2018

Pediatric Normothermia During Surgery

Shayna Marie Fleming
Bethel University

PEDIATRIC NORMOTHERMIA DURING SURGERY

A MASTER'S PROJECT

SUBMITTED TO THE GRADUATE FACULTY

OF THE GRADUATE SCHOOL

BETHEL UNIVERSITY

BY

SHAYNA M. FLEMING

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE IN NURSING

APRIL 2018

BETHEL UNIVERSITY

PEDIATRIC NORMOTHERMIA DURING SURGERY

SHAYNA M. FLEMING

APRIL 2017

Approvals:

Approved: BERNITA MISSAL Advisor

_____Bernita Missal___Signature

APPROVED

Diane Dahl

_____

Dean of Nursing: DIANE DAHL

Pamela K. Friesen

_____

Director of Nurse Educator Program: PAMELA FRIESEN

Abstract

Background: The World Health Organization estimated the number of surgical procedures for 2012 to be 312.9 million around the world (Weiser et al., 2016). Children may be at an elevated risk of hypothermia in the perioperative environment due to their size and inconsistent use of nursing interventions. Maintaining normothermia during surgery is vital, but practices between organizations and even nursing staff can affect hypothermia rates. Research has found that even mild hypothermia can increase the incidence of surgical site infections, the need for oxygen, adverse cardiac events, blood loss, changes in medication absorption, and impaired wound healing (Rosenberger, Politano, & Sawyer, 2011). Determining if there is an ideal warming protocol throughout the perioperative environment is vital to improving patient outcomes.

Purpose: To review current literature to determine that implementing a patient care bundle would decrease the risk of perioperative hypothermia in children.

Results: Studies identified (n=21) examining the interventions used to maintain normothermia of surgical patients throughout the perioperative period. These studies were analyzed using Kolcaba's Comfort Theory which states that when nurses meet the patient's needs, the patient can maintain a system of wellness or homeostasis.

Conclusions: Findings from the studies (2005-2017) support the use of forced air warming throughout the entire perioperative environment to prevent the complication of unplanned hypothermia during surgery. However, many of the studies included many active and passive warming interventions and it was difficult to determine which intervention was the most responsible for decreasing the risk of unplanned hypothermia.

Implications for Research and Practice: Further research is needed to determine the best practices to prevent unplanned hypothermia in pediatric patients. This would include best active

and passive warming interventions, costs associated and environmental impact of the different interventions. A common nomenclature is needed to allow more straightforward comparison of research across all disciplines practicing in the perioperative environment.

Keywords: normothermia, unplanned hypothermia, pediatric population

Table of Contents

Abstract....3

Chapter One: Introduction....7

Need for Critical Review of a Nursing Problem....9

Statement of Purpose/Research Questions....10

Significance to Nursing....10

Conceptual Model/Theoretical Framework....11

Summary....12

Chapter Two: Methods....13

Search Strategies Used to Identify Research Studies....13

Criteria for Including or Excluding Research Studies....14

Number and types of Studies Selected....15

Criteria for Evaluating Research Studies....15

Summary....15

Chapter Three: Literature Review and Analysis....16

Major Findings....16

Strengths and Weaknesses of the Research Studies....23

Summary....24

Chapter Four: Discussion, Implications, and Conclusions……..…….……25

Answer to Practice Question…….25

Gap and Trends……..……26

Implications for Nursing…….27

Recommendations for Nursing……..……..…….28

Integration of Theoretical Framework……..…….29

Summary……..……..29

References…….…….31

Appendix: Literature Matrix.....36

Chapter One: Introduction

Inadvertent hypothermia during the perioperative environment for pediatric patients is one of the most common complications during surgery. Research studies have found that even mild hypothermia can increase the incidence of surgical site infections, the need for oxygen, adverse cardiac events, blood loss, changes in medication absorption, and impaired wound healing (Rosenberger, Politano, & Sawyer, 2011). Hypothermia leads to longer post-anesthesia care recovery time, decreased patient satisfaction, and increased costs for the patient and hospital. Maintaining normothermia was identified by the Joint Commission throughout the perioperative environment as a Surgical Care Improvement Project (SCIP) for all patients having surgery (Rosenberger, Politano, & Sawyer, 2011).

The history of the Surgical Care Improvement Project (SCIP) founded on evidence-based medicine had changed the way hospitals are reimbursed from insurers for care. SCIP started as a panel of experts composed primarily of physicians who consistently used all the guidelines published across health care disciplines to ensure that evidence-based research is utilized (mainly to reduce the risk of surgical site infections). As measures are developed, there is coordination with the Joint Commission, National Quality Forum, Centers for Medicare and Medicaid Services (CMS), and the United States Centers for Disease Control and Prevention. SCIP research began in the 1990's; as a result of the research was identified that patients who experienced hypothermia in the operating room had more negative outcomes. The SCIP-inf-10 was initiated in 2009 using the steps described above to require organizations to report the scope of the problem and the implications on patient care (Rosenberger, Politano, & Sawyer, 2011). In the fiscal year 2011, reporting was required of the perioperative temperature management of patients to ensure reimbursement from Centers for Medicare and Medicaid Services. This

protocol has been reported and researched by many facilities certified by the Joint Commission and CMS, as individual institutions track their internal perioperative temperature data, many have continued to find that patients are still becoming hypothermic.

Extent of the Problem

According to the World Health Organization (WHO), the number of surgical procedures worldwide was estimated to be 234.2 million in 2008 (Weiser et al., 2008). In a later report, the WHO estimated the number of surgical procedures for 2012 to have increased to 312.9 million around the world (Weiser et al., 2016). This data collection by the WHO included all surgical procedures regardless of age that took place in the operating room. Potential complications related to hypothermia could be quite vast and have implications for every culture and nation. According to the Centers for Disease Control and Prevention (CDC), the number of United States surgical procedures was estimated in 2010 to be 48.3 million. This number is rising exponentially due to technological advances such as lasers, minimally invasive techniques, and laparoscopic procedures while anesthesia has become better at providing analgesia (Hall et al., 2017). This data does not include patients who undergo general anesthesia for diagnostic procedures such as endoscopies. Children treated in hospitals are exposed to general anesthesia at higher rates than adults due to the need for general anesthesia to complete procedures such as endoscopies, MRIs, CTs, and central line placement. It has been found that when patients are exposed to anesthesia yet have no invasive procedures, they still have the potential for hypothermia (Dalal et al., 2016).

Surgical procedures and diagnostic testing provide a lot of revenue for hospitals. Approximately $400 billion is spent annually, and this amount is expected to increase more than economic growth. For example, major complications, besides patient harm, add an average cost

of $11,500 per patient (Eappen et al., 2013). Hospitals are required to deliver the best care for every patient for the best value. Also, the addition of "never" events contributes to payers not reimbursing the hospital at all. There are financial risks to the hospitals for not decreasing or eliminating surgical complications. A lot is at stake financially for medical institutions around the country; the need for appropriate care with minimal complications should be expected for every patient.

Accidental hypothermia is associated with poor outcomes for surgical patients. For example, hypothermia in the operating room could easily be caused by exposure to the cold environment and anesthetics that can cause impaired thermoregulatory control of the patient in surgery. Infants and children are more at risk for hypothermia due to their immature thermoregulatory capacity, increased heat loss from the head, higher skin surface to weight ratio, and decreased stores of subcutaneous fat (Beedle, Phillips, Wiggins, & Struwe, 2017). Published estimates of pediatric hypothermia range from 4.2-60%, a percentage much higher than in the adult population (Kim, Taghon, Fetzer, & Tobias, 2013). Hypothermia is a challenging complication to manage in the pediatric population across all healthcare disciplines.

Need for Critical Review

There are numerous studies from many different disciplines that reflect the complications that occur when a patient becomes hypothermic in the perioperative setting (Hooper et al., 2010). This setting also incorporates rapidly changing technologies through multiple surgical disciplines and nursing units that work together in the perioperative environment. It is a fast-paced setting with many demands placed upon the healthcare providers. Effective methods have been identified to decrease these challenges, yet many institutions have a hard time implementing them (Eappen et al., 2013). Recent ideas are being implemented through the use of patient safety

care bundles to help change practices among all disciplines to ensure the initiative is being addressed.

McClarigan, Mader, Larabie, Gokey, and Leitsch, (2014) found in their research the following:

> Using bundles helps to solve problems related to: high uncertainty, low predictability, frequent interruptions, and poor outcomes. The theory behind care bundles is that when several evidence-based interventions are grouped together in a single cluster of care, it will improve patient outcomes. (p. 46)

In this literature review it was found that creating a patient care bundle could provide best practices throughout the patient care continuum. A bundle is a structured set of best practices across all disciplines. They are grouped to ensure the same methods are used consistently throughout the entire continuum of care; taking these measures would help lead to better patient outcomes. Beedle, Phillips, Wiggins, and Struwe, (2017) demonstrated that using an evidence-based clinical practice guideline consistently prevented unplanned hypothermia in the perioperative environment.

Research Question

Implementation of consistent, cost-efficient and effective nursing interventions to decrease the risk of unplanned hypothermia in pediatrics can be challenging in the fast-paced setting of the perioperative environment. The focus question in this review is: Would implementing a pediatric normothermia bundle prevent perioperative hypothermia in children?

Significance to Nursing

In 2010, approximately 51.4 million inpatient surgical procedures were performed in the United States (Kurnat-Thoma, Roberts, & Corcoran, 2016). According to Association of Operating Room Nurses (AORN) guidelines, approximately 20-40% of all surgical patients

became hypothermic at some point during the perioperative period (AORN, 2016). Inadvertent hypothermia is an unacceptable complication for anyone having surgery. Much of the research concerning hypothermia in the operating room involves adults. Pediatrics is also a vulnerable population that suffers adverse outcomes when hypothermia is allowed to occur. Infants and children are considered to be more susceptible to hypothermia in the surgery area, making this a priority for nurses in the perioperative setting.

The American Society of PeriAnesthesia Nurses (ASPAN), the Association of Operating Room Nurses (AORN), the American Association of Nurse Anesthetists, and the Society of Pediatric Anesthesiology have all created clinical practice guidelines focusing on perioperative normothermia. Core body temperatures outside the normal range pose a risk for all patients in surgery; therefore, unplanned hypothermia is a patient safety concern (Hooper et al., 2010). Infants and children are thought to have a higher risk "of developing unplanned hypothermia because of different body size, their limited stores of subcutaneous fat, and less effective regulatory capacity" (Beedle, Phillips, Wiggins, & Struwe, 2017, p. 172). Many of the initiatives brought about by regulating bodies such as the Joint Commission, the Centers for Medicare and Medicaid Services, and the World Health Organization focused on adult research that is primarily based on the care of adults. These same issues are essential for pediatrics as well; however, they are more challenging because less information and research is available. There is limited information in the pediatric population related to risk factors, incidence, and the means to prevent hypothermia in the pediatric population; this indicates the significance of this patient care problem for nurses (Kim et al., 2013).

Conceptual Framework

The theoretical framework for this question will be a middle range nursing theory namely Kolcaba's Comfort Theory. This theory states that when nurses meet the patient's needs, the patient can maintain a system of wellness or homeostasis. Comfort is defined as "the holistic nature of human beings-that individuals have mental, spiritual, and emotional lives, which are intimately connected with their physical bodies" (Wilson & Kolcaba, 2004, p. 166). In the surgery area, a patient may experience anxiety, pain, cold, or nausea, and nurses can help ease or comfort patients while they are in the perioperative environment. Kolcaba (2004) divides the environment, or the area that we are manipulating to ensure a patient's comfort, into the physical, psychospiritual, environmental, and socio-cultural areas. A patient's physical environment can be enhanced or controlled through passive warming blankets, increased room temperatures, and forced air-warming devices. This theory is very effective in the pediatric population because it takes into account the family, which plays an integral role in the care of any pediatric patient. In other words, the care of the pediatric patient depends on meeting the needs of the entire family. The comfort care model is "proactive, energized, intentional, and longed for by patients and families in all settings" (Wilson & Kolcaba, 2004, p. 168).

Summary

In this chapter, the problem of pediatric hypothermia was introduced and discussed the causes, implications, and significance to nursing of unplanned hypothermia in the perioperative environment. Kolcaba's Comfort Theory was introduced as the conceptual framework for this review.

Chapter Two: Methods

This chapter contains the literature review related to pediatric hypothermia in the surgical setting and the interventions needed throughout the perioperative period. The search strategy included finding relevant studies, identifying inclusion and exclusion criteria as well as criteria for evaluating those studies. The chapter concludes with the criteria for assessing these studies.

Definitions

Common words and their definitions used throughout this literature review include the following:

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

Unplanned Hypothermia. Unplanned hypothermia is considered during any phase of the perioperative environment (preoperative, intraoperative, or post-anesthesia care unit) as the core body temperature under 36 degrees (96.8F) (Beedle, Phillips, Wiggins, & Struwe, 2017).

Pediatric Population. The American Academy of Pediatrics defines the ages of the pediatric population from infancy to the age of twenty-one (AAP, 2017).

Search Strategy

A literature search was conducted using PubMed, CINAHL Plus with Fulltext, and Cochrane Database of Systematic Reviews. The search words included: pediatric normothermia, unplanned hypothermia, hypothermia and pediatric surgery, and perianesthesia nursing unplanned hypothermia. Seven hundred and ten articles were initially found using these search words in CINAHL plus Fulltext and PubMed. Only thirty-two articles included the words unplanned hypothermia and surgery. These were evaluated to determine if they were related to the research question and only seventeen articles pertained to the research question and are

included in the matrix. Of these sixteen articles, only ten articles are specific to the pediatric population.

Three articles were found in Cochrane Database of Systematic Reviews relating to these specific search words: pediatric normothermia, unplanned hypothermia, hypothermia and pediatric surgery, and perianesthesia nursing unplanned hypothermia. None of them pertained to the research question. The search was expanded by not including the use of the word pediatric during the search of the Cochrane Database of Systematic Reviews. Expanding the search using only the search words of hypothermia and surgery resulted in four articles that related to the research question. Those four articles are included in the matrix.

The research question also questions the role of patient care bundles used in healthcare. Only three articles that refer to patient care bundles were found during the original search and pertain to process improvement or quality improvement projects for pediatric hospitals. These three articles are included in the Matrix.

Inclusion and Exclusion Criteria

The resulting thirty-two articles were examined to verify that they were published less than ten years ago and to determine if they addressed the research question resulting in the reduction of articles to twenty. Articles were accepted if they related to temperature measurement in any of the perioperative settings to include pre-operative, intraoperative, and post-operative. Some articles that were included related to the adult population in the perioperative environment due to the lack of pediatric-specific articles in the perioperative environment. The resulting twenty articles were appraised and found applicable to the evidence-based practice question.

Each article was appraised using the tools from the Johns Hopkins Nursing Evidence-Based Practice Model (Dearholt & Dang, 2012). Once the Synthesis and Recommendations Tool was completed and tallied, the synthesis included five level I articles of high quality and one level II articles of high quality. Eight level III articles with five appraised at high quality, two good quality, and one low quality were also included. Two level IV articles of high quality and four level V articles with three articles of high quality and one good quality article completed the list of sources.

Criteria for Evaluating Research Studies

Each article was systematically evaluated and rated to identify the strength of evidence using the Johns Hopkins Nursing Evidence-Based Practice Model (Dearholt & Dang, 2012) model's appraisal tools for research and non-research evidence. Quality was also assessed with the Johns Hopkins Nursing Evidence-Based Practice Guidelines (Dearholt & Dang, 2012); both quality and evidence ratings were placed in a matrix for review.

Summary

This chapter defined keywords, discussed the search strategy used, and identified inclusion and exclusion criteria. This chapter also described the process by which each article was evaluated for level of evidence and quality.

Chapter Three: Literature Review and Analysis

In this chapter, the major findings from the studies will be discussed. The various strengths and weaknesses of the studies will be discussed.

Major Findings

Level I evidence. A total of five level I articles are included in this review. Of the five, three are from the Cochrane Database of Systematic Reviews, all of the articles are of high quality, and only one identifies the pediatric population specifically. The articles from the Cochrane included data from 188 randomized controlled trials. The major findings included forced air warming appeared to offer clinically important results to include maintaining normothermia and the reduction in time to return to normothermia if the patient becomes hypothermic (Alderson, 2014, Madrid, 2016, & Warttig, 2014). The evidence for other types of warming interventions was non-existent or scant. The article by Alderson (2014), stated that the National Institute of Health and Clinical Excellence (NICE) clinical guidelines based on the National Health System in the UK established in 2008 are still clinically applicable. This article upheld the guideline recommendations of using forced air warming devices on patients that have inadvertent postoperative hypothermia. Madrid (2014) found that extending the systemic warming in the pre-operative period could be more beneficial than limiting forced air warming only for the surgical period and after the surgery. One of the level I articles was a reported randomized controlled trial of the use of heating and humidifying the airway to prevent hypothermia in adult patients undergoing arthroscopic hip surgery (Park, Yoon, Youn, Song, & Hwang, 2017). This study showed no statistical difference of intraoperative hypothermia or shivering in the PACU when the intervention was used versus when it was not used.

The final level I article by Liu et al., 2007 focused on children under the age of three that used passive warming with blankets, active warmed with electric blanket, and the use of active warming with electric blanket and forced air warming. The patients were all of similar age, weight, and intraoperative temperatures. The combination of the electric blanket and forced air warming was the most effective method of warming the patient with post-operative hypothermia. It was clear that active warming methods will rewarm patients faster than passive warming devices.

Level II evidence. There is only one article identified as level two article in this review. This article focused on the intervention of warming intravenous fluids in the perioperative environment. The results of this systematic review and high-quality article found that warmed intravenous fluids kept patients ½ degree warmer than patients without warmed fluids. No difference was found if warmed irrigation fluids were used (Campbell et al., 2015). The difficulty with this data is the confounding variables such as non- blinding of researchers, and the use of forced air warming and warmed blankets throughout the study making it difficult to determine if the results of warming IV fluids were clinically significant.

Level III evidence. There is a total of eight articles in this level, and four of them were directly related to the pediatric population. Two of the articles reported studies that assessed the level of knowledge of nurses that work in the perioperative environment.

Three articles in this section reported studies in which the subjects were infants in the surgical area. These studies explored infant temperatures from the NICU to the return to the NICU environment and tried to determine the area where the infants are more likely to become hypothermic and what interventions could be used to prevent this from occurring. All samples

were convenience samples and data collection focused on reviewing charts for temperature readings during the identified time periods.

Tander et al., (2005) investigated the type of surgery, patient age, operating room temperature, and the initial temperatures of the neonates. Neonates are defined by the age of fewer than 30 days and infants over the age of 30 days. Significant findings included the type of surgery, and the operating room temperature of fewer than 78.8 degrees as the main reasons temperature decreased in the neonates and infants. The researchers found that the temperature is most likely to fall in the first ten minutes after general anesthesia is initiated and that neonates temperatures were much more unstable than infants. The study concluded that all neonates and infants are at risk for hypothermia and temperature should be monitored at all times.

Schroeck, Lyden, Benedict, and Ramachandran, (2016) wanted to determine the frequency of post-operative hypothermia over nine years. Their study attempted to identify independent factors associated with postoperative hypothermia and hyperthermia. Major findings included that the sicker the patient, the higher the risk for hypothermia. Once forced air warming was introduced in 2010 there was a lower incidence of hypothermia in all patients. In the most recent years, there was a noticeable trend towards hyperthermia. This pattern was seen in longer surgeries. This study did note that using incubators for transfer to and from the NICU resulted in lower rates of hypothermia and hyperthermia in all patients.

The study by Morehouse et al., (2014) was unique in that it evaluated outcomes and the hypothermia risk in patients undergoing surgery in the operating room or the NICU. Out of the 108 infants being studied 50% had surgery in the operating room, and 49% had procedures in the NICU. There was no difference in gender or race between the two groups with 40% of the patients developing hypothermia regardless of the surgery location. The operating room had

significantly higher rates of hypothermia. However, there was an unacceptable rate of hypothermia in both groups of patients. Hypothermic patients suffer more respiratory, cardiac, and adverse metabolic events than normothermic patients. The researcher found that the infants in the operating room were ten times more likely to develop hypothermia and all infants regardless of location are hypothermic and, 67% more likely to stay hypothermic in the postoperative period

Chuang, Li, and Cherng, (2015) conducted a study with thirty four subjects that explored the unexpected patient outcome of hyperthermia in surgery and explored possible mechanisms. This study found that patient temperature increased for pediatric patients age three to nine years old having dental rehabilitation surgery. The temperature increases were associated with lengthy operations, and the etiology was uncertain.

Kurnat-Thoma, Roberts, and Corcoran, (2016) attempted to discover if using a thermal reflective blanket instead of passively warmed cotton blankets was a better therapeutic intervention. This quasi-experimental study followed patients age 18-70 years old to determine if one method was better than the other. This study found patient temperatures were strongly related to the operating room temperature. A forced air warming device was used on 83.9% of the patients. There were no cost savings related to the use of the thermal reflective blanket versus using four cotton warmed blankets.

Hegarty et al., (2009) introduced the idea of evaluating the perioperative nurse's knowledge of inadvertent hypothermia. At the conclusion of this study, it was found that the Association of Operating Room Nurses (AORN) and the Association of Perianesthesia Nurses (ASPAN) needed clear guidelines and definitions of normothermia and hypothermia. This study indicated lack of uniformity of preventative measures, continuing education programs on the

risks associated with hypothermia, and patient care outcomes. A follow-up study of similar design and using the same survey was conducted by Giuliano and Hendricks (2017) to see if after guidelines were established by AORN and ASPAN there is better nursing knowledge on the hypothermia in the perioperative environment. It was found that understanding of hypothermia by nursing personnel can reduce the occurrence and consequences of hypothermia in the perioperative setting. Nurses need ongoing training, competency evaluation, and organizational support to ensure that the guidelines established are used.

The study by Winslow et al. (2012) was of low quality and explored the temperatures of adult patients' in the pre-op, intraoperative, and post-op time periods. A major finding included significant differences between the temperature readings of the temporal thermometer and bladder thermometer readings. One primary result to note was that the operating room temperature of seventy degrees or higher allowed the patient's temperature to remain stable throughout the surgical procedure. Further research is needed on the temperature monitoring methods, thermal comfort and patient satisfaction, and with a larger population of patients. Many different warming interventions were used throughout this study, and the data were collected only on the passive warming interventions. Warming interventions varied with the nurse taking care of the patient rather than being controlled for this study.

Level IV evidence. Two articles, both with a focus on pediatrics, were categorized as a level IV. One article reported a study that used a new two nozzle forced air device, and its efficacy and the other article reported on the implementation of a clinical practice guideline to maintain normothermia in surgical patients.

A study by Beedle, Phillips, Wiggins, and Struwe, (2017) measured the perioperative hypothermia rates in pediatric surgical patients ages 31 days or older and younger than ten years

after implementing the evidence-based clinical practice guideline. This study identified that after implementation of the guideline the incidence of unplanned hypothermia decreased to 1.8%. This study also determined that if the patient was hypothermic before anesthesia induction these same patients were unable to maintain normothermia during surgery without added warming interventions. Patients that registered hypothermic had significantly lower temperature measurements at all documented temperature points throughout the study.

Witt et al., (2013) explored the use of a newer technology of forced air warming that uses two nozzles instead of one. The study suggested that this more modern technology increases the airflow leading to better heat transfer to the infants in the study. Inclusion of study participants was based on weight and only included patients under the weight of 10kg. The study did find that failing to reduce the temperature at the right time resulted in hyperthermia in the postoperative period. Continuous monitoring of temperature is needed in all perioperative areas to prevent both hypothermia and hyperthermia.

Level V evidence. Four articles were found to apply to Level V of evidence, three of the four articles directly applied to the pediatric population and all three were of high quality. The fourth article focused on preventative treatment to prevent hypothermia related morbidity and mortality.

Billeter, Hohmann, Druen, Cannon, and Polk Jr., (2014) conducted a study on adults over the age of 18 and reviewed chart data on hypothermic patients in surgery. Those patients that were found to be hypothermic experienced a fourfold increase in mortality and a doubled complication rate in which sepsis and stroke increased the most. Several risk factors were identified to increase the hypothermia risk including anemia, chronic renal impairment, unintended weight loss, the severity of illness, male, neurologic disorders, and being over the age

of sixty-five. This article stated that preventative treatment before the operation and aggressive warming measures of the at-risk population might decrease hypothermia-related morbidity and mortality in elective operations.

Dalal et al., (2016) followed 161 NICU patients needing an MRI under general anesthesia. The purpose of this study was to develop and implement a process to decrease the occurrence of hypothermia in NICU patients undergoing MRIs. This study was also trying to identify demographic, clinical, and anesthetic variables associated with post-scan hypothermia. The major findings included that the younger the age, lower the weight, presence of an airway device, lower pre-scan temperature and the use of propofol as the anesthetic technique were associated with higher odds of developing a postoperative decrease in body temperature. The use of the quality improvement process decreased the occurrence of hypothermia from 65% to 18%. Propofol may have a significant effect on temperature regulation versus an inhaled anesthetic anesthesia of Sevoflurane. This study found that using a multidisciplinary team to develop a protocol, identify risk factors, and increase vigilance decreased the risk of hypothermia in this population of patients.

Kim, Taghon, Fetzer and Tobias (2013) developed a quality improvement project to decrease the incidence of pediatric perioperative hypothermia by 50%. The authors sought to bundle the most effective techniques commonly used to prevent hypothermia. The temperature management bundle was able to decrease the incidence of hypothermia by 53% in all pediatric patients at this facility. This study found pediatric patients most at risk were between the ages of 12-18 and underwent orthopedic procedures. This study found that placing the warming device in specific areas of the hospital unit increased compliance and encouraged the use of the temperature management bundle. The authors also used a prompt in the electronic medical

record to use warming devices. This study also indicated that a multidisciplinary team to create the bundle increased compliance and provision of education of the risks associated with hypothermia.

A study by Tveit, Belew, and Noble, (2015) focused on the pre-operative intervention of pre-warming. A process improvement project using a multidisciplinary team to maintain normothermia throughout the perioperative period using active warming interventions with pediatric patients before surgery was implemented. There was an increase in warming of patients from 53.6% to 72.5% and positive parent satisfaction during the trial. Over the next eight months, compliance with the use of active warming interventions averaged 63%. This study was based on the ASPAN's recommendation that surgical patients receive thirty minutes of pre-warming to reduce the risk of hypothermia during the perioperative period.

The findings from these studies support the use of multiple interventions to prevent unplanned hyperthermia in the operating room. Most of the studies either directly or indirectly support the use of forced air warming for a minimum of thirty minutes in the pre-operative area, continuous use in the operating room, and use in the post-anesthesia care unit. Increasing the temperature of the operating room and staff education of the risks of hypothermia and prevention measures available throughout the perioperative setting will increase use of therapeutic warming interventions for all patients. Further research is needed in all areas concerning preventing unplanned hypothermia in the perioperative area.

Strengths and Weaknesses of the Research Studies

The strengths of the studies in this review were that many of them are of good or high-quality evidence according to the John Hopkins Guidelines. This allows for much of the evidence to translate into future replicated research studies. There are numerous studies on the

adult and neonatal populations established physiologic risk to patients in the perioperative environment. These studies can be used as a guide for best practices in future studies in the sub population of pediatrics. This literature review has identified that when evidence-based practices and nursing innovations are applied to nursing interventions, quality outcomes can be attained in the pediatric perioperative environment.

The weaknesses of these studies include that very few focus on the pediatric population of age 31 days to the age of 18. This limitation needs to be taken into consideration when nurses are focused on pediatrics patients. It is difficult to determine if the research studies directed for adults will apply to the care of pediatric patients. While the quality of the level one studies was high, there was lack of level I evidence. Of the level one studies only one was related to pediatrics, and it had a small sample of 346 patients. Many of the studies lacked any blinding by the researchers, confounding issues such as the use of multiple warming interventions. Every article mentioned the use of forced air warming even though different interventions were being considered. The methods of measuring temperature varied from study to study and within the individual studies themselves. It is not certain that one temperature taking method is more reliable than another and measurements could differ from one nurse to another. The researchers were not blinded to the study participants in any of the studies.

There is lack of a common language or comparative language used throughout the studies that would make replication of the studies in different settings more difficult. There was also a consistent lack of consideration of the costs of the various warming interventions used throughout the studies.

Summary

In this chapter, the available evidence related to unplanned hypothermia in the pediatric population undergoing surgery was reviewed and summarized. Definitions that researchers have used for normothermia, unplanned hypothermia, and pediatric age range were explored. Methods of active and passive warming interventions were discussed and compared throughout the perioperative environment. This chapter concluded with a discussion of the strengths and weaknesses of the findings of the studies considered in this literature review.

Chapter Four: Discussion, Implications, and Conclusions

In this chapter, I will answer the practice question: Would implementing a pediatric normothermia bundle prevent perioperative hypothermia in children? Next, the gaps and trends in this particular study of literature will be discussed. I will then consider nursing practice implications, recommendations for future research, and the integration of Kolcaba's Comfort Theory (Wilson & Kolcaba, 2004).

Answer to Practice Question

The studies reviewed had three common recommendations on best evidence-based practices that when used together throughout the continuum of care could decrease the likelihood of unplanned hypothermia. The three elements discussed in the articles reviewed included forced air warming in the perioperative period, temperature monitoring at set intervals, and having the operating room temperature at seventy degrees upon arrival to the operating room. For the criteria of a bundle to be met, there must be three to five evidence-based interventions strategically used by the multidisciplinary team to meet the requirements of answering the practice question.

Therefore, the studies reviewed support a positive response to the question that implementing a bundle would help prevent perioperative hypothermia in children. Based on the current evidence it would be reasonable to recommend that active forced-air warming is used for thirty minutes of pre-warming in the pre-operative environment and continuous forced air warming be used in the operating room as well as the post-anesthesia care unit. The forced air warming device should have two settings, warming and room temperature, this ensures the patient can be warmed or cooled if the patient should become too warm. The operating room temperature should be maintained at at least seventy degrees for all children in the operating

room. A pediatric patient should be monitored for temperature at set intervals to include the pre-operative temperature, continuous temperature monitoring throughout the entire surgical procedure, and upon arrival to the post-anesthesia care unit. The staff should remain vigilant and the organization provide support of continued education about the effects of hypothermia on the patient in surgery. Consistent warming interventions and vigilance by the multidisciplinary team will help ensure that unplanned hypothermia will be less likely to occur.

Gap and Trends

One of the gaps in the literature is the method of measuring temperature and lack of standardization of the information on trials. The different methods of measurement affect the comparability of study results that are used throughout the perioperative environment.

One of the trends in the literature is studies on bundling warming interventions and reports of quality improvement or process improvement projects. This trend along with studies using multiple warming interventions simultaneously as a new intervention is being introduced causes the difficulty of determining which intervention is causing the best results. The use of forced air warming and patients becoming hyperthermic following the aggressive use of forced air warming devices in the operating room is another new area of study.

Implications for Nursing

Every time a pediatric patient enters the perioperative area and undergoes anesthesia for care, the patient is at risk of becoming hypothermic. A pediatric patient's risk of unplanned hypothermia is preventable with the appropriate education and consistently applied nursing interventions to include active warming, temperature monitoring, and ensuring the temperature of the operating room is at seventy degrees. The number of surgical cases is expected to rise as

surgical, and anesthesia practice becomes more refined in the operating room. Complications resulting from hypothermia have been documented in the literature and include cardiac arrhythmias, poor wound healing, extended hospital stays, and increased cost to the patients and the institution (Billeter, 2014). Nurses need current and continuing education about best practices for preventing hypothermia throughout the perioperative environment.

This knowledge surrounding this issue also requires further research to fully understand the scope and implications of unplanned hypothermia in children fully. There are many studies relating to the NICU baby and surgery as well as individuals from the age of 18 and older. The sub-population of pediatric patients between the ages of 30 days to 17 years of age are vulnerable due to being missed in the current research. Applyng this knowledge to prevent hypothermia has implications in nursing due to "the primary goal of a professional nurse remains the same: to be the client's advocate and provide optimal care on the basis of evidence obtained through research" (Tingen et al., 2005, p. 67). Nurses are at the forefront of nursing care and should conduct research to further the professional practice of nursing.

Recommendations for Nursing

The American Society of PeriAnesthesia Nurses, the Association of Operating Room Nurses, the American Association of Nurse Anesthetists, and the Society of Pediatric Anesthesiology have all created clinical practice guidelines focusing on perioperative normothermia. My recommendation is to have one, comprehensive guideline that involves the primary disciplines that practice in the perioperative setting. A multidisciplinary approach would ensure the best chance of avoiding unplanned hypothermia in the operating room. An interdisciplinary approach could include a standard nomenclature to allow future research to be

comparable and replicable in the different sub-populations including pediatric patients.

Further research is needed to determine the best active and passive warming interventions, costs, and accurate temperature measurement devices with the emphasis in the pediatric population. The costs associated with the different warming interventions or the environmental impact should also be addressed. Some interventions include the use of one-time use blankets or expensive warming equipment. Further research is needed to determine what method of measuring temperature is the most accurate when multiple nursing personnel are taking the same measurement. Many of the studies in this literature review would benefit from replication studies in different settings with different subpopulations to determine if the same results would occur (Liu et al., 2017, Madrid, 2016).

Hyperthermia is just beginning to be a trend that is related to forced-air warming, and further research is needed to determine what patient care outcomes occur when the patient becomes too warm in the operating room. As new research comes available, new information should be incorporated into the education and training of perioperative personnel. Additionally, the organization, as well as nursing leaders should assure that budgets include the purchase of additional or updated equipment as well as the education needed to sustain the practice of preventing unplanned hypothermia in the operating room.

Integration of Theoretical Framework

Integrating the theoretical framework of Kolcaba's Comfort Theory in the perioperative environment focuses on the basic needs of the patient and the family's desire for comfort (Wilson & Kolcaba, 2004). Nurses in the perioperative setting are meeting the patient and family's need for physical comfort by maintaining normothermia in the perioperative

environment. In the surgery area, the patient can experience many unpleasant emotions including anxiety, pain, unpleasant sensations, nausea, vomiting, and cold. Nurses and the rest of the multidisciplinary team can meet the needs of the patient and family by alleviating anxiety and providing physical comfort through a warmed blanket, increasing the room temperature, and through the use of forced air warming devices. The use of these interventions can decrease the chance of the patient having these unpleasant sensations. Increasing the patient's comfort will improve the patient's satisfaction with the care delivered by the nursing staff as well. This theory includes the impact on the whole family because when the needs of the child are met the family is more at ease in the unfamiliar environment. The comfort care model is "proactive, energized, intentional, and longed for by patients and families in all settings" (Wilson & Kolcaba, 2004, p. 168).

Summary

In this chapter, I have addressed the implications for nursing and recommended that forced-air warming is used throughout the perioperative period for all pediatric patients. Gaps and trends in the literature were discussed, as well as the integration of the theoretical framework of Kolcaba's Comfort Theory.

References

Alderson, P. (2014). Thermal insulation for preventing inadvertent perioperative hypothermia. *Cochrane Database of Systematic Reviews,* (6), 1-69.

American Academy of Pediatrics. (2017). *Age limits of pediatrics*. American academy of pediatrics: http://pediatrics.aappublications.org/content/49/3/463.

Beedle, S. E., Phillips, A., Wiggins, S., & Struwe, L. (2017). Preventing unplanned perioperative hypothermia in children. *AORN Journal, 105*(2), 170-183.

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

Campbell, G., Alderson, P., Smith, A. F., Warttig, S., Campbell, G., Alderson, P., . . . Warttig, S. (2015). Warming of intravenous and irrigation fluids for preventing inadvertent perioperative hypothermia. *Cochrane Database of Systematic Reviews,* (4), N.PAG. doi:10.1002/14651858.CD009891.pub2

Chuang, Y., Li, C., & Cherng, C. (2015). Body temperature increases during pediatric full mouth rehabilitation surgery under general anesthesia. *Journal of Dental Sciences, 10*(4), 372-375. doi:10.1016/j.jds.2015.01.003

Dalal, P. G., Porath, J., Parekh, U., Dhar, P., Wang, M., Hulse, M., . . . McQuillan, P. M. (2016). A quality improvement project to reduce hypothermia in infants undergoing MRI scanning. *Pediatric Radiology, 46*(8), 1187-1198. doi:10.1007/s00247-016-3592-0

Eappen, S., Lane, B. H., Rosenberg, B., Lipsitz, S. A., Sadoff, D., Matheson, D., . . . Gawande, A. A. (2013). Relationship between occurrence of surgical complications and hospital finances. *Jama, 309*(15), 1599-1606. doi:10.1001/jama.2013.2773

Giuliano, K., & Hendricks, J. (2017). Inadvertent perioperative hypothermia: current nursing knowledge. *AORN Journal, 105*(5), 453-463.

Hall, M., Schwartzman, A., Zhang, J., & Liu, X. (2017, February 28). *CDC National Health Statistics Reports.* Retrieved December 22, 2017, from CDC National Health Statistics Reports: https://www.cdc.gov/nchs/data/nhsr/nhsr102.pdf.

Hegarty, J., Walsh, E., Burton, A., Murphy, S., O' Gorman, F., & Mcpolin, G. (2009). Nurses' knowledge of inadvertent hypothermia. *AORN Journal, 89*(4), 701-713. doi:10.1016/j.aorn.2008.09.003

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

Kim, P., Taghon, T., Fetzer, M., & Tobias, J. D. (2013). Perioperative hypothermia in the pediatric population: A quality improvement project. *American Journal of Medical Quality, 28*(5), 400-406. doi:10.1177/1062860612473350

Kurnat-Thoma, E., Roberts, M. M., & Corcoran, E. B. (2016). Perioperative heat loss Prevention A feasibility trial. *AORN Journal, 104*(4), 307-319. doi:10.1016/j.aorn.2016.07.012

Liu, X., Shi, Y., Ren, C., Li, X., & Zhang, Z. (2017). Effect of an electric blanket plus a forced-air warming system for children with postoperative hypothermia: A randomized controlled trial. *Medicine*, *96*(26), e7389. http://doi.org/10.1097/MD.0000000000007389.

Lynch, S., Dixon, J., & Leary, D. (2010). Reducing the risk of unplanned perioperative hypothermia. *AORN Journal, 92*(5), 553-565.

Madrid, E. (2016). Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *Cochrane Database of Systematic Reviews,* (4)

McClarigan, L., Mader, D., Larabie, S. E., Gokey, L., & Leitsch, M. (2014). Why not a patient care bundle? Improving patient and family satisfaction by bundling evidence-based best practices at the bedside. *Nurse Leader, 12*(6), 45-48. doi:10.1016/j.mnl.2014.09.004

Morehouse, D., Williams, L., Lloyd, C., McCoy, D. S., Miller Walters, E., Guzzetta, C. E., . . . Lou Short, B. (2014). Perioperative hypothermia in NICU infants: Its occurrence and impact on infant outcomes. *Advances in Neonatal Care, 14*(3), 154-164. doi:10.1097/ANC.0000000000000045

Park, S., Yoon, S.-H., Youn, A. M., Song, S. H., & Hwang, J. G. (2017). Heated wire humidification circuit attenuates the decrease of core temperature during general anesthesia in patients undergoing arthroscopic hip surgery. *Korean Journal of Anesthesiology*, *70*(6), 619–625. http://doi.org/10.4097/kjae.2017.70.6.619.

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

Schroeck, H., Lyden, A. K., Benedict, W. L., & Ramachandran, S. K. (2016). Time trends and predictors of abnormal postoperative body temperature in infants transported to the intensive care unit. *Anesthesiology Research and Practice, 2016*, 7318137. doi:10.1155/2016/7318137

Tander, B., Baris, S., Karakaya, D., Ariturk, E., Rizalar, R., & Bernay, F. (2005). Risk factors influencing inadvertent hypothermia in infants and neonates during anesthesia. *Pediatric Anesthesia, 15*(7), 574-579.

Tingen, M. S., Burnett, A. H., Murchison, R. B., & Zhu, H. (2009). The importance of Nursing Research. *The Journal of Nursing Education*, *48*(3), 167–170.

Tveit, C., Belew, J., & Noble, C. (2015). Prewarming in a pediatric hospital: Process improvement through interprofessional collaboration. *Journal of PeriAnesthesia Nursing, 30*(1), 33-38.

Warttig, S. (2014). Interventions for treating inadvertent postoperative hypothermia. *Cochrane Database of Systematic Reviews,* (11)

Weiser, T. G., Haynes, A. B., Molina, G., Lipsitz, S. R., Esquivel, M. M., Uribe-Leitz, T., . . . Gawande, A. A. (2016). Size and distribution of the global volume of surgery in 2012. *Bulletin of the World Health Organization, 94*(3), 201-209. doi:10.2471/BLT.15.159293

Weiser, T. G., Regenbogen, S. E., Thompson, K. D., Haynes, A. B., Lipsitz, S. R., Berry, W. R., & Gawande, A. A. (2008). An estimation of the global volume of surgery: A modeling strategy based on available data. *The Lancet, 372*(9633), 139-144. doi:10.1016/S0140-6736(08)60878-8

Wilson, L., & Kolcaba, K. (2004). Practical application of comfort theory in the perianesthesia setting. *Journal of PeriAnesthesia Nursing, 19*(3), 164-173.

Witt, L., Dennhardt, N., Eich, C., Mader, T., Fischer, T., Bruer, A., . . . Bosenberg, A. (2013). Prevention of intraoperative hypothermia in neonates and infants: Results of a prospective multicenter observational study with a new forced-air warming system with increased warm air flow. *Pediatric Anesthesia, 23*(6), 469-474. doi:10.1111/pan.12169

Winslow, E. H., Cooper, S. K., Haws, D. M., Balluck, J. P., Jones, C. M., Morse, E. C., Kelly, P. A. (2012a). Unplanned perioperative hypothermia and agreement between oral, temporal artery, and bladder temperatures in adult major surgery patients. *Journal of*

PeriAnesthesia Nursing, 27(3), 165-180. doi:10.1016/j.jopan.2012.01.0

Appendix: Literature Matrix

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Alderson, P. (2014). Thermal insulation for preventing inadvertent perioperative hypothermia. *Cochrane Database of Systematic Reviews,* (6), 1-69. Level: I Quality: High	To update previous studies with more recent research. To determine if the NICE recommendations are still accurate Estimate the effectiveness of treating periop hypothermia by using forced air warming postoperatively	699 participants 10 Randomized Controlled Studies were examined for analysis	Systematic review of RCTs	Multiple methods of temperature measurements	Forced air warming, appears to offer a clinically important reduction in mean time taken to achieve normothermia. Temperature goes back to normal (36-37degrees C) more than an hour faster when active warming devices are used. High quality evidence on other clinical outcomes is lacking, unclear if active warming offers other benefits or harms. High-quality evidence on other warming methods is also lacking, unclear whether other rewarming methods are as effective in reversing postoperative hypothermia.	Further studies are needed to determine if active warming confers benefits or harm for pts. & if other rewarming methods are as effective in reversing postoperative hypothermia. The NICE guidelines from 2008 are not contradicted by this article. These guidelines recommend the use of forced air warming for pts that have inadvertent postoperative hypothermia. No clear benefits of reflective blankets clothing increasing the pts' temperature.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Beedle, S. E., Phillips, A., Wiggins, S., & Struwe, L. (2017). Preventing unplanned perioperative hypothermia in children. *AORN Journal, 105*(2), 170-183. doi:10.1016/j.aorn.2016.12.002 Level: IV Quality: High	Measure the rate of perioperative hypothermia in pediatric surgical population after implementing the evidence-based clinical practice guideline (CPG)	1,190 pts Age 31 days or older and younger than 10yrs. Females that have not reached menarche, ASA I-III, surgery procedure longer than 30 minutes 146-bed freestanding regional pediatric hospital in the Midwestern US – more than 11,000 surgical procedures /year of simple to complex acuity patients.	Quantitative descriptive research design	Temporal Scanner artery thermometers	The study demonstrated that the CPG consistently prevented unplanned hypothermia Patients that have mild hypothermia before anesthesia induction were unable to maintain normothermia throughout the intraoperative period w/o added warming interventions The incidence of unplanned periop hypothermia after implementation was 1.84% Having a low body temp at the beginning of the procedure was an indicator of risk for developing hypothermia. pts with hypothermia had significantly lower temps than those with normothermia at all documented temp points	Temporal artery thermometer decreased the variation of temps between pts – when taken on the same child. Active surveillance and steps to prevent hypothermia are warranted for all pediatric age groups. Ongoing nursing education on practice and improvement of maintaining normothermia in surgery. Further research to promote CPGs that establish effective and high quality nrsg care. Consistent CPG implementation can create high quality nursing care for the pediatric population

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Billeter, A. T., Hohmann, S. F., Druen, D., Cannon, R., & Polk Jr., H. C. (2014). Unintentional perioperative hypothermia is associated with severe complications and high mortality in elective operations. *Surgery, 156*(5), 1245-1252. doi://doi.org.ezproxy.bethel.edu/10.1016/j.surg.2014.04.024 Level: V Quality: High	Investigated the outcomes of pts who became hypothermic <35 C after elective operations and compared with non-hypothermic pts to better define the impact of hypothermia on surgical outcomes.	Sample: 707 operative pts over the age of 18 Setting: University Health System Consortium >200 University or University affiliated hospitals submit data to the UHC database	Retrospective review of chart data	Temperature	Hypothermic pts experienced a 4-fold increase in mortality and a doubled complication rate in which sepsis and stroke increased the most. Several independent risk factors for hypothermia were amendable to preoperative improvement: anemia, chronic renal impairment, & unintended weight loss. Severity of illness on admission, >65yrs old, male sex, and neurologic disorders were also risk factors Hypothermia is associated with an increased rate of mortality and complications. Preventative treatment of these risk factors before operation and aggressive warming measures in the at-risk population may decrease hypothermia related morbidity and mortality in elective operations.	Further studies - RCTS should be conducted to evaluate the impact of aggressive warming measures. Prevention is pivotal because there are no established treatments besides rapid rewarming. Hypothermia can easily be avoided by strict adherence to established quality measures and standardized procedures for the at-risk pts.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Campbell, G., Alderson, P., Smith, A. F., Warttig, S., Campbell, G., Alderson, P., . . . Warttig, S. (2015). Warming of intravenous and irrigation fluids for preventing inadvertent perioperative hypothermia. *Cochrane Database of Systematic Reviews,* (4), N.PAG. doi:10.1002/14651858.CD009891.pub2 Level: II Quality: High	To estimate the effectiveness of preoperative and intraoperative warming of intravenous and irrigation fluids in preventing hypothermia in adults.	1250 participants from 24 studies	Systematic review of RCTs and quasi-experimental studies and randomized controlled studies	Core body Temperature	Warmed intravenous fluids kept pts ½ degree warmer than those w/o having warmed fluids No difference was found if warmed irrigation fluids were used. It is difficult to know if the warmed fluids result is clinically significant due to the use of other warming interventions such as forced air and warmed blankets.	Further trials needed and they should be high quality. The outcome data should be easily translated into pt outcomes. As there are many different interventions available the design of future studies should be based on all relevant comparisons.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Chuang, Y., Li, C., & Cherng, C. (2015). Body temperature increases during pediatric full mouth rehabilitation surgery under general anesthesia. *Journal of Dental Sciences, 10*(4), 372-375. doi:10.1016/j.jds.2015.01.003 Level: III Quality: Good	This study is to demonstrate unusual intraoperative hyperthermia and discuss possible mechanisms.	34 medical records 19 boys and 15 girls age range 3-9yrs old	Retrospective chart review	Tympanic or axillary temperature measurements	Body temperature transiently increased during pediatric surgery and in this study, was associated with the lengthy surgical duration. Etiology of the increased temperature is uncertain.	Repeating the same study with / larger number of pts/ different dentists/ another facility or other organizations. Continuous temperature monitoring of all patients having pediatric dental procedures. Use of a forced air warming device that can do both warm and use room temperature air is recommended.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Dalal, P. G., Porath, J., Parekh, U., Dhar, P., Wang, M., Hulse, M., . . . McQuillan, P. M. (2016). A quality improvement project to reduce hypothermia in infants undergoing MRI scanning. *Pediatric Radiology, 46*(8), 1187-1198. doi:10.1007/s00247-016-3592-0 Level: V Quality: High	To identify demographic, clinical and anesthetic variables associated with post-scan hypothermia in infants. To develop and implement processes to reduce occurrence of hypothermia in NICU pts undergoing MRI	164 NICU infants needing MRI scan Penn State Medical Center	Prospective audit of post-scan body temps in infants presenting for MRI to identify the extent of the hypothermia problem.	MRI compatible temperature monitor Exergen TemporalScanner for before and after temp measurements Digital axillary thermometer Sure Temp Plus for NICU pts that were intubated	Results: younger age (NICU), lower weight, lower pre-scan temp combined with primary anesthetic technique with propofol, advanced airway device associated with higher odds for developing post-scan decrease in body temp. QI processes decreased the occurrence of hypothermia from 65% to 18% Age, weight, pre-scan temperature, use of propofol and an advanced airway are associated with a decrease in post-scan temps. Propofol may have more significant effect on temp regulation vs the use of sevoflurane. Hypothermia is a significant problem in this population	Use of non-sedated technique using a vacuum immobilizer device led to decrease cardiorespiratory risks, potentially neurotoxic effects of general anesthesia & cost implications. A multidisciplinary team to develop a protocol, risk factor identification, & increased vigilance (through education of all disciplines about hypothermia) and Use of vacuum immobilizer (no sedation needed when immobilizer used) to decrease the risk of hypothermia.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Giuliano, K. & Hendricks, J. (2017). Inadvertent perioperative hypothermia: current nursing knowledge. *AORN Journal, 105*(5), 453-463. Level: III Quality: High	Assess the current level of nursing knowledge regarding perioperative hypothermia and compare with survey from approximately ten years ago	324 Nurses completed a survey.	Convenience sample of AORN conference attendees with a minimum of five year's experience in surgery. Non-experimental survey research.	Survey with the same Questionnaire as the Hegarty et al.	Sent over 5,000 e-mails to current AORN members with an overall response rate of 6.5% Inadvertent hypothermia is preventable. Nurses' knowledge can prevent its occurrence and consequences to patients. Nurses require ongoing training and competency evaluation and organizational support to ensure they are knowledgeable of the current guidelines.	Ongoing education, training and evaluation of the effectiveness of the training. Organization commitment to education on the causes, risk factors, consequences and strategies to prevent inadvertent hypothermia. Future research should evaluate strategies to improve nurses' knowledge. Conduct observational studies that monitor nurses' activities to prevent and manage hypothermia.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Hegarty, J., Walsh, E., Burton, A., Murphy, S., O'Gorman, F., & McPolin, G. (2009). Nurses' knowledge of inadvertent hypothermia. *AORN Journal, 89*(4), 701-713. doi://doi.org.ezproxy.bethel.edu/10.1016/j.aorn.2008.09.003 Level: III Quality: Good	To evaluate knowledge of periop nurses regarding the prevention of inadvertent periop hypothermia This study also assessed knowledge of nurses after AORN updated the guideline for prevention of unplanned hypothermia.	130 Volunteer convenience sample Irish Anesthetic and recovery nurses Assn. Annual Conference Republic of Ireland, Oct 2007	Quantitative and descriptive design	Two surveys adapted by the primary authors found through a literature review	65.7% response rate of survey 130 out of 198 in attendance Nurses were unsure of correct definitions of hypothermia and normothermia Overall staff displayed extensive knowledge in hypothermia prevention Clinical guidelines should be readily available and adopted for use in the periop environment. (AORN & ASPAN). Should have quality continuing education on normothermia to keep practitioners up to date on clinical evidence.	Associations (AORN-ASPAN) need clear guidelines to define normothermia and hypothermia AND uniformity of literature definitions of preventative measures. Development of continuing education programs to keep practitioners up to date with current best evidence Cold infusion fluids is a major risk factor. Preformulated guidelines that would prompt practitioners on the important factors of hypothermia would be helpful in the clinical area. Further research - a RCT of before survey of knowledge and survey of knowledge after education or even an observational study to monitor nurses' activities in relation to hypothermia prevention.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Kim, P., Taghon, T., Fetzer, M., & Tobias, J. D. (2013). Perioperative hypothermia in the pediatric population: A quality improvement project. *American Journal of Medical Quality, 28*(5), 400-406. doi:10.1177/1062860612473350 Level: V Quality: High	To decrease the incidence of perioperative hypothermia by 50% The authors sought to bundle the most effective techniques commonly used to prevent hypothermia.	7532 surgical pts 460 bed tertiary care center, located in Columbus, Ohio. Avg. 24,000 surgery cases/year	Retrospective evaluation of the EMR over a four-month period to determine the baseline incidence of hypothermia.	Axillary temp probe	Following the institution of the hypothermia bundle the incidence of hypothermia went from 8.9% to 4.2%, which was a sustained 53% reduction in hypothermia The highest incidence of hypothermia was in 12-18 years of age – majority of these pts had orthopedic procedures. A temperature management bundle was 53% effective in reducing hypothermia rates in all pediatric patients. Hypothermia may increase the risk of SSIs, prolong hospital stay, increase cost of care	To be concerned and vigilant with hypothermia in pediatrics Because peds pts are equally if not more susceptible as adult pts to hypothermia. Educate staff on the emphasized risk of hypothermia in pts of all ages A prompt added to the EMR to use warming devices. Warming devices placed in specific areas in the OR to increase compliance and encourage use of the temperature management bundle. Create a multidisciplinary team to create a bundle most effective techniques to prevent unplanned hypothermia.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Kurnat-Thoma, E., Roberts, M. M., & Corcoran, E. B. (2016). Perioperative heat loss prevention a feasibility trial. *AORN Journal, 104*(4), 307-319. doi:10.1016/j.aorn.2016.07.012 Level: III Quality: High	To discover if the use of a thermal protective blanket and one cotton blanket vs standard practice of warmed cotton blankets only improved the normothermia and thermal comfort throughout the periop environment.	224 patients total in a convenience sample of pts 18-70yrs of preop normothermic pts. 110 had the thermal blanket, 114 had standard cotton blankets. 187 bed Community Hospital in Washington DC – with 11 ORs	Quasi-experimental comparison study	Tympanic thermometry sensors NVAS to assess pt's comfort level.	Pts were age 18-70, with a mean age of 46.5. Primarily female -72.9% with an average surgery duration of 101.5 minutes. Use of forced air warming blankets were used on 83.9% of the participants. This was equally distributed between both groups of pts. Pt's periop temp was strongly related to the operating room's temperature. Cost of one blanket and thermal blanket vs 4 cotton blankets were the same – eliminating any cost savings as a consideration. Use of a single use item and its disposal would add additional cost to the facility and environment	It is not clear if thermal reflective blankets are more effective than standard blankets for a warming intervention. This study used active warming on all pts with surgery longer than 30 minutes. It is hard to determine if exact change of interventions would change the outcome of temperature when there are other variables such as active warming is still in use. Use of a larger sample size of homogenous surgical subpopulation in another institution for further research.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Liu, X., Shi, Y., Ren, C., Li, X., & Zhang, Z. (2017). Effect of an electric blanket plus a forced-air warming system for children with postoperative hypothermia: A randomized controlled trial. *Medicine*, *96*(26), e7389. http://doi.org/10.1097/MD.0000000000007389 Level: I Quality: High	To determine if certain rewarming techniques – the use of warm blanket, electric blanket, or electric blanket and forced air warmers are better for managing pediatric pts that are hypothermic in the PACU.	346 children age <3 that were post anesthesia & hypothermic	Prospective RCT with the pts split into three groups. Group 1: used a warmed blanket. Group 2: Warmed with electric blanket. Group 3: Warmed with both electric blanket and forced air warming.	Rectal thermometer	The combination of an electric blanket and forced air warming blanket was an effective method for rewarming of pts with post anesthesia hypothermia. The patients were very similar in age, weight, and intraoperative temperatures. Pts with the electric blanket and forced air warming had less incidence of n/v, shivering, arrhythmias compared to the other two groups.	Further multicenter prospective studies are needed to verify that this technique is effective and can attain the same outcomes. The use of active warming devices vs passive warming interventions in the PACU will rewarm pts faster.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Madrid, E. (2016). Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *Cochrane Database of Systematic Reviews,* (4) Level: I Quality: High	We reviewed the effects of warming the body by transferring heat through the skin surface to prevent complications caused by unintended low body temperature (hypothermia) in adults undergoing surgery	5438 participants- all adults over age 18 and gender 67 Randomized Controlled trials	Systematic review of RCTs	Temperature	Forced air warming applied in the pre-and intraoperative phases seem to have a beneficial effect in terms of lowering surgical site infections and complications compared to not applying any warming device. All pts use forced air warming regardless of the length of procedure. The evidence for other types of patient warming devices are scant. Some evidence suggests that extending systemic warming to the preoperative period could be more beneficial than limiting it only to during surgery.	Further studies needed to see if the same results can be duplicated. Larger studies of high quality and focused on clinically relevant outcomes. Studies need to be more blinded and incorporate cost-effectiveness and assessing the risk of medical devices.

Citation/Quality	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Morehouse, D., Williams, L., Lloyd, C., McCoy, D. S., Miller Walters, E., Guzzetta, C. E., . . . Lou Short, B. (2014). Perioperative hypothermia in NICU infants: Its occurrence and impact on infant outcomes. *Advances in Neonatal Care, 14*(3), 154-164. doi:10.1097/ANC.0000000000000004 Level: III Quality: High	Describe perioperative thermal instability of infants and identify where (OR, NICU) and when it occurs. Describe adverse and support interventions of cardiovascular respiratory, and metabolic outcomes associated with hypothermia.	A total of 108 infants admitted to the NICU – 440g to 6kg under one year of age. subsequently scheduled for an operative procedure in the OR or NICU were included in the study A mid-Atlantic regional pediatric referral center.	This was a prospective study, using a case-control design	Temperature	108 infants - 50% had a procedure in the OR, 49% in the NICU, no difference of gender or race between both groups, 40% developed hypothermia regardless of surgery location. OR pts experienced significantly higher rates of hypothermia than NICU pts, both groups experienced unacceptable rates of hypothermia. 67% stayed hypothermic in the post-op period. Hypothermic infants suffer more respiratory, cardiac, negative metabolic events than normothermic pts. Infants with OR procedures are 10 times more likely to develop hypothermia.	Pediatric institutions need to replicate this study to increase the generalizability of study findings. Consider the types of anesthetic agents, All OR pts used inhaled anesthetics and NICU pts did not use them. Inhaled anesthetics are known to cause hypothermia. Hyperthermia should be included in future studies. Warmers used in the OR for the procedure. Bair hugger used and pre-warmed IV fluids for all pts. Pt returned to warmed isolette despite open crib mode of transportation. OR/NICU room set to 75 degrees. Temp communicated on pt handoffs. Educate staff.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Park, S., Yoon, S.-H., Youn, A. M., Song, S. H., & Hwang, J. G. (2017). Heated wire humidification circuit attenuates the decrease of core temperature during general anesthesia in patients undergoing arthroscopic hip surgery. *Korean Journal of Anesthesiology*, *70*(6), 619–625. http://doi.org/10.4097/kjae.2017.70.6.619 Level: I Quality: High	The use of heating and humidifying the airway to prevent hypothermia in pts undergoing arthroscopic hip surgery.	56 pts age 20-65	RCT	Esophageal thermometer And tympanic membrane thermometer.	No statistical difference in the incidence of intraoperative hypothermia or shivering in the PACU. Both pt groups showed gradual decrease of temperature according to time in surgery.	Further studies are needed to determine if the results are the same. This method could be considered for another method to use as an intervention for patients undergoing surgery for longer than two hours. Active warming was also used in this study.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Schroeck, H., Lyden, A. K., Benedict, W. L., & Ramachandran, S. K. (2016). Time trends and predictors of abnormal postoperative body temperature in infants transported to the intensive care unit. *Anesthesiology Research and Practice, 2016*, 7318137. doi:10.1155/2016/7318137 [doi] Level: III Quality: High	1. determine the frequency of postoperative hypothermia <36°C and postoperative hyperthermia >37.5°C in all infants returning to the ICU from the OR over 9-years. 2. determine the independent factors associated with postoperative hypothermia and hyperthermia in these critically ill infants.	2350 ICU infants (aged 0– 365 days) who were transferred to the neonatal or pediatric intensive care unit immediately postoperatively between June 1, 2006, and May 31, 2014. Single institution, University of Michigan	Retrospective Retrieval of Preop & postop temperature readings, patient characteristics, and procedural factors of critically ill infants at a single institution from June 2006 until May 2014.	Temperature, (nasal, oral, oropharyngeal, esophageal, bladder, rectal, or skin)	An overall increase in normothermia rates in sick infants transferred to the ICU during the study period. Abnormal temps continued to occur with a trend towards hyperthermia in recent years. Hypothermia was more likely to occur in sicker pts with higher ASA status and less likely since 2010 when convective warming was used intraoperatively. Successful intraoperative warming was associated with post op hyperthermia. Length of surgery was not independently associated with increasing body temp, contrasts with findings from recent studies in both pediatric and adult patients. Longer surgeries may allow more time for correction/overheating.	Future research is needed to understand the implications of hyperthermia in sick neonates, may be r/t poor surgical outcomes. Prevalence of postop hyperthermia is expanding r/t the increase use of active warming measures. Recommends an analysis of hyperthermia from multiple centers to achieve adequate power. Hyper and Hypothermia were less likely following the two large scale interventions of incubators for transfer and convective warming. Vigilance in temp monitoring throughout the intraoperative period.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Tander, B., Baris, S., Karakaya, D., Ariturk, E., Rizalar, R., & Bernay, F. (2005). Risk factors influencing inadvertent hypothermia in infants and neonates during anesthesia. *Pediatric Anesthesia, 15*(7), 574-579. Level: III Quality: High	To investigate the effects of the type of surgery, pt age, OR room temp, and initial temperature on the core temp of neonates and infants during general anesthesia.	60 pts total. convenience sample 31 neonates and 29 infants – all infants under the age of 6 months.	Temps of pts in the pre-op area and at 10, 30, 60, and 90 minutes of anesthesia.	Rectal thermocouple probe	The type of surgery and temperature of the OR are the main factors for decrease of the core body temp of neonates and infants. Temp decreased at ten minutes after general anesthesia started. Major surgery (open body cavity such as thoracotomy or laparotomy was considered major surgery) was 2.66 times more likely to decrease body temp. Low operating room of less than 26 degrees C /78.8 degrees F made it 1.96 times more likely that body temp would fall. Infants had less of a decrease of temp than neonates. Neonates and infants are more susceptible to hypothermia than adults. R/T increased body surface to body weight ratio. The keratin layer of infant skin thinner than an adult leading to greater evaporative heat losses. Neonates cannot maintain their body temp during the course of anesthesia.	Repeat this study at another facility with increased number of patients of the same age group. Active warming methods were used during this study with all participants. Warm gel pads, warmed IV fluids, & irrigation fluids warmed if used. All neonates and infants should have their temp monitored during all procedures and maintain normothermic temperature with active warming devices.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Tveit, C., Belew, J., & Noble, C. (2015). Prewarming in a pediatric hospital: process improvement through interprofessional collaboration. *Journal of PeriAnesthesia Nursing, 30*(1), 33-38. doi://doi.org.ezproxy.bethel.edu/10.1016/j.jopan.2014.01.008. Level: V Quality: Good	Interprofessional QI project to promote the maintenance of normothermia through active prewarming and improve compliance with this intervention. Compliance with active warming, reuse of gowns, and parent satisfaction	200 surgical cases during one month of surgery cases Gillette Children's specialty hospital St Paul, MN	Process improvement project – QI team used the Plan, Do, Study, Act (PDSA) model as the basis of process improvement. Data from the month of trial was compared against the pre-trial data.	Paper audit compliance form to check for increased use of active warming gown prior to procedure. Survey of staff regarding issues w/Bair hugger blankets & one following study about feedback on new product Survey of parents to determine parental satisfaction	Increase of Bear Paws use went from 53.6% in December to 72.5% in January (month of trial). Positive Parent satisfaction from survey during trial. During 8 month compliance averaged 63% and never fell below 57%. Nurses compiled data/developed a formal practice change proposal for the implementation of the Bair Paws product on a permanent basis. Was approved through management. Nurses successfully introduced a new active warming method through collaboration of multiple disciplines using the PDSA method.	Interprofessional team is an effective way to make a practice change in a surgery environment. (MDA, CRNA, Pre-op RNs, OR RNs, PACU RNs) Increased compliance with ASPAN's pre-surgical warming – that pts receive 30min. of pre-warming to reduce risk of subsequent hypothermia. Use of the Plan, Do, Study, Act (PDSA) was an effective method to promote a new practice plan. This is model to accelerate improvement and change in a health care organization from the Institute of Healthcare Improvement.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Warttig, S. Campbell, G., Smith A. (2014). Interventions for treating inadvertent postoperative hypothermia. *Cochrane Database of Systematic Reviews,* (11) Level: I Quality: High	To estimate the effectiveness of treating inadvertent perioperative hypothermia through postoperative interventions to decrease heat loss and apply passive and active warming systems in adult patients who have undergone surgery.	699 participants over the age of 18 and 111 trials	RCTs or quasi-experimental design of in-terventions used during the postoperative period.	Temperature	Forced air warming, appears to offer a clinically important reduction in mean time taken to achieve normothermia (normal body temperature between 36°C and 37.5°C) in patients with postoperative hypothermia. High- quality evidence on other important clinical outcomes is lacking; it's unclear whether active warming offers other benefits and harms. High-quality evidence on other warming methods is also lacking; therefore, it is unclear whether other rewarming methods are effective in reversing postoperative hypothermia.	Overall active warming results in a shorter amount of time to reach normothermia if inadvertent hypothermia occurs. Evidence was limited overall, and reporting of outcomes other than those related to temperature was limited in the available evidence. These results are likely to be applicable to a range of surgical situations for a variety of patients - subgroup analysis was not possible due to limited evidence.

Citation	Purpose	Sample	Design	Measurement	Results & Conclusions	Recommendations
Witt, L., Dennhardt, N., Eich, C., Mader, T., Fischer, T., Bräuer, A., & ... Bosenberg, A. (2013). Prevention of intraoperative hypothermia in neonates and infants: Results of a prospective multicenter observational study with a new forced-air warming system with increased warm air flow. *Pediatric Anesthesia*, *23*(6), 469-474. doi:10.1111/pan.12169 Level: IV Quality: High	To evaluate a new forced-air warming system in neonates and infants during pediatric anesthesia. 2 nozzle forced air warming device vs conventional 1 nozzle forced air warming device.)	119 neonates and infants weighing up to 10 kg with an ASA risk score of I–V. The general inclusion criterion was anesthesia required for a surgical or diagnostic procedure. Median weight was 4.1kg and duration of procedures were 105min long. Five medical centers in Germany	Neonates and infants (body weight <10kg) enrolled in a prospective multicenter observational study	Temperature was measured in the distal esophagus, rectum or bladder.	2 nozzle warming unit was able to protect 119 neonates and infants up to 10kg in the study from perioperative hypothermia w/o any serious side effects, irrespective of the surgical procedure. 8 pts were hyperthermic and was more of a risk with increased length of procedure. Body temp had no correlation with type of surgery procedure. Conventional 1 nozzle forced-air warming devices are the most effective warming devices but are not always sufficient when used as a sole device. Combination of different warming devices are needed to maintain normothermia. This increases cost, may not have consistent use and may increase risk of thermal injuries when combining methods. 2 nozzle has increased airflow/results better distribution of heat leading to an increase in heat transfer to the infant. Possibly r/to the weight to surface area ratio. This method has may have better efficiency and performance than conventional 1 nozzle type. Failing to reduce the temperature at the right time resulted in hyperthermia. Vigilance needed in monitoring temperature throughout the perioperative period.	2 nozzle forced air warming device is effective on preventing perioperative hypothermia when used as a sole warming device to protect neonates and infants under 10kg during pediatric anesthesia. Continuous monitoring of body temperature to prevent both hypo and hyperthermia.

Citation	Purpose	Sample	Design@	Measurement	Results & Conclusions	Recommendations
Winslow, E. H., Cooper, S. K., Haws, D. M., Balluck, J. P., Jones, C. M., Morse, E. C., . . . Kelly, P. A. (2012a). Unplanned perioperative hypothermia and agreement between oral, temporal artery, and bladder temperatures in adult major surgery patients. *Journal of PeriAnesthesia Nursing, 27*(3), 165-180. doi:10.1016/j.jopan.2012.01.012 Level: III Quality: Low	To describe pre-, intra, and postoperative temps in surgical pts at risk for unplanned perioperative hypothermia Describe factors that contribute to hypothermia Identify active and passive warming methods used. Explore thermal comfort of pts Describe differences of temporal and oral temps pre-op and temporal and bladder temps post-op.	Convenience sample of 64 pts Large urban hospital in the southwest US	Prospective, descriptive study	Temporal thermometer Electric oral thermometer Bladder thermometer	Inadequate agreement between the temporal artery thermometer and bladder thermometer. No significant difference in hypothermia rates based on gender. Pts over 65 were more likely to be hypothermic Obese pts are at lower risk for hypothermia than pts with normal BMIs. OR rooms with temps at 70 degrees or higher the pts temp remained stable throughout the surgery procedure. No difference between the laparoscopic vs open abdominal procedures on temp. No significant difference with temp r/t surgery duration. Too many different warming interventions used to figure out exactly which intervention was the most effective.	Further research on temperature monitoring methods. Further research on thermal comfort and pt satisfaction. Further studies on a larger pt population. Many different warming interventions were used throughout the study. Data was only collected om the use of passive warming. Better documentation of warming interventions used. Warming interventions used was determined by the nurse taking care of the patient rather than being controlled for this study. Higher ambient room temps are a way to decrease hypothermia in the OR