoperative surgical site infection (SSI). Unfortunately, there are 500,000-750,000 SSIs reported on a yearly basis in the United States (Roesler, Halowell, Elias, & Peters, 2010). These result in anything from minor inconveniences, delayed recovery, additional and repeated surgical procedures, to death (Roesler et al., 2010). SSIs negatively impact patients, families, and health care providers, and are detrimental to the financial health and clinical reputation of an organization. In October of 2008, the Centers for Medicare and Medicaid Services (CMS) began significantly decreasing reimbursement for certain conditions patients acquired during their hospital stay (Barnett, 2007; Rosenthal, 2007). These conditions included retained foreign objects after surgical procedures, air embolism, blood incompatibility reactions, catheter-associated urinary tract infections (CAUTI), pressure ulcers, vascular catheter associated infections, and mediastinitis after coronary artery bypass grafting (Rosenthal, 2007).

The implementation of the Affordable Care Act (ACA) in 2010 added additional rules and reimbursement criteria to acute care facilities (Blumenthal, Abrams, & Nuzum, 2015). This expanded on the program started in 2008 by CMS by adding additional criteria for avoidable infections, medication events, skin injuries, and patient falls (Blumenthal, Abrams, & Nuzum, 2015). Under these new rules Medicare and other insurance companies no longer reimburse acute care facilities for care and costs associated with hospital acquired conditions which includes SSIs. Hospitals could also

be subject to an additional overall 1% Medicare reimbursement penalty if they are rated in the bottom quarter of U.S. hospitals (Blumenthal, Abrams, & Nuzum, 2015). Since these new rules have been implemented, the incidence of SSIs has decreased 3% in the United States (Blumenthal, Abrams, & Nuzum, 2015), but there is still work to do to keep patients safe and reduce SSIs.

The impact of SSIs can affect patients and their families socially, mentally, and financially (Andersson, Bergh, Karlsson, & Nilsson, 2010). The repercussions of a SSI can lead to loss of wages, negatively impacting potentially already strained finances. Socially, these patients may find themselves needing more care and assistance then they can provide for themselves (Andersson et al, 2010). This may require an admission to a transitional care unit (TCU), home health services, or additional familial support. Mentally, patients can potentially suffer from a loss of independence. Patients could also suffer from pain related to infection (Tanner, Padley, Davey, Murphy, & Brown, 2012a), depressive mood, and a loss of control. Surgical site infections "…can take over the life of patients and their families long after they have been discharged from the hospital" (Tanner et al., 2012a, p. 167).

Extent of the Problem

The Institute for Healthcare Improvement (IHI, 2015) notes that SSIs continue to make up a high percentage of hospital acquired infections (HAIs). The patient and financial impacts have resulted in SSI reduction being named a prime concern (IHI, 2015). There are varying reports of how many SSIs occur annually. According to the Centers for Disease Control (CDC, 2015), in 2011 there were a total of 721,800 HAIs in the United States, and of these, 157,500 were SSIs. Another study regarding

intraoperative glucose control noted there were approximately 374,000 SSIs annually in 2002 (Jeon, Furuya, Berman, & Larson, 2012). Yet another article about preventing SSIs reported the rate at between 500,000 and 750,000 SSIs annually (Roesler et al., 2010). Although the reports of incidence vary, it is clear that SSIs are a universal and widespread issue.

Although there has been limited study about the actual costs of SSIs (de Lissovoy, Fraeman, Hutchins, Murphy, Song, and Vaughn, 2009) the treatment costs associated with SSIs are substantial. In 2009, a study was completed using the Nationwide Inpatient Sample (NIS) database from 2005. This study estimated 1.6 billion dollars and 928,663 additional inpatient days are accrued related to SSIs (de Lissovoy et al., 2009).

Need for Critical Review

There have been extensive studies and interventions focused on decreasing SSIs. Some interventions have strong evidence that they contribute to decreased SSIs. Evidence-based interventions include pre-procedure antibiotics with weight based dosing, pre-admission bathing, intra-operative glucose control, antibiotic irrigation during the surgical procedure, strict adherence to surgical attire policies, methicillin-resistant staphylococcus aureus (MRSA) or methicillin-susceptible staphylococcus aureus (MSSA) surveillance, peri-operative hair removal, and antimicrobial suture use (Edmiston & Spencer, 2014). In contrast, the association of perioperative maintenance of patient normothermia with SSIs has received relatively little attention. According to Kumar, Wong, Melling and Leaper (2005) perioperative hypothermia potentially occurs in up to half of surgical cases. This review will evaluate normothermia maintenance as a potentially effective intervention for the prevention of SSIs.

Research Question

The focus question in this review is: What is the association of patient normothermia with the incidence of SSIs in adult patients undergoing general surgery?

Significance to Nursing

Perioperative nurses play a significant role in keeping patients safe. One of those safety measures is to maintain the patient's body heat and keep them warm. Patients may associate a positive perioperative experience with their feelings of comfort. A warm blanket placed at the right time is perceived as a comfort measure and gives the patient a sense of well-being. In the operating room patients are at the mercy of the staff and place their trust in them. The patient is placed in a gown with no undergarments and wheeled into a cold and sterile environment where everything may look foreign and frightening. Keeping a patient warm and offering a sense of comfort while they undergo a surgical procedure may help reduce the risks, mortality, morbidity, and suffering for patients. A patient's core body temperature maintained near or at normothermia is a physiological necessity for normal organ and body processes function and should be maintained to support optimal health and best patient (Hooper, Chard, Clifford, Fetzer, Fossum, & Godden, 2010)

If evidence is determined to be sufficient to recommend a change in practice, the significance of this possible practice change recommendation could be reflected in potentially reduced costs to both organizations as a whole, as well as the patient. Whether it is through the use of warm blankets or other warming devices, the treatment of hypothermia can be a cost effective and efficient way of addressing a potential risk factor for SSIs. Optimizing the patient's core body temperature prior, during, and

directly after a surgical procedure could reduce length of stay by avoiding infection, decrease costs by avoiding additional antibiotics, drains, procedures, and increase patient satisfaction due to comfort measures. An even less discussed byproduct could potentially be decreased blood loss during the surgical procedure.

Conceptual Framework

This review will be completed through the lens of the conceptual framework of Betty Neuman's Systems Model (McEwen & Wills, 2014). The systems model notes all systems must work in harmony to be in optimal health, and is consistent with the suggestion that normothermia plays an integral part in maintaining optimal health. According to Neuman's model the addition of stressors into a patient's life, in this case hypothermia, can infiltrate their lines of defense (McEwen & Wills, 2014). Neuman's model also reference the concept of prevention as an intervention (McEwen & Wills, 2014). This suggestion is in line with the prevention of hypothermia in surgical patients in all aspects of the perioperative experience. By utilizing interventions which prevent hypothermia and maintain normothermia during the perioperative experience, patients may have the highest opportunity for what Newman calls "reconstitution" (McEwen & Wills, 2014, p. 151). Reconstitution happens when interventions are implemented, bringing body systems back to a homeostatic state (McEwen & Wills, 2014).

Summary

In this chapter I have introduced the problem of surgical hypothermia, given background on the problem of surgical hypothermia, and discussed surgical hypothermia's significance for nursing. Finally, I identified a conceptual framework for this review.

Chapter Two: Methods

The second chapter contains a critical review of literature related to normothermia and SSIs. This chapter will begin with definitions of general surgery, SSIs and normothermia, followed by the search strategy used to identify relevant studies, including the inclusion and exclusion criteria used. Finally, this chapter will provide an overview of the level of evidence, the quality of this evidence, and the criteria used to evaluate each study.

Definitions

General surgery. For this review the definition of general surgery cases will be cases which typically do not require the services of a specialty surgeon. They can include both laparoscopic and open cases such as open and laparoscopic cholecystectomies, skin excisions, bowl resections, and abdominal surgery. The American Board of Surgery (2015) defines general surgical procedures as including the following areas: alimentary tract (including bariatric surgery), abdomen and its contents, breast, skin and soft tissue, endocrine system, solid organ transplantation, pediatric surgery, surgical critical care, surgical oncology (including head and neck surgery), trauma/burns and emergency surgery, and vascular surgery cases.

Surgical site infections. SSIs are infections occurring in the superficial or deep surgical layers up to 30 days after a surgical procedure, and up to one year if an implant has been placed (Owens & Stoessel, 2008; Reichman & Greenburg, 2009).

Normothermia. Normothermia is defined by Hooper et al. (2010) as a core temperature range between 36 C (96.8 F) and 38 C (100.4 F).

Search Strategy

Using the initial search terms *surgical, normothermia*, *hypothermia*, *warming* and *intra-operative*, a search was completed in Medline, CINAHL, and PubMed which yielded 945 articles. Of these articles, 145 were found to actually reference surgical normothermia. Adding the additional search term *infection* narrowed the results to 64 articles.

Inclusion and Exclusion Criteria

The 64 articles were further reduced by eliminating articles which referenced specialty surgery such as cardio-thoracic surgery, plastic surgery, orthopedic surgery, and neurological and spine related procedures. The remaining 37 articles specifically referenced SSI in all surgical procedures. After eliminating articles referencing non-general surgical procedures, 27 articles remained. Two additional articles were eliminated. One of these discussed multi-modalities of SSI prevention and did not reference intraoperative patient temperature control. The second article was eliminated because it was a brief clinical article of secondary source material and was not a systematic review. This left 25 articles, of which 5 were eliminated as they were greater than 15 years old, leaving 20 articles for review and analysis. One additional reference was included, because although it was greater than 15 years in age, it is considered a legacy study and continues to be referenced by current researchers. This left a total of 21 articles for review.

Using the Johns Hopkins Nursing Based Appraisal tools (Dearholt & Dang, 2012), a level of evidence was assigned to each of the 21 remaining articles. Two studies were randomized controlled trials, so were rated Level I. One article was a systematic

literature review containing only randomized prospective trials so was rated Level I. Eight articles reported quasi-experimental trials and were rated Level II. Five articles were rated Level III, of which four were retrospective studies of existing data and one was a preparatory study for larger randomized clinical trial. Two articles were rated IV as they were evidence based clinical practice guidelines. An additional three articles were rated V, of which two were non-systematic literature reviews and one was a quality improvement project.

Criteria for Evaluating the Studies

Each article was systematically evaluated and rated for strength of evidence according to the Johns Hopkins Nursing Evidence Based Appraisal Tools (Dearholt & Dang, 2012) for both research and non-research evidence. Quality for each article was assessed using the Johns Hopkins Nursing Evidence Based Appraisal Tools (Dearholt & Dang, 2012). Both evidence and quality ratings were placed into a matrix chart for review.

Summary

This chapter defined key words, provided the search strategy, inclusion and exclusion criteria, and described the process by which each article was evaluated for both level of evidence and quality.

Chapter 3: Literature Review and Analysis

In this chapter I will first discuss major definitions and the variance in definitions I have found from each group of researchers. I will then discuss the major findings of the studies.

Major Definitions and Findings

In any major area of study, it is important to evaluate whether researchers are sharing similar operational definitions of important concepts. In the case of perioperative hypothermia there are varied definitions for each researcher and no gold standard for measurement or reference.

Hypothermia. In their literature review, Adamina, Gié and Demartines (2013) defined mild hypothermia as a temperature of 34 to 36 degrees Celsius. In their quasi-experimental studies, Baucom, Phillips, Ehrenfeld, Muldoon, Poulose, Herline, and Geiger (2015) and Hedrick, Heckman, Smith, Sawyer, Fried, and Foley (2007) defined hypothermia as a body temperature of less than 36 degrees Celsius, as did Baucom, Phillips, Ehrenfeld, Holzman, Martin, Nealon, and Poulose (2014) in their retrospective analysis. Hypothermia was defined as a body temperature of less than 36 degrees Celsius by Bull, Wilson, Worth, Stuart, Gillespie, Waxman, and Richards (2011) and Crolla, Veen, Laan, Heniks, van Schendel, and Kluytmans (2012). Flores-Maldonado, Medina-Escobedo, Ríos-Rodríguez, and Fernández-Domínguez (2001) defined hypothermia as a tympanic ear temperature of less than 36 degrees Celsius. Hooper, et al. (2010) provided clinical practice guidelines which defined hypothermia as a core temperature below 36 degrees Celsius. Kurz, Sessler and Lenhardt (1996), in a double blind randomized controlled trial, defined hypothermia as a body temperature below 36.4 degrees Celsius.

Reynolds, Beckman, and Kurz (2008) define mild hypothermia as a core body temperature between 34 and 36 degrees Celsius. Twelve of the other studies included in this review did not give specific parameters for their definitions of hypothermia.

Normothermia. Normothermia has been specifically defined by various researchers. Bull et al. (2011) defined normothermia as a body temperature of greater than or equal to 36 degrees Celsius. Crolla et al. (2012), in a quasi-experimental study, define normothermia as a body temperature between 36 and 38 degrees Celsius. Hedrick et al. (2007) defined normothermia in a quasi-experimental study as a body temperature of greater than 36 degrees Celsius. Hooper et al. (2010) defined normothermia as a core temperature between 36 and 38 degrees Celsius. Kurtz, Sessler, and Lenhardt (1996) defined normothermia as a core body temperature maintained near 36.5 degrees Celsius. Sixteen of the studies included in this review did not specifically mention normothermic body temperature ranges.

Physiological effects of hypothermia. Intraoperative hypothermia has physiological effects to patient well-being beyond SSI. Studies from Adamina, Gié, and Demartines (2013) and Reynolds, Beckmann and Kurz (2008) noted hypothermia induced coagulopathies can increase procedural blood loss and increase the potential requirement of allogenic blood transfusions. They noted a decrease in collagen deposition in surgical wounds which can impair wound healing. Kurz, Sessler, and Lenhardt (1996) noted a significant increase in collagen deposition in the surgical wounds of normothermic versus hypothermic patients (328 +/- 135 vs 254+/- 115 micrograms respectively). They noted a shortened hospital stay for normothermic patients versus hypothermic patients (12.1 +/- 4.4 vs 14.7 +/- 6.5 days respectively). The

literature review by Reynolds, Beckmann, and Kurz (2008) evaluated physiological effects from a surgical anesthesia perspective. They found propofol concentrations increased by approximately 30% in patients with only a 3 degree Celsius decrease in core body temperature. These researchers found the actions of vecuronium more than doubled with only a 2 degree Celsius decrease in core body temperature. They noted hypothermia is associated with mild hypokalemia.

Hypothermia and surgical site infection.

Level I evidence. Kurtz, Sessler, and Lenhardt (1996), in a randomized double blind controlled trial of 200 individuals undergoing colorectal surgery, revealed a 5.7% infection rate in the normothermia group and an 18.7% infection rate in the hypothermia group ($p = 0.009$). They noted intraoperative core temperatures near 2 degrees Celsius below normothermia (36 degrees Celsius) tripled the rate of surgical wound infection and prolonged hospitalization by 20%. Melling, Ali, Scott, and Leaper (2001) completed a randomized controlled trial on 421 patients having clean breast, hernia, and varicose vein surgeries. Three groups were randomly assigned to one of three different groups. The groups were systemic warming, local warming of surgical site, and no warming. The researchers noted there was a reduced infection rate associated with both the local warming (SSI rate 4%, $p = 0.003$) and the systemic warming (SSI rate 6%, $p = 0.026$) versus the non-warmed group (SSI rate 14%). Reynolds, Beckman, and Kurz (2008) completed a systematic literature review containing randomized clinical trials among humans, upon which they based clinical practice guidelines. They noted a 1.9 degree Celsius drop in core body temperature tripled the incidence of surgical wound infection following colon resection cases.

Level II evidence. Adamina, Gié, and Demartines (2013) noted that hypothermia can cause vasoconstriction and decrease the oxidative nature of neutrophils at the surgical site. Baucom, Phillips, Ehrenfeld, Muldoon, Poulose, Herline, and Geiger's (2015) quasi-experimental study, which included 296 patients, concluded that patients undergoing segmental colectomy with intraoperative hypothermia, were no more likely to develop a SSI than those who were normothermic. Cima, Dankbar, Lovely, Pendlimari, Aronhalt, and Nehring (2013) noted the Mayo Clinic's project interventions reduced the infection rate in colorectal surgeries from 9.8% to a one year post intervention rate of 4% ($p < 0.05$), although it is difficult to determine if normothermia maintenance was a factor in the reduction. Crolla et al. (2012) also used a bundled care approach to their quasi-experimental study. The researchers noted the implementation of their care bundle was associated with a 36% reduction in SSI in colorectal procedures.

Flores et al. (2001) examined the association between mild hypothermia and surgical wound infection in a quasi-experimental study. The researchers studied 261cholecystectomy patients, 156 (58%) of whom arrived in the recovery room with a body temperature of less than 36 degrees, finding that 11.5% of those patients went on to develop a SSI compared to only 1.9% of those with normothermia ($p = 0.004$). Forbes (2008) completed a quasi-experimental pre- and post- intervention trial which implemented a bundle of care including maintenance of normothermia, preoperative antibiotic administration and glucose control with diabetic patients. The researchers showed a decrease in both superficial and organ space infections in colorectal surgery patients. The study revealed a pre to post-intervention decrease in SSI rates from 14% to

8.7 % (p = 0.21) for superficial infections and from 7.6% to 6.8% (p=0.81) for organ space infections. However, there was no statistical difference between the two cohorts.

Hedrick et al. (2007) completed a quasi-experimental study on patients undergoing colorectal resections with a basal metabolic index (BMI) of less than 25. This was also a bundled care study which found the overall infection rate for these colorectal patients decreased from 25.6% to 15.99% ($p < 0.05$). Because the care was bundled, it was not possible to determine which intervention was responsible for the decreased infection rate. Keenan et al. (2014) completed a quasi-experimental study which also implemented a bundle of care for colorectal surgery patients using the American College of Surgeons National Quality Improvement Program (ACS NSQUIP) program. The retrospective study revealed the care bundle was associated with the rate of superficial SSI reduced from 19.3% pre-intervention to 5.7% post-intervention ($p < 0.001$). The intervention was associated with a reduced rate of operative sepsis: 8.5% pre-intervention versus 2.4% post-intervention ($p = 0.009$). There was no statistical significance in the rates of deep or organ space infections, wound disruption, length of stay, or 30 day readmission.

Level III evidence. Baucom et al.'s (2014) retrospective study did not find an association between patient temperature and SSIs, suggesting perioperative normothermia may only decrease SSI in at-risk populations. The retrospective chart review by Billeter, Hohmann, Druen, Cannon, and Polk (2014) found unintentionally hypothermic patients undergoing elective procedures had four times the rate of mortality (17% versus 4%, $p < 0.001$). Seamon, Wobb, Gaughan, Kulp, Kamel, and Dempsey (2012) completed a retrospective review of patient charts (n = 524) who survived 4 days

after an urgent trauma laparotomy at a single trauma center, noting patients who developed SSI (36.2%) had a lower mean intraoperative temperature nadir ($p = 0.009$). Sessler (2006) completed a literature review to determine non–pharmacological methods of reducing infection risk. Sessler found hypothermia can cause vasoconstriction and impaired T-cell function which may increase the risk for SSIs. Tanner, Padley, Davey, Murphy, and Brown (2015b) completed a literature review with meta-analysis to determine the effectiveness of care bundles in reducing SSIs. The researchers' meta-analysis noted a 15% infection rate (585/3866) in the non-bundled care group and a 7% infection rate (328/4649) in the bundled care group.

Level IV evidence. Odom-Forren's (2006) clinical practice guidelines following recommendations by the International Health Institute (IHI) and the Centers for Disease Control (CDC) noted the appropriate use of antibiotics, appropriate hair removal, glucose control and keeping patients warm postoperatively are interventions associated with reduced rates of SSI.

Level V evidence. Bull et al. (2011) completed a quality improvement project implementing a "bundled care approach". They noted a decrease in the surgical infection rate of colorectal surgeries from 15% (95% CI 10.4-20.2) to 7% (95% CI 3.4-12.6) 12 months after the project. The project included improvement factors such as normothermia maintenance, blood glucose control, oxygen delivery, blood pressure monitoring, and prophylactic antibiotic administration; thus, it is difficult to determine if normothermia maintenance was a factor in the reduction. Rosenberger, Politano and Sawyer (2011) completed a literature review to provide evidence to support Surgical Care Improvement Project (SCIP) measures. The researchers noted a 19% wound infection

rate in the hypothermia group versus a 6% wound infection rate in the normothermia group ($p = 0.009$).

Strengths and Weaknesses

The findings from many of the included research studies support an association between intraoperative normothermia and a decrease in SSIs in general surgery cases. Many of these studies are of high quality and design and could be replicated in other institutions. Three randomized controlled trials (RTCs) were identified which demonstrated that hypothermia is significantly associated in higher rates of SSI. Randomized controlled trials are the highest level of evidence and can be used to support or change practice (Dearholt & Dang, 2012).

There are some weaknesses in the studies reviewed. Studies and projects using bundled care interventions make it difficult to determine if individual interventions are connected to the results. Without research that focuses on individual interventions it is impossible to determine which interventions or combination of interventions were related to outcomes.

Another weakness of the research is there has yet to be universal language developed on what constitutes normothermia and hypothermia by a regulating body for purposes of research. Without a common language each researcher is basing their work on their own definitions. Comparing data and results between studies is difficult.

Summary

In this chapter I have reviewed and summarized the available evidence related to hypothermia and SSIs. I have included the definitions researches have used for hypothermia and normothermia. I then discussed the findings researchers had on the

physiological effects of hypothermia and researchers' findings on how surgical hypothermia effects SSIs. Finally, I discussed the strengths and weaknesses of the findings.

Chapter 4: Discussion, Implications, and Conclusions

In this chapter I will answer the practice question and discuss gaps and trends in the literature. I will then discuss nursing practice implications, recommendations for future research, and integration of Betty Neuman's systems model.

Answer to the Practice Question

Studies reviewed support an association between intraoperative hypothermia and a decrease in SSIs in general surgery cases. Based on review of current evidence, a reasonable recommendation is that peri-operative personnel maintain patient body temperature at normothermia (between 36-38 degrees Celsius). Many of the studies have intraoperative interventions bundled within a protocol such as SQIP. Therefore further studies are needed to determine which, if any, individual intervention was responsible for the decrease in SSI rate.

Gaps and Trends

One of the gaps in the literature is researchers have yet to agree on a universally agreed upon method of measuring and defining normothermia or hypothermia. There has been no universally accepted nomenclature to identify a difference between desired core body temperatures. There is also no unified method of measure. Typically it comes down to clinical practice. Each point of care in the surgical experience may use a different method of temperature monitoring.

One of the trends in the literature is to use bundles of care in attempt to reduce SSIs. Although researchers have found success with this approach it is very difficult to determine which interventions of combination of interventions were responsible to the results

Implications for Nursing

Part of nursing's responsibility is to define itself as a profession. According to Dr. Jane Rutty, nursing has struggled to define itself as an occupation or a profession. Professionals provide services which are valued by the public and have a "…defined knowledge base, (2) power and authority over training and education, (3) registration, (4) altruistic service, (5) code of ethics, (6) lengthy socialization and (7) autonomy" (as cited in McEwen & Wills, 2014, p. 2-3). Thus conducting research and developing practice recommendations further supports nursing as a professional practice.

Recommendations

Recommendations for future researchers include breaking apart the bundled care protocols used in SQIP protocols to determine which interventions are most beneficial, or if by bundling care it actually is a cumulative effect. Secondly, national guidelines from a regulating body or organization such as CMS could determine universally agreed upon definitions for normothermia and hypothermia so research could more easily be compared. Recommendations for practice are offered within in the context of interprofessional collaboration. Perioperative nurses have the opportunity to advocate for normothermia by assuring the surgical team is aware of current practice related evidence. An update of related hospital protocols and practices may benefit from a collaborative review and update for the perioperative team (physician, nursing, and anesthesia) to assure normothermia is recognized as important and supported in practice. Secondly, nursing leaders should assure budgets reflect additional or updated equipment to support normothermia.

Integration of Theoretical Framework

Betty Neuman's systems model focuses on the human organism's need for protection and stress relief, which nurses can identify and intervene upon both actively and proactively (McEwen & Wills, 2014). Neuman views the human body as a dynamic system which is constantly changing and gravitating toward system stability and varying degrees of instability. Patients who have become hypothermic have had a failure of their normal lines and flexible lines of defense (McEwen & Wills, 2014). These concepts are specifically important for the perioperative nursing team. Perioperative and advanced practice nursing professionals are in unique positions to positively change patient outcomes. They have the ability to prevent peri-operative hypothermia by preventing exposure, raising operating room temperatures, and keeping non-operative body parts covered. They are also essential in the maintenance of peri-operative normothermia by use of forced air warmed blankets, fluid and blood warmers (McEwen & Wills, 2014). These interventions help to support patient lines of defense and what Neuman refers to as "reconstitution" or the reestablishment of system homeostasis following an intervention (McEwen & Wills, 2014, p. 141).

Summary

In this chapter I have discussed the implications for nursing, have recommended normothermia be maintained as a surgical site preventions strategy in general surgical cases, and have discussed normothermia maintenance and hypothermia prevention in the context of the Neuman systems model.

References

Adamina, M., Gié, O., Demartines, N., & Ris, F. (2013). Contemporary perioperative care strategies. *British Journal of Surgery, 100*(1), 38-54. doi:10.1002/bjs.8990

Andersson, A. E., Bergh, I., Karlsson, J., Nilsson, K. (2010). Patients' experiences of acquiring a deep surgical site infection: An interview study. *AJIC: American Journal of Infection Control, 38*(9), 711-717. doi:10.1016/j.ajic.2010.03.017

Barnett, T. E. (2007). The not-so-hidden costs of surgical site infections. *AORN Journal, 86*(2), 249-258. doi:10.1016/j.aorn.2007.03.012

Baucom, R. B., Phillips, S. E., Ehrenfeld, J. M., Muldoon, R. L., Poulose, B. K., Herline, A. J., & Geiger, T. M. (2015). Association of perioperative hypothermia during colectomy with surgical site infection. *JAMA Surgery, 150*(6), 570-575. doi:10.1001/jamasurg.2015.77

Baucom, R. B., Phillips, S. E., Ehrenfeld, J., Holzman, M. D., Martin, B. J., Nealon, W. H., & Poulose, B. K. (2014). Defining intraoperative hypothermia: The effect of temperature on surgical site infection in ventral hernia patients. *Journal of Surgical Research, 186*(2), 537-538. doi:10.1016/j.jss.2013.11.421

Billeter, A. T., Hohmann, S. F., Druen, D., Cannon, R., & Polk, H. C. (2014). Unintentional perioperative hypothermia is associated with severe complications and high mortality in elective operations. *Surgery, 156*(5), 1245-1252. doi:10.1016/j.surg.2014.04.024

Blumenthal, D., Abrams, M., & Nuzum, R. (2015). The affordable care act at 5 years. *The New England Journal of Medicine, 372*(25), 2451-2458. Retrieved from http://search.proquest.com/docview/1689866616?accountid=8593

Bull, A., Wilson, J., Worth, L. J., Stuart, R. L., Gillespie, E., Waxman, B., & Richards, M. (2011). A bundle of care to reduce colorectal surgical infections: An Australian experience. *Journal of Hospital Infection, 78*(4), 297-301. doi:10.1016/j.jhin.2011.03.029

Cima, R., Dankbar, E., Lovely, J., Pendlimari, R., Aronhalt, K., & Nehring, S.(2013). Colorectal surgery surgical site infection reduction program: A national surgical quality improvement program-driven multidisciplinary single-institution experience. *Journal of the American College of Surgeons, 216*(1), 23-33. doi:10.1016/j.jamcollsurg.2012.09.009

Centers for Disease Control (CDC). (2016). National center for health statistics. Retrieved from http://www.cdc.gov/nchs/fastats/inpatient-surgery.htm

Centers for Disease Control (CDC). (2015). Data and statistics. Retrieved from http://www.cdc.gov/HAI/surveillance/index.html

Crolla, R. M. P. H., Veen, E. J., Laan, v. d., L, Heniks, Y., van Schendel, C., & Kluytmans, J. A. J. W. (2012). Reduction of surgical site infections after implementation of a bundle of care. *Plos One, 7*(9), e44599. doi:10.1371/journal.pone.0044599

de Lissovoy, G., Fraeman, K., Hutchins, V., Murphy, D., Song, D., & Vaughn, B. B. (2009). Surgical site infection: Incidence and impact on hospital utilization and treatment costs. *American Journal of Infection Control, 37*(5), 387-397. doi:10.1016/j.ajic.2008.12.010

Dearholt, S. L., & Dang, D. (2012). *Johns Hopkins Nursing Evidence –Based Practice: Model and Guidelines*. Indianapolis, IN: Sigma Theta Tau International.

Edmiston, C. E., & Spencer, M. (2014). Patient care interventions to help reduce the risk of surgical site infections. *AORN Journal, 100*(6), 590-602. doi:10.1016/j.aorn.2014.10.008

Flores-Maldonado, A., Medina-Escobedo, C. E., Ríos-Rodríguez, H. M. G., & Fernández-Domínguez, R. (2001). Mild perioperative hypothermia and the risk of wound infection. *Archives of Medical Research, 32*(3), 227-231. doi:10.1016/S0188-4409(01)00272-7

Forbes, S. (2008). Implementation of evidence-based practices for surgical site infection prophylaxis: Results of a pre and post intervention study. *Journal of American Colorectal Surgery, 207*(3), 336-341. doi:10.1016/j.jamcollsurg.2008.03.014

Hedrick, T. L., Heckman, J. A., Smith, R. L., Sawyer, R. G., Fried, C. M., & Foley, E. F. (2007). Efficacy of Protocol Implementation on Incidence of Wound Infection in Colorectal Operations. Journal of the American College of Surgeons, 205(3), 432-438. doi:http://dx.doi.org.ezproxy.bethel.edu/10.1016/j.jamcollsurg.2007.04.042

Hooper, V. D., Chard, R., Clifford, T., Fetzer, S., Fossum, S., & Godden, B. (2010). ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia: Second edition. *Journal of Perianesthesia Nursing, 25*(6), 346-365. doi:10.1016/j.jopan.2010.10.006

Institute for Healthcare Improvement (IHI). (2015). Surgical site infection. Retrieved from http://www.ihi.org/Topics/SSI/Pages/default.aspx

Jeon, C. Y., Furuya, E. Y., Berman, M. F., & Larson, E. L. (2012). The role of pre-operative and post-operative glucose control in surgical-site infections and mortality. *Plos One, 7*(9), 1-7. doi:10.1371/journal.pone.0045616

Keenan, J. E., Speicher, P. J., Thacker, J. K. M., Walter, M., Kuchibhatla, M., & Mantyh, C. R. (2014). The preventive surgical site infection bundle in colorectal surgery an effective approach to surgical site infection reduction and health care cost savings. *JAMA Surgery, 149(*10), 1045-1052. doi:10.1001/jamasurg.2014.346

Kumar, S., Wong, P. F., Melling, A. C., & Leaper, D. J. (2005). Effects of perioperative hypothermia and warming in surgical practice. *International Wound Journal, 2*(3), 193-204. doi:10.1111/j.1742-4801.2005.00102.x

Kurz, A., Sessler, D. I., & Lenhardt, R. (1996). Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of wound infection and temperature group. *The New England Journal of Medicine, 334*(19), 1209

McEwen, M., & Wills, E. M. (2014). *Theoretical basis for nursing.* Philadelphia, PA: Lippincott Williams & Williams.

Melling, A. C., Ali, B., Scott, E. M., & Leaper, D. J. (2001). Effects of preoperative warming on the incidence of wound infection after clean surgery: A randomized controlled trial. *The Lancet, 358*, 876-880. doi:10.1016/S0140-6736(01)06071-8

Odom-Forren, J. (2006). Preventing surgical site infections. *Nursing, 36*(6), 58-64.

Owens, C. D., & Stoessel, K. (2008). Surgical site infections: epidemiology, microbiology and prevention. *Journal of Hospital Infection, 70, Supplement 2*, 3-10. doi:10.1016/S0195-6701(08)60017-1

Reichman, D. E., & Greenberg, J. A. (2009). Reducing surgical site infections: A review. *Reviews in Obstetrics & Gynecology, 2*(4), 212-221.

Reynolds, L., Beckmann, J., & Kurz, A. (2008). Perioperative complications of hypothermia. Best Practice and Research: *Clinical Anesthesiology, 22*(4), 645-657. doi:10.1016/j.bpa.2008.07.005

Roesler, R., Halowell, C. C., Elias, G., & Peters, J. (2010). Chasing zero: Our journey to preventing surgical site infection. *AORN Journal, 91*(2), 224-235. doi:10.1016/j.aorn.2009.08.013

Rosenberger, L. H., Politano, A. D., & Sawyer, R. G. (2011). The surgical care improvement project and prevention of post-operative infection, including surgical site infection. *Surgical Infections, 12*(3), 163-168. doi:10.1089/sur.2010.083

Rosenthal, M.B. (2007). Nonpayment for performance? Medicare's new reimbursement rule. *The New England Journal of Medicine, 357*(16), 1573-1575. doi:10.1056/NEJMp078184

Sawyer, R. G., & Pruett, T. L. (1994). Wound infections. *Surgical Clinics of North America, 74*(3), 519-536.

Seamon, M. J., Wobb, J., Gaughan, J. P., Kulp, H., Kamel, I., & Dempsey, D. T. (2012). The effects of intraoperative hypothermia on surgical site infection: An analysis of 524 trauma laparotomies. *Annals of Surgery, 255*(4), 789-795. doi:10.1097/SLA.0b013e31824b7e35

Sessler, D. I. (2006). Non-pharmacologic prevention of surgical wound infection. *Anesthesiology Clinics, 24*(2), 279–297.

Tanner, J., Padley, W., Davey, S., Murphy, K., & Brown, B. (2012a). Patients' experiences of surgical site infection. *Journal of Infection Prevention, 13*(5), 164-168. doi:10.1177/1757177412452677

Tanner, J., Padley, W., Davey, S., Murphy, K., & Brown, B. (2012b). Patient narratives of surgical site infection: Implications for practice. *The Journal of Hospital Infection, 83*(1), 41-45. doi:10.1016/j.jhin.2012.07.025

The American Board of Surgery. (2015) Specialty of general surgery defined. Retrieved from http://www.absurgery.org/default.jsp?aboutsurgerydefined

Appendix: Literature Matrix

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Adamina, M., Gié, O., Demartines, N., & Ris, F. (2013). Contemporary perioperative care strategies. *British Journal of Surgery, 100*(1), 38-54. doi:10.1002/bjs.8990	To report on the current advances in perioperative care, to assess whether they translate into improved outcomes and discuss their related contributions.	Review performed using the PubMed and Cochrane Library for articles published 1966 - 2012 on specific perioperative interventions with the potential to improve outcomes of surgical oncology patients. Included articles had to be randomized controlled trials, prospective or nationwide series, or systematic reviews meta-analyses published in English, French, or German. Exclusion criteria included retrospective series, papers published in languages other than English, French, and German, and papers excluding cancer.	Review of the Literature.	Literature Review Defines mild hypothermia as 34-36 degrees Celsius.	Mild hypothermia (34-36 degrees) occurs on 30-70% of surgical patients. Coagulopathy induced by hypothermia leads to impairment of thrombocyte activity and inactivation of coagulation factors, all of which increase blood loss and the requirement of allogeneic blood transfusions. Hypothermia promoted the development of SSI. Hypothermia induced vasoconstriction occurs in more than 75% of surgical patients. Vasoconstriction in turn decreased oxygen tension and the oxidative activity of neutrophils. Collagen deposition in the surgical wound of hypothermia patients is decreased and cell proliferation is impaired, compromising wound healing.	This review reinforced the perception that small changes in practice make a difference to patients with gastrointestinal cancer.	II A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Baucom, R. B., Phillips, S. E., Ehrenfeld, J. M., Muldoon, R. L., Poulose, B. K., Herline, A. J., & Geiger, T. M. (2015). Association of perioperative hypothermia during colectomy with surgical site infection. *JAMA Surgery, 150*(6), 570-575. doi:10.1001/jamasurg.2015.77	To determine whether intraoperative hypothermia in patients who undergo segmental colectomy is associated with post-operative surgical site infection.	Single institution, Vanderbilt University. Includes patients who underwent segmental colectomy by one of 4 surgeons. Total patients included in the study n=296.	Quasi-experimental.	Hypothermia defined as a body temperature less than 36 degrees Celsius. Continual body temperature was recorded during the intraoperative period. Four methods of tracking body temperature were used: temperature nadir, percentage of time spent at the temperature nadir, percentage of time spent at a temperature less than 36 degrees Celsius, and mean temperature nadir.	The rate in the group who attained the AHRQ metric was not statistically different from the rate of those patients who were considered hypothermic (12.4% vs 9.5%, $p>0.99$). Patients who underwent segmental colectomy and sustained a period of intraoperative hypothermia were no more likely to develop an SSI than those who were normothermic.	Although the findings in this study suggest that peri-operative normothermia does not decrease the rate, the authors acknowledge that maintaining normothermia is likely important for other physiological reasons.	II B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Baucom, R. B., Phillips, S. E., Ehrenfeld, J., Holzman, M. D., Martin, B. J., Nealon, W. H., & Poulose, B. K. (2014). Defining intraoperative hypothermia: The effect of temperature on surgical site infection in ventral hernia patients. *Journal of Surgical Research, 186*(2), 537-538. doi:10.1016/j.jss.2013.11.421	To determine if intraoperative normothermia can affect surgical site infection (SSI) rates in patients undergoing ventral hernia repair surgeries.	553 patients who underwent "clean case" ventral hernia repair between the years of 2005 and 2012. Patients were eligible if the procedure was classified as a clean case. Patients who were included in the Vanderbilt Procedural Outcomes Database (VPOD) and not in the National Surgical Quality Improvement (NSQIP) databases were excluded. Single facility.	Retrospective analysis of Vanderbilt Procedural Outcomes Database (VPOD), and National Surgical Quality Improvement Program (NSQIP).	VPOD to determine patient demographics, clean or contaminated case, procedure information, and patient co-morbidities. NSQIP for determining if there was an SSI. Perioperative Data Warehouse (IRB approved data repository) to determine intraoperative core body temperature data. Hypothermia defined as a measured temperature less than 36 deg Celsius by esophageal or bladder temperature probe. To account for erroneous readings from dislodged probes, readings greater than 3 standard deviations were excluded. Only class I, II, and III infections as defined by the Centers for Disease Control (CDC) and NSQIP were included in study. Class IV was considered wound disruption for this study.	Model one: patient core temperature dipped below 36 deg C in relation to SSI Temp nadir: 0.94 (0.78-1.1) p=0.5 BMI: 1.5 (1.0-2.2) p=0.05 Length of surgery: 1.9 (1.5-2.4) p< 0.001 Smoker: 2.9 (1.4-6.3) p=0.006. Model two: percent of time core temperature readings below 36 deg C in relation to SSI % time at nadir -1.5 (0.98-2.2) p=0.06 BMI: 1.5 (1.0-2.2) p=0.05 Length of surgery: 2.1 (1.6-2.8) p<0.001 Smoker: 3.0 (1.4-6.6) p=0.005. Model three: mean of core temperature in relation to SSI Mean temp: 1.1 (0.56-2.2) p=0.76 BMI: 1.5 (1.0-2.2) p=0.05 Length of surgery: 1.9 (1.5-2.4) p< 0.001 Smoker: 2.9 (1.4-6.4) p=0.006. No association between patient temperature and SSIs in ventral hernia repair patients. Authors suggested perioperative normothermia may only decrease SSI in at-risk populations.	Efforts to reduce SSIs in the patients undergoing ventral hernia repairs should focus on smoking cessation, weight loss, and increased operating room efficiency.	III A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Billeter, A. T., Hohmann, S. F., Druen, D., Cannon, R., & Polk, H. C. (2014). Unintentional perioperative hypothermia is associated with severe complications and high mortality in elective operations. *Surgery, 156*(5), 1245-1252. doi:10.1016/j.surg.2014.04.024	To evaluate the impact of hypothermia in a broader group of operative patients on outcome parameters to include cardiac complications and death. To identify risk factors that may be used to identify patients at risk for peri-operative hypothermia amenable to specific preventative measures.	University of Louisville. University Health System Consortium database was used to identify adult elective surgery patients who had become unintentionally hypothermic October 2008 to March 2012. Total patients evaluated n= 2138.	Non-experimental. Retrospective Chart Review.	University Health System Consortium database.	Unintentionally hypothermic patients undergoing elective procedures experienced a 4-fold increase in mortality (17% vs 4%, $p<0.001$).	Randomized trials should be conducted to evaluate the impact of aggressive warming measures in the at-risk population.	III A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Bull, A., Wilson, J., Worth, L. J., Stuart, R. L., Gillespie, E., Waxman, B., & Richards, M. (2011). A bundle of care to reduce colorectal surgical infections: An Australian experience. *Journal of Hospital Infection, 78*(4), 297-301. doi:10.1016/j.jhin.2011.03.029	The objective of this project was to assess the feasibility of implementing a "bundle of care" for patients undergoing colo-rectal surgery with the aim of reducing surgical site infections. The bundle of care incorporated maintenance of normothermia, oxygenation, and blood pressure and blood sugar levels.	Total of 275 patients undergoing colorectal surgery (Jan 2009, and Dec 2009) Colorectal Surgical Unit at Dandenong Hospital, Australia.	Quality Improvement Project.	Direct surveillance. Researchers defined normothermia at a body temperature of greater than or equal to 36 deg Celsius. Methods of measurement were not documented.	There was a statistically significant association between the use of warming devices and improved maintenance of normothermia. The infection rate fell from 15% (95% CI 10.4-20.2) before the project to 7% (95% CI 3.4-12.6) 12 months after the project, which included normothermia, diabetic control, oxygen delivery, blood pressure monitoring, and prophylactic antibiotic delivery. Unable to determine which interventions were responsible as the interventions were bundled.	Future research may focus on the design, preparation, and implementation of bundles of care to optimize the impact.	V C

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Cima, R., Dankbar, E., Lovely, J., Pendlimari, R., Aronhalt, K., Nehring, S., & Colorectal Surgical Site Infection Reduction Team. (2013). Colorectal surgery surgical site infection reduction program: A national surgical quality improvement program-driven multidisciplinary single-institution experience. *Journal of the American College of Surgeons, 216*(1), 23-33. doi:10.1016/j.jamcollsurg.2012.09.009	To reduce colorectal surgical site infections by 50% in a single organization using SQUIP Protocols.	Mayo Clinic Rochester, MN. Total of n=729 patients. Pre-initiation of SQUIP protocols n=531. Post-initiation of SQUIP protocols n=198.	Quasi-experimental.	The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQUIP) database was used to gather data both pre-intervention and post- intervention.	Pre-intervention infection rate in 2009-2010 was 9.8%. One year post-intervention infection rate declined to 4.0% ($p<0.05$). Superficial infection rate declined to 1.5% ($p<0.05$). Organ space infections declined to 2.6% ($p=0.10$), which was not statistically significant.	Unable to determine which interventions impacted the results due to the bundled nature of the protocol.	II A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Crolla, R. M. P. H., Veen, E. J., Laan, v. d., L, Heniks, Y., van Schendel, C., & Kluytmans, J. A. J. W. (2012). Reduction of surgical site infections after implementation of a bundle of care. *Plos One, 7*(9), e44599. doi:10.1371/journal.pone.0044599	Implement a bundle of care and measure the effect of surgical site infections.	Single Hospital, Amphia Hospital, Breda, Netherlands from January 1, 2008 until January 1, 2012. As part of a National patient safety initiative, a bundle of care consisting of 4 elements was introduced in 2009. The elements were perioperative antibiotic prophylaxis, hair removal before surgery, perioperative normothermia and discipline in the operating room. 1537 total colorectal procedures were performed during the study.	Quasi-experimental.	Normothermia defined as a body temperature between 36-38 degrees Celsius at the end of a surgical procedure.	There were a total number of 1537 colo-rectal procedures completed within the study period. The authors did not discuss the included participants in the cohort. The implementation of a care bundle in the hospital was associated with a substantial (36%) decrease of SSI rate after adjustment of confounders. CI and *p* were not discussed in the authors' results specific to the SSI rate reduction. The authors did note the bundle compliance was increased significantly from 2009 to 2010 ($p<0.001$).		II B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Flores-Maldonado, A., Medina-Escobedo, C. E., Ríos-Rodríguez, H. M. G., & Fernández-Domínguez, R. (2001). Mild perioperative hypothermia and the risk of wound infection. *Archives of Medical Research, 32*(3), 227-231. doi:10.1016/S0188-4409(01)00272-7	To examine the association between mild peri-operative hypothermia and surgical wound infection.	Hospital Benito Juares Garcia in Merida, Yucatan, Mexico. Consecutive sample of 290 patients undergoing cholecystectomy with post-surgical surveillance at 30 days. Male and female patients between the ages of 15 to 60 years of age, ASA Risk of 1-2, surgical time of 120 minute or less, hospital stay of 1-2 days. Exclusion criteria included pregnancy, HIV positive status, blood transfusion within 30 days, respiratory or ear infections, steroid or chemotherapy treatment, pre transplant candidates, tympanic temperature of greater than 38 degrees upon entering recovery, patients receiving a blood transfusion during surgery and patient who had two subsequent absences from post-operative visits. A total of 261 patients concluded the follow up and were included in the study.	Quasi-experimental prospective cohort design.	Tympanic ear temperatures less than 36 degrees Celsius were determined to be hypothermic. Surgical wound infection was diagnosed based on the definition of Surgical Wound Infection Task Forced published by Sawyer & Pruett (1994).	261 of 290 patients concluded follow up (90%). Of these: 40 (15.3%) were men and 221 (84.7%) were women. The average age was 40 +/- 12 years. ASA 1, 201 (77%) ASA 2, 60 (23%). 169 open cholecystectomies (64.8%) 92 laparoscopic cholecystectomies (35.2%). When admitted for recovery, 156 (59.8%) of patients showed hypothermia and had an infection rate of (18/156) 11.5% (p=0.004). When admitted to recovery 105 (40.2%) of patient showed normothermia, and had an infection rate of (2/105) 1.9% (p=0.004).	If cholecystectomy patients were prevented from hypothermia, post-operative infections could be decreased by up to 85%.	II A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Forbes, S. (2008). Implementation of evidence-based practices for surgical site infection prophylaxis: Results of a pre and post intervention study. *Journal of American Colorectal Surgery, 207*(3), 336-341. doi:10.1016/j.jamcollsurg.2008.03.014	To assess the safety and feasibility of implementing evidence -based care practices to prevent SSIs.	208 patients in a single university medical center (365 bed hospital) in Ontario Canada. Patients undergoing major colorectal and hepato-biliary operations were enrolled. Patients were enrolled during two time periods. Cohort I, (October 2004 to April 2005). Cohort II, (April 2006 to February 2007).	Quasi-experimental A prospective, double-cohort (pre and post intervention) trial.	Followed until their first outpatient visit 4 weeks after discharge, where they were assessed by the treating surgeon for the presence of a surgical site infection (SSI). Then direct assessment of interventions including: Changing the location of antibiotic administration from the admissions unit to the operating room and use of preprinted preoperative order forms to help standardize antibiotic selection. A new system for maintenance of perioperative normothermia included warming the OR to 22 deg Celsius during induction and emergence of anesthesia, use of IV fluid warmers, and two forced air warming devices per patient. Patients identified as having diabetes were started on a weight-based NPH insulin program.	Perioperative normothermia rates improved between: Cohort 1 (mean temperature 36.6 deg Celsius +/- 0.50 deg Celsius) (67.5% of patients at normothermia at arrival to PACU). Cohort 2 (mean temperature 36.7 deg Celsius +/- 0.53 deg Celsius) (97.6% of patients at normothermia at arrival to PACU). Surgical site infection rate in Cohort I was 14% for superficial infections and 7.6% in organ space infections. Surgical site infection in Cohort II was 8.7% (p=0.21) for superficial infections and 6.8 % (p=0.81) for organ space infections. No statistically significant difference in SSI rate between Cohorts 1&2. Note: Researchers note the implementation of the glucose control strategy in the study was not followed for all patients.	Study was designed to serve as a pilot study for a larger mutli-center study in the future.	II B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Hedrick, T. L., Heckman, J. A., Smith, R. L., Sawyer, R. G., Fried, C. M., & Foley, E. F. (2007). Efficacy of Protocol Implementation on Incidence of Wound Infection in Colorectal Operations. *Journal of the American College of Surgeons, 205*(3), 432-438. doi:http://dx.doi.org.ezproxy.bethel.edu/10.1016/j.jamcollsurg.2007.04.042	To decrease the incidence of surgical site infections (SSIs) in patients undergoing colo-rectal resection with a Basal Metabolic Index (BMI) >25.	University of Virginia Health System study February 2000-August 2005. Pre-Intervention data collection was between February 2000- January 2002 (n=175). Post-Intervention data between January 2005-August 2005 (n=132).	Quasi-experimental.	Normothermia defined as a body temperature of >36 degrees Celsius.	Overall infection rate decreased from 25.6% to 15.99% ($p \leq 0.05$). SSIs in patients with BMI $\geq$25 improved from 32.6% (31 of 95) during baseline to 18.4% (14 of 76) during the study (p=0.04). The study protocol was found to be associated with a decreased incidence of SSI.	Limitations of the study relate to the before and after study design. It is imperative that institutional efforts strive to reach benchmark compliance, as pay-for-performance standards become increasingly important in the health care delivery system. Unable to determine what effect individual interventions had on the decrease of infection rate.	II A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Hooper, V. D., Chard, R., Clifford, T., Fetzer, S., Fossum, S., Godden, B., & ASPAN. (2010). ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia: Second edition. *Journal of Perianesthesia Nursing, 25*(6), 346-365. doi:10.1016/j.jopan.2010.10.006	To improve health outcomes in adult surgical patients through the development of multi-disciplinary, mutli-modal evidence based clinical practice guideline directing the promotion of perioperative normothermia.	Literature review was completed for all phased of the peri-operative experience. Recommendations were given for each of the following areas: Risk factors for peri-operative hypothermia, temperature measurement, preadmission/preoperative assessment and management, intraoperative patient assessment and management, and post-operative patient assessment and management.	Clinical Practice Guideline.	Defines normothermia as a core temperature between 96.8-100.4 degrees F.	Risk factors for Perioperative hypothermia: Weak evidence: Extremes of age, systolic blood pressure of less than 140 mm Hg, female gender, level of spinal block. Insufficient evidence: BMI below normal, Normal BMI, procedural duration, body/surface area uncovered, anesthesia duration, history of diabetes with autonomic dysfunction. Temperature Measurement Recommendations: Strong Evidence: Near-core measure of oral temperature best approximates core, the same route of temperature measurement should be used throughout the perianesthesia period for comparison purposes; and caution should be takes in interpreting extreme values from any site with near-core instruments. Weak Evidence: Temporal artery measurements approximate core temperature at normothermic temperatures but not extremes outside of normothermia; infrared tympanic thermometry does not provide accurate temperature measurement during the peri-anesthesia period.	The guidelines recommended several further areas for study, including: Research to develop a risk factor stratification and prediction model for perioperative hypothermia. Further study to characterize the risk factors for perioperative hypothermia. Study of the relationship between core and near-core temperature measurements. Replication of studies investigating perioperative normothermia using consistent measures of temperature. Study of the relationship between temperature and thermal comfort from a patient perspective.	IV A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Hooper, et. al. (continued).	(continued).	(continued).	(continued).	(continued).	Preadmission/Preoperative Period: Implement passive thermal care measures, maintain ambient room temperature at or above 24 degrees Celsius, institute active warming for patients who are hypothermia, consider preoperative warming to reduce the risk of intraoperative/postoperative hypothermia (evidence suggests pre-warming for a minimum of 30 minutes may reduce the risk of subsequent hypothermia). Intraoperative: Limit skin exposure to lower ambient environmental temperatures, initiate passive warming measures including cotton blankets, surgical drapes, plastic sheeting, and reflective composites (space blankets), maintain ambient room temperatures from 20-24 degrees Celsius based on AORN recommendations. Patients undergoing a procedure with an anticipated procedure time greater than 30 minutes or who are hypothermic preoperatively should initiate active warming measures. Postoperative: If the patient is normothermic, provide thermal comfort.	Study of the following research questions: What patients would benefit from pre-operative warming? What is the most effective single or combination of preoperative warming measures? What is the impact of intraoperative warming measures on patient outcomes across the broad, heterogeneous populations? What is the best method or combination of methods, to maintain perioperative normothermia across the broad heterogeneous population? What is the best warming method for certain populations such as major spine procedures performed on specialty devices and plastic surgery procedures in which large areas are prepared as donor sites so as not to be amenable to overlying forced air warming device?	(continued)

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Keenan, J. E., Speicher, P. J., Thacker, J. K. M., Walter, M., Kuchibhatla, M., & Mantyh, C. R. (2014). The preventive surgical site infection bundle in colorectal surgery. An effective approach to surgical site infection reduction and health care cost savings. *JAMA Surgery, 149*(10), 1045-1052. doi:10.1001/jamasurg.2014.346	To determine the effect of a prevalent SSI bundle on SSI rates and costs in colorectal surgery.	A total of 559 patients were included in the study. Pre-implementation of the care bundle (n=346). Post implementation of the care bundle (n=213).	Quasi-experimental.	Retrospective review of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQUIP) database was used to gather data both pre-intervention and post intervention.	Implementation of the care bundle was associated with a reduced superficial surgical site infection rate of 19.3 % pre-implantation to 5.7 % post-implementation ($p<0.001$). Implementation of the care bundle was associated with a reduced post-operative sepsis rate of 8.5 % pre-implantation to 2.4 % post-implementation ($p=0.009$). No statistical significance was noted in the rates of deep SSI, organ space SSI, wound disruption, length of stay, and 30 day re-admission.	Further study is needed to assess whether the bundle can be effective in a wider application and what level of compliance with bundle measures are needed to achieve positive results.	II A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Kumar, S., Wong, P. F., Melling, A. C., & Leaper, D. J. (2005). Effects of perioperative hypothermia and warming in surgical practice. *International Wound Journal, 2*(3), 193-204. doi:10.1111/j.1742-4801.2005.00102.x	To address aspects of thermal homeostasis relevant to surgical patients. To consider the adverse effects of hypothermia. To Discuss methods of delivering heat and appraises laboratory and clinical evidence of the effects of use of heat in surgical patients.	Number of articles and inclusion/ exclusion criteria not discussed by the author.	Literature Review.	Searches of MEDLINE CINAHL, the health assessment database, EMBASE, and the Cochrane Library.	Thermal homeostasis seems to be closely linked to many other homeostatic mechanisms crucial for survival, and this integration is evident across cellular and extracellular levels involving many organ systems. Non-physical deviations of temperature in surgical patients whose homeostatic systems are often challenges in the perioperative period are poorly tolerated. Reduction in wound infection and blood loss with warming is promising but not proven.	More research including randomized trials are necessary.	V C

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Kurz, A., Sessler, D. I., & Lenhardt, R. (1996). Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of wound infection and temperature group. *The New England Journal of Medicine, 334*(19), 1209	To test the hypothesis that hypothermia both increases susceptibility to surgical wound infections and lengthens hospitalization in patients undergoing colorectal surgery.	200 patients were randomly assigned to routine intraoperative thermal care (hypothermia group) or additional warming (normothermia group). Single facility. Patients were assigned to the normothermia group (n=104). Patients to the normothermia group (n=96).	Randomized controlled trial (double blind).	Normothermia was defined as a core body temperature maintained near 36.5 deg F. Direct measurement and assessment of body core temperature measured by tympanic thermometer in two different groups: normothermia group with warming by forced air and IV fluid warmers, and hypothermia group with no active warming interventions.	6 (5.7%) wound infections in the normothermia group compared to 18 (18.7%) wound infections in the hypothermia group (p=0.009). Significantly more collagen (328 +/- 135 vs 254 +/- 115 micrograms per centimeter) was deposited in the surgical wounds of normothermia patients that of the hypothermia patients. Hospitalizations of normothermia patients were shorter than hypothermia patients (12.1 days +/-4.4, vs 14.7 +/- 6.5 respectively). (p=0.001). Intraoperative core temperatures approximately 2 deg Celsius below normal tripled the incidence of wound infection and prolonged hospitalization by 20 percent.	Maintaining intraoperative normothermia is likely to decrease infectious complications and shorten hospitalization in patients undergoing colorectal surgery.	I A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Melling, A. C., Ali, B., Scott, E. M., & Leaper, D. J. (2001). Effects of preoperative warming on the incidence of wound infection after clean surgery: A randomized controlled trial. *The Lancet, 358*, 876-880. doi:10.1016/S0140-6736(01)06071-8	To assess whether warming patients before short duration, clean surgery would decrease SSIs.	421 patients having clean (breast, hernia, or varicose vein) surgery. Only surgeries that would create a scar no more than 3cm in length. Single facility.	Randomized controlled trial. Three randomized groups were assigned: a local wound area warming using a radiant device, a systemic warming (forced air) device, and a non-warmed group.	Direct assessment and documentation in the preoperative and intraoperative stages. Single trained observer who was unaware of treatment allocation observed patients at their homes at 2 and 6 weeks postoperatively to assess for infections.	The core temperatures were significantly increased by both local and systemic warming. Rates of infection: Local warming: n=5 (4%) Systemic warming: n=8 (6%) Non warmed: n=19 (14%) There was a lower rate of infection in both the systemic warmed (p= 0.026) and the locally warmed (p=0.003) groups.	Preoperative warming may be an alternative to the controversial use of prophylactic antibiotics.	I A

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Odom-Forren, J. (2006). Preventing surgical site infections. *Nursing, 36*(6), 58-64.	To describe four evidence based components of care endorsed by the Institute for Health Care Improvement (IHI) for preventing SSIs.	Not applicable.	Clinical Practice Guideline.	Clinical Practice Guideline.	Use of appropriate prophylactic antibiotics. A short course of antibiotics involving clean surgical wounds helps to reduce the number of microbes at the incision site. Surgical cases classified as dirty or contaminated require a longer therapeutic course of antibiotics. Follow appropriate hair-removal procedures. Shaving the skin before surgery is no longer recommended as is causes microscopic cuts which increase the incidence of surgical site infections. Keep blood glucose under control. Hyperglycemia increases of SSI. The degree of hyperglycemia postoperatively has been correlated with the SSI rate for major cardiac surgery sternal wounds, and glucose control has been shown to decrease mortality in critical ill patients with diabetes. Keep patients warm postoperatively. Patients who become hypothermic during surgery as especially vulnerable to SSIs.	By following the recommendations of the IHI, CDC, and other organizations with infection control expertise, one can help the post-operative patient avoid a preventable, costly, and possibly fatal SSI.	IV B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Reynolds, L., Beckmann, J., & Kurz, A. (2008). Perioperative complications of hypothermia. *Best Practice and Research: Clinical Anesthesiology, 22*(4), 645-657. doi:10.1016/j.bpa.2008.07.005	To evaluate the mechanisms of hypothermia related complications. To elucidate the mechanisms involved in the genesis of adverse cardiac events in hypothermic patients. To examine ways to enhance immune defenses in hypothermia and under conditions of low oxygen availability. To evaluate whether hypothermia affects mortality in critical patient populations	Systematic literature review containing only randomized prospective human trials.	Clinical Practice Guideline.	Mild hypothermia defined as a core body temperature between 34 and 36 degrees Celsius.	Propofol blood plasma concentrations increase by approximately 30% in patients with a 3 degree decrease in core body temperature. In patients with mild hypothermia (2 degree decrease) the duration of action of vecuronium more than doubled. Hypothermia can lead to increases in peri-operative blood loss, due to temperature-related coagulation disorders: Platelet function, clotting factor enzyme function and fibrinolytic activity. Only 1.9 degree core hypothermia triples the incidence of surgical wound infection following colon resection. Hypothermia is also associated with mild hypokalemia.		I B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Rosenberger, L. H., Politano, A. D., & Sawyer, R. G. (2011). The surgical care improvement project and prevention of post-operative infection, including surgical site infection. *Surgical Infections, 12*(3), 163-168. doi:10.1089/sur.2010.083	To confirm evidence based measures for each of the 10 surgical care improvement project (SCIP) initiatives.	A literature review was completed providing evidence for each of the 10 SCIP measures.	Literature Review.	Variables studied include: Mediastinitis rate with electric vs manual shaving of body hair prior to open heart surgery. SSI rates in patients receiving perioperative warming measures vs no warming measures.	One study shows significantly lower rate of mediastinitis in patients who had their body hair clipper with electrical clippers vs manual shavers before open heart surgery. Patients with mediastinitis out of 990 in the electrically shaved group: n=4 (0.4%). Patients with mediastinitis out of 990 in the manually shaved group: n=13 (1.3%). One study noted significantly lower surgical site infection rate in the warming group vs the non-warmed group. 6 (6%) wound infections in the normothermia group compared to 18 (19%) wound infections in the hypothermia group (p=0.009).	Standardized practices can reduce surgical site infections. These measures have generally decreased SSI rates.	V B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Seamon, M. J., Wobb, J., Gaughan, J. P., Kulp, H., Kamel, I., & Dempsey, D. T. (2012). The effects of intraoperative hypothermia on surgical site infection: An analysis of 524 trauma laparotomies. *Annals of Surgery, 255*(4), 789-795. doi:10.1097/SLA.0b013e31824b7e35	To determine whether intraoperative hypothermia predisposes patients to postoperative SSIs after trauma laparotomy.	A retrospective review of all patients between July 2003 and June 2008 who survived 4 days or more after an urgent trauma laparotomy at a single level one trauma center (n= 524).	Non-experimental.	Intraoperative temperatures were measured by esophageal temperature probes.	The mean intraoperative temperature nadir of the study population was 35.2 +/- 1.1 degree Celsius; 35% of patients had at least one temperature measurement less than 35 degree Celsius. Patients who developed SSI (36.2%) had a lower mean intraoperative temperature nadir (p=0.009).	Just as intraoperative hypothermia is an SSI risk factor in patients undergoing elective colorectal procedure, intraoperative hypothermia less than 35 degrees adversely affects SSI rates after trauma laparotomy.	III B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Sessler, D. I. (2006). Non-pharmacologic prevention of surgical wound infection. *Anesthesiology Clinics, 24*(2), 279–297.	To review non-pharmacological methods of reducing infection risk, with special emphasis on methods available to anesthesiologists.	Not applicable.	Review of the Literature.	Review of the Literature.	General and neuraxial anesthesia profoundly impairs thermoregulatory control. Consequently, nearly all unwarmed surgical patients become hypothermic. Hypothermia may facilitate peri-operative wound infections in two ways, First, sufficient intraoperative hypothermia triggers thermoregulatory vasoconstriction, which can decrease subcutaneous tension in humans which is correlation with wound infection. There is considerable evidence indicating mild core hypothermia impairs immune function including T-cell mediated antibody production and nonspecific oxidative bacteria killing neutrophils. A 1.9 degree Celsius decrease in normothermic core temperature triples the incidence of surgical wound infection following colon resection.	There is a clear association that providing supplemental oxygen and keeping patients normothermic reduces surgical site infections.	III B

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations	Level & Quality
Tanner, J., Padley, W., Assadian, O., Leaper, D., Kiernan, M., & Edmiston, C. (2015). Do surgical care bundles reduce the risk of surgical site infections in patients undergoing colorectal surgery? A systematic review and cohort meta-analysis of 8,515 patients. *Surgery, 158*(1), 66-77. doi:10.1016/j.surg.2015.03.009	To assess the effectiveness of care bundles to reduce surgical site infections among patients undergoing colorectal surgery.	Literature search from 2002-2014 from PubMed, CINAHL, Ebase, Scopus, The Cochrane Database of Systematic Reviews, The Central Register of Controlled Trials, Academic Search Premiere, and clinicaltrials.gov. Total of 16 studies included in the qualitative synthesis. Total of 13 studies included in the quantitative analysis (meta-synthesis). Total number of patients in meta-analysis (n=8514). Non-bundled group (n=3866). Bundled group (n=4649).	Review of the Literature.	Literature Review with meta-analysis.	Meta-analysis: Non-bundled group 585/3866 (15% SSI rate). Bundled group 328/4649 (7% SSI rate). The systematic review and analysis show there is an association between the implementation of a surgical care bundle and the decreased development of SSIs.	Not all studies reported bundle compliance. This review suggests a multidisciplinary approach using selective evidence based interventions is associated with a decrease in SSIs.	III A