Implementation of a National Practice Guideline for Maintaining a Neutral Thermal Environment in Preterm Infants at an Academic Medical Center

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Abstract

Background/Significance: Thermal management is a cornerstone of care within the neonatal population. Technology has progressed from a relatively simple incubator to one that is fully automated and designed to keep a neonate warm while maintaining a neutral thermal environment. If used correctly and to their full capacity, these advanced incubators provide improved temperature regulation to support neonatal growth and reduce morbidities.

Purpose: The purpose of this evidence-based practice initiative is to reduce variability and create standardization of the use of the servo control thermoregulation function for infants less than 32 weeks gestation.

Methods: The Iowa Model-Revised (2017) was the framework for implementing this project. The National Association of Neonatal Nurses (NANN) guideline for thermoregulation in the NICU was utilized to educate NICU RN staff regarding thermoregulation and the use of the incubator servo control mode. Chart audits of infants meeting criteria for servo mode were conducted pre and post the education sessions (Time 1 and Time 2).

Results: There was improved compliance with set temperature point from 53.3% to 86.6%. Alternative sites for probe placement were utilized by the staff to include the axilla. Documentation in the EHR improved with additional rationale added when appropriate, reflecting nurses understanding of the education provided and the incorporation of key points into their practice.

Implications for Practice: Utilizing established practice guidelines can facilitate education and optimize nursing practice.

Key Words: thermoregulation, neonatal, servocontrol, temperature control, preterm

Introduction

"There are tiny, puny infants with great vitality. Their movements are untiring and their crying lusty, for their organs are quite capable of performing their allotted functions. These infants will live, for although their weight is inferior … their sojourn in the womb was longer."
Pierre Budin, The Nursling, Professor of Obstetrics University of Paris, 1907

Thermal management is a cornerstone of care within the neonatal population. Dating back to the 1890s in Paris, France, preterm infants were first placed in incubators with set consistent circulating air temperatures to help maintain their internal body temperature. Dr. Pierre Budin, a pioneer for the neonatal field and savior for thousands of infants (Budin, 1998) based his research on his own personal clinical experience and suspicions of the role of cold stress on infant mortality, specifically for those born prematurely. Some statistics outlined in Dr. Budin's early published works give sobering recounts of early infant mortality when body temperatures directly following birth were allowed to fall markedly. From 1895-1897, 142 infants weighing less than 2000 grams were admitted to the ward with rectal temperatures of less than 32˚C. All but three of the 142 infants died, giving a truly appalling mortality rate of 98% (Budin, 1998). Of course, other causes of death for these infants were also considered, which for that time largely included syphilis and feeding issues. However, the decrease in body temperature played a principal role in their tragic, and almost certain demise. Following what Dr. Budin felt was inexcusable odds, the standard care of low birth weight and premature infants was changed to include immediately placing them in incubators to prevent chilling. Subsequently, in a group of infants with a birthweight <2000 grams mortality rate was reduced to 23%. A full 75% decrease in mortality rate was realized from the simple intervention of not allowing premature infants to become chilled following delivery: a revolutionary change for this time.

Fast forward to present day. Our understanding of thermoregulation, sources of heat loss and consequences of hypothermia are well understood and a part of standard neonatal practice.

Technology has progressed from a relatively simple incubator to one that is fully automated, humidified, double-walled, and designed to keep a neonate warm while maintaining a neutral thermal environment. If used correctly and to their full capacity these technologically advanced incubators provide for improved temperature regulation to support neonatal growth.

Background and Significance

Back in the 1890s, despite the early promising statistics previously mentioned, the use of incubators was not initially well received by the critical medical community, and they were written off as pseudo-science. Dr. Budin resorted to recruiting the help from his associate, Dr. Martin Couney, who took the task of helping premature infants to a whole new level (Columbia University, 2015). In 1896 he was able to “borrow” some premature babies from the Berlin Charity Hospital to demonstrate the usage of incubators for an exhibit at the World Exposition in Berlin. Dr. Couney remarkably kept all six of the infants alive and warm. He then took his display to New York City and created the exhibit now famously known as *The Coney Island Infantorium*. While now considered almost appalling to condone, Dr. Couney’s circus type display of tiny infants in incubators led to the survival of thousands of little lives that would have otherwise perished from the effects of cold stress (Columbia University, 2015).

Expanding from the early discoveries of *cold stress*: the exposure to cold, clamping of the umbilical cord, the stress of transitioning to extrauterine life, thermoregulation and the prevention of hypothermia continues to be an important area of study as infants at the edge of viability are now surviving. The practice of thermoregulation and keeping infants in a neutral thermal environment is an important cornerstone of care. Globally, cold stress remains a contributor to neonatal mortality and morbidity, and the potential impact on survival of delivering optimal thermal care on infant health is huge (Martin et al., 2020).

Neonates are not capable of shivering thermogenesis (the ability of generating heat by involuntary muscle contraction) so once the umbilical cord is clamped, non-shivering thermogenesis (the ability of generating heat by metabolic breakdown of brown adipose fat) is instead initiated. Therefore, a cold-exposed infant depends primarily on this chemical thermogenesis to avoid hypothermia (Martin et al., 2020). Exposure to cold induces a sympathetic surge that acts on receptors in brown fat stores, stimulating lipolysis (Polin et al., 2022). This breakdown of brown fat, predominately found in the axilla, groin, and neck produces heat from the unique and key enzyme UCP1, or thermogenin. This protein has also been referred to as the proton conductance pathway of brown adipose tissue mitochondria (Polin et al., 2022). The metabolic rate of a newborn has been observed to increase up to threefold when maximally stimulated by cold. Unlike term newborns, preterm infants have a limited thermogenic capacity due to these brown fat stores being scarce, as most brown fat production happens in the last few weeks of gestation (Martin et al., 2020).

As a result of decreased amounts of brown adipose tissue and subsequent reduction of UCP1 production, this vast increase in metabolic rate is the main consequence of cold stress on an infant, which leads to even more global body complications. When the metabolic rate of an infant is increased, the need for oxygen also increases. A two degree drop in environmental temperature can double the newborn's oxygen need, and as cold stress progresses, surfactant production also diminishes, thereby impeding lung expansion. As a result, hypoxemia will ensue, and mild respiratory distresses can soon become severe if oxygen is then being used for heat production (Perlman & Kjaer, 2016). Additionally, when the metabolic rate is increased there is then an increased consumption of glucose, resulting in hypoglycemia. As the demand of glucose surges, the body compensates for this need by converting glycogen stores to glucose, therefore quickly using up these stores and consequentially leading to hypoglycemia. An even further downstream effect is having less available glucose supply for growth and development (Perlman & Kjaer, 2016). In a premature infant with limited to no fat stores depending on gestational age, this can lead to significant cardiorespiratory compromise.

Newborns are at greater risk for hypothermia because of their large surface area to body mass ratio, decreased subcutaneous fat and greater body water content. Their immature skin leads to increased evaporative water and heat losses and poorly developed mechanisms for responding to thermal stress (Fanaroff & Fanaroff, 2019). These risks are further compounded with decreasing gestational age and lower birthweight (Martin et al., 2020). In addition, extremely low birth weight (ELBW) infants have ineffective heat production and limited capacity for heat preservation via rapid peripheral vasoconstriction (Knobel-Dail et al., 2017). Subsequently, an infant's problems and prognosis are in large part determined by its birth weight and gestational age.

Under non cold stress situations, or normothermia, neonates dedicate their energy expenditure to weight gain, body growth, basal metabolism, and towards maintaining their temperature. Therefore, they should be kept inside a closed incubator that can essentially take care of at least one of those requirements; providing an ideal ambient temperature range, defined as thermoneutrality, to then optimize the amount of energy that is devoted to growth and weight gain (Degorre et al., 2015). The incubator is designed not only to provide a heat source but to reduce heat losses from the four key mechanisms: radiation, convection, conduction and evaporation.

Immediately following birth, ELBW infants are exposed to numerous stabilization procedures, cool room temperatures, cold intravenous infusions, and procedural drapes in the first 24 hours of life. With the number of opportunities for heat loss occurring via evaporation, conduction, convection, and radiation, some newly born premature infants can reach central temperatures as low as 33˚C, with their body temperatures potentially dropping by 1-3˚C every 5 minutes (Perlman & Kjaer, 2016). In premature infants, a major vector to these four sources of heat loss is their very thin and underdeveloped skin, which increases transepidermal water loss (TEWL). TEWL is inversely correlated with gestational age so, as age increases, TWEL decreases (Knobel et al., 2013). In addition to hypothermia, this fluid loss can contribute to electrolyte derangements and dehydration (Segar, 2020). Assessing skin integrity and implementing interventions to maintain this essential barrier is an important aspect of neonatal nursing care.

The incubator devices used to maintain thermal stability in preterm infants have advanced considerably since the late 1800s, from the early devices adapted from chicken incubators to the current use of state-of-the-art technology that carefully titrates the air temperature to the individual infant (Sherman et al., 2006). Incubator design now incorporates features to reduce convective and conductive heat losses, reduce TEWL, and serve as a physical barrier from environmental noise to reduce stress and promote rest.

One specific feature of modern incubators is the servo controlled humidity and thermal regulation system. This system works by utilizing a skin temperature probe (STP) placed on the infant's skin surface with the other end connected to the incubator. The incubator has a computerized servo control that then allows the care provider to set the control point for the ideal environment temperature. Using feedback mechanisms from the STP readings, the heat output in the incubator will increase or decrease in order to achieve the temperature set point and maintain normothermia (Joseph et al., 2017). As the infant heats up or cools down in response to either outside stressors/interventions or internal physiologic factors, the bed will adjust the temperature of the circulating air to keep the infant's body temp as close to the set thermoneutral temperature as possible. Essentially, the bed is fully automated to maintain a steady thermoneutral environment (also referred to as normothermia) so the infant can utilize all of its energy towards growth and development, thus metabolic demands are minimized. Use of servo control also avoids the physiologic consequences of inadvertent hyperthermia or hypothermia.

The alternative to skin servo control mode (SSC) is the use of air temperature control mode (ATC). When using ATC mode, the care provider sets the air temperature of the incubator and manually adjusts the air temperature set point based on the infant's actual skin temperature during routine vital signs. Therefore, the bed will maintain a heat output based upon the air temperature setting, regardless of what the STP is reading from the infant (Joseph et al., 2017). This method can result in temperature fluctuations, which pull the infant away from a neutral thermal environment.

In summary, neonates are the most vulnerable population in regard to temperature control. The smallest and most premature are unable to protect themselves against fluctuations in environmental temperature. Neonatal nurses and advanced practice providers, along with state-of-the-art equipment, are the first line of defense for this population. The technology in current incubators needs to be understood by all providers and utilized fully for neonates to receive the most benefit and best chance at a consistent neutral thermal environment for optimal growth and development.

Purpose and Clinical Question

Even though a NICU may have up-to-date incubator beds with the latest thermoregulation technology, to include the servo control system, there is great variability in the utilization of these advanced incubator features specifically aimed at maintaining a thermoneutral environment. Managing a premature infant's microenvironment is challenging, and the nurse needs to have a working knowledge of thermoregulation and of the intricate capabilities of the incubator. Therefore, the clinical question that arises is how to optimize the use of the servo control function of the incubator and assure a neutral thermal environment in VLBW and ELBW infants in the NICU. *The purpose of this evidence-based practice initiative is to reduce variability and create standardization of the use of the servo control thermoregulation function built-in to the neonatal incubator, for infants less than 32 weeks gestation.*

Definition of Terms

The definition of **hypothermia** for neonates varies slightly depending on the source. According to the American Academy of Pediatrics (AAP, Ringer, 2013), hypothermia in neonates occurs when a newborn's axillary temperature drops below 36.5˚C. The National Association of Neonatal Nurses' guidelines on thermoregulation do not specifically define hypothermia but describe the **normothermic** range to be between 36.5 and 37.5 ˚C. This is considered the optimal range allowing for minimal metabolic demand and maintaining homeostasis (NANN, 2021).

The concept of an optimum thermal environment for infants, or thermoneutral zone, or **neutral thermal environment** (NTE) is defined as the range of temperature within which the infant can maintain a normal body temperature at minimal metabolic rate with use of non-evaporative (vasoconstriction, vasodilation, and/or changes in posture) processes only.

The designations: **low birth weight** (LBW), **very low birth weight** (VLBW), and **extremely low birth weight** (ELBW) are applied to all infants weighing less than 2500g, 1500g, and 1000g at birth, respectively, regardless of the length of gestation. (Fanaroff & Fanaroff, 2020,).

Skin temperature servocontrol, or servo control (SSC) is an electronic feedback system which functions as a thermostat to maintain a constant temperature at the site of a *thermistor probe* (usually on the skin over the abdomen or under the armpit) by regulating the heat output of an incubator or radiant warmer. Maintaining a constant abdominal skin temperature between 36.0 and 36.5ÁC is the simplest way to provide a "thermoneutral" environment, minimizing the number of calories needed to maintain normal body temperature and reducing the risks of cold stress or overheating (University of Iowa Stead Family Children's Hospital, 2012).

Air temperature control (ATC) is used to control the circulating air temperature within the incubator regardless of the continual skin temperature probe reading from the infant. By setting the incubator to ATC mode the incubator will maintain the heat output of the desired, set temperature. Sometimes ATC is preferred over SSC in the infrequent case where a neonate consistently requires an air temperature higher than 37˚C (University of Iowa Stead Family Children's Hospital, 2012). If the incubator is being directed to consistently keep the bed at this high temperature it will then potentially shut off when in SSC mode, therefore ATC mode is preferable for this one instance.

Conceptual Model of Evidence-Based Practice – The Iowa Model

Proposing a practice change or adoption of new guidelines involves the identification of robust evidence involving well-designed research, clinical expertise to implement the change, and a consideration of the patient needs within varying situations. This is the cornerstone of evidence-based practice (EBP). Therefore, this project will be designed and implemented using guidance from The Iowa Model Revised: Evidence-Based Practice To Promote Excellence in Health Care | University of Iowa Hospitals & Clinics, in order to bring these national guidelines to the bedside most effectively. The University of Iowa Hospitals and Clinics have a commitment to EBP, which has led to the establishment and copyright of this now internationally acclaimed model. The Iowa Model guides clinical decision-making and EBP processes from both the clinician and systems perspectives (*The Iowa Model Revised*, 2016). The model starts by identifying triggering issues or opportunities for change; both clinical and patient specific, within an institution, organization, or even broadly at a state or national level. Once recognized, it is determined if the triggering issue is a priority to change. This step is central to both the model and towards eliciting actual change, as having joint interest amongst key stakeholders, medical providers, and overall team members is imperative for change to result. Once the triggering issue is deemed significant, the next step within the Iowa model is to form a team. Ideally, this team should be comprised of individuals within the institution who have a special interest or job role specifically related to the primary issue. Them members should be individuals whom are interested or passionate in seeing this change addressed as well as members who hold authority to implement such a practice. Team members should also be diverse among the work population to include varying roles/levels/degrees of employees related to the area of change. The role of the team is then to assemble, appraise and synthesize evidence through a systematic search of the literature to determine if there is sufficient evidence to support a practice change. The next step is the heart of the model. During this step, methods for creating the actual practice change are designed and piloted. Necessary resources and constraints are considered, a protocol or guideline is developed, evaluation plan is made and data collected, methods for change are implemented with adoption encouraged and supported with re-evaluation of the data post-pilot. The fulfillment of the model is then to determine if the change was worth it and with significant enough results to then warrant widespread adoption of the new practice, thus requiring a plan for sustainment. Ongoing assessments through quality improvement will encourage and reinforce the change. The final step of the model is then to collect all the data and present the results internally to help solidify the change and then further disseminate findings through publication so future collaboration can be fostered beyond just the unit in which the change was initially founded.

Identifying Triggering Issues/Opportunities

An informal environmental scan across two semesters of practicum at an academic medical center's NICU in Central Virginia revealed that the servo function (best practice for maintaining neutral thermal environment) within the incubator and the use of the air temperature control settings were not used consistently. Thus, weaning from servo control to air control as the infant matured was variable, and an overall guideline for utilizing the servo control feature as a default was lacking. The target practice setting is highly engaged with the concepts of reducing variability and standardizing care, with the goal of improving outcome. Key stakeholders are invested in addressing this topic and integrating associated practice change. Discussions with attending physicians, neonatal nurse practitioners, and the nurse educator confirmed the need to standardize the approach and utilization of the servo control mode. Lending support for a practice change was the recent publication of a thermoregulation practice guideline by the National Association of Neonatal Nurses (NANN). This guideline provides a comprehensive, evidenced based approach to thermoregulation from the delivery room to discharge and includes the use of servocontrol and the importance of the neutral thermal environment.

Form a Team

This project took place at an academic medical center within a Neonatal Intensive Care Unit. The advanced practice providers as a group were eager for this initiative to help bring unit wide compliance up to the national standard. Additionally, physician colleagues, a nurse educator and a charge nurse were actively invested in the project implementation.

Assemble, Appraise, and Synthesize Body of Evidence

Assemble The Relevant Literature

A systematic literature review was conducted to examine the effects of the servo-controlled thermoregulation function of the infant incubator on overall weight gain, infant thermoregulation status, and mortality. Using both keywords and MeSH headings, four databases were searched: PubMed, CINAHL, Cochran, and The U.S. National Library of Medicine's Clinical Trials.

The search performed within PubMed included the keywords servo controlled and incubator combined with the Boolean operator OR, as well as the keywords thermoregulation and temperature control also combined with the Boolean operator OR. These search phrases were then combined together, further using the Boolean operator AND separated by the keyword neonatal: *(servo-controlled OR incubator) AND neonatal AND (thermoregulation OR temperature control)*. Results were limited by year with the latest article allowed being from 2010, set to include only full text articles, and be in the English language. This yielded 110 results.

For the next database a stepwise search was performed within CINAHL. Under the advanced search section, "servocontrol OR incubator" was searched as a keyword and then also included the subheading of "infant warmers." This comprised Search 1. The second search used “neonatal” as a keyword and then also included the subheadings “intensive care units, neonatal” and “intensive care, neonatal.” The third search was performed with the phrase “thermoregulation OR temperature control” as a keyword and then also included the subheadings of “body temperature regulation, core body temperature, skin temperature, body temperature.” A search was then performed using those three searches, S1, S2 and S3 with the Boolean operator AND, using the “search with AND” button within CINAHL. These results were then refined by limiting results to academic journals, publications from 2010-2021, and articles within the English language. The final total of results following these inclusion and exclusion criteria was 22 articles. Those articles were then imported into a reference management system to join the articles from PubMed waiting for further synthesis.

An advanced search within the Cochrane Library was performed using the same string from the PubMed search *(servo-controlled OR incubator) AND neonatal AND (thermoregulation OR temperature control),* resulting in 6 reviews and 92 trials. After limiting results to publications from 01/01/2010 to 01/01/2021 3 reviews and 62 trials remained. These were then also imported into Zotero for further synthesis.

The same string *(servo-controlled OR incubator) AND neonatal AND (thermoregulation OR temperature control)* was again used, this time within ClinicalTrials.gov. Filters were applied to exclude any trials that were suspended, terminated, or withdrawn and 23 total studies resulted. These studies were then saved and added to a folder within the reference management system collecting articles from all previously searched databases.

Appraisal and Synthesis

Summary of Literature

The total number of articles from all four combined databases was 225. Using Zotero, all duplicates were removed leaving 194 articles to review and further apply inclusion and exclusion criteria to. Upon review of the titles and abstracts of the 194 articles left, the collection was further narrowed down to 10 articles. The 184 articles that were removed were eliminated for the following reasons: not focused on thermoregulation for the neonate as related to the incubator and its functions specifically, not related to thermoregulation at all, trial being done on only animal subjects, and the thermoregulation topic being discussed was in relation to hypothermia and body cooling vs maintaining infant temperature on a day-to-day basis while in the NICU. Some articles were also removed because access to their full text was not available as well as a few clinical trials not yet having published results. The 10 remaining articles were retained for literature review synthesis. Figure 1 details the search process, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

Method of Literature Analysis

The levels of evidence synthesized for this review as categorized using the Johns Hopkins Nursing Evidence-based Practice Model (JHNEBP) (Vera, n.d.) ranged mostly from level I-A to level III-B with one article of level IV rating. Three different articles received the rating of level I-A (high quality) evidence and were all randomized controlled trails. Two articles were quasi-experimental studies rated with level II-A quality and four articles with descriptive or comparative study designs classified with level III A-B ratings. One article was a peer review highlighting one case-study earning it a rating level of IV, but it was kept in this literature review because of the value and detailed background knowledge it provided on the topic. One systematic review through the Cochrane Library was included after the initial literature review was conducted as it was found within one of the references for one of the ten articles during further synthesis. This systematic review received a B Level II with high quality rating as its inclusion criteria included both RCT and quasi-experimental studies. The following four themes were identified throughout the literature synthesis and noted to be central to the topic of neonatal thermoregulation, specifically as it relates to the usage of current incubator temperature control systems: the benefit of using skin servo control over air temperature control, the target temperature point at which the incubator should be programed to maintain, the ideal body location for the thermistor probe to be placed, and the method for which a manual temperature reading should be collected from an infant.

Identified Themes

Skin servo control vs. Air temp control

As previously explained in this review, incubators provide a micro-environment especially suited to infants' thermoregulatory abilities. Incubators are operated in either skin servo or air servo control modes, and these operation modes produce differing patterns of incubator and infant temperatures (Thomas, 2003). While incubator control appears straightforward, the regulation of incubator and infant temperature is complex. External thermal disruptions, such as initiation of phototherapy, produce large, sustained changes in incubator thermal environment requiring sometimes up to 3 hours to reach new equilibrium (Dollberg et al., 1995). Aside from the thermal control of the ambient room temperature, three control systems are in effect: the infant's thermoregulatory control, the incubator's set point, and the caregiver making adjustments to the incubator set point (Thomas, 2003). The ongoing interaction of these control systems is further complicated by one extremely important condition: the incubator is not a closed system. Caregiving involves opening the incubator and potentially disrupting incubator temperature. For neonates requiring sometimes as frequent as hourly interruption into their closed environment, this can dramatically impact the ability for their surrounding temperature to maintain at a steady and neutral state.

The servo control function of current state-of-the-art incubators tries to address this problem directly. By having a skin temperature probe (thermistor probe) directly adhered to the infant's body giving continual temperature reading feedback to the incubator, it is able to heat up or cool down all on its own in response to outside factors and the infant's resounding changes in temperature (Cavallin et al., 2021). If an incubator is set to air temperature control (ATC) mode, the incubator's circulating temperature is set to a certain temperature and no feedback from the infant is taken into account. As caregiver's enter the infant's environment through the portholes of the incubator and perform vital sign measurements, diaper changes, or other necessary medical interventions; warm air inevitably escapes while also ambient outside air permeates into the vulnerable neonate's space. A new feature on some incubator's called the "air curtain" provides a shield of warm air over the portholes at the push of a button to help minimize this disruption to the incubator environment (GE Healthcare, 2021) but the point remains that *any* disturbance to the internal environment of the infant's incubator *will* cause a change in temperature to which the infant now has to adjust. Under ATC mode where the air temperature remains set, the infant's temperature may drop considerably following a necessary caregiver interaction and may take the infant several hours to return to their ideal baseline body temperature (Sinclair, 2002), and that is assuming their environment is not breached again soon after. However, despite attempts to cluster care, the environment is inevitably disturbed again and often before an infant has had sufficient time to recover from the previous interaction, thus making an infant thermoregulated under ATC mode potentially never able to fully reach their desired temperature. With the incubator's readings though showing the circulating air temperature to be at its set point, a caregiver isn't necessarily aware that the infant inside the environment is still cooler. *Unless…* the servo control system is utilized. With continuous skin temperature readings occurring even during caregiver interactions, the incubator responds to said readings in real time and can adjust its air temperature up quickly the moment the infant's environment takes an insult from prolonged disruption significant enough to cause the infant's skin temp to waiver (Cavallin et al., 2021). This provides a much more adequate and consistent environmental temperature for the infant inside the incubator.

Ideal Skin Temperature Set Point for Servo Control Mode

In addition to investigating the various methods of providing an infant within an incubator a neutral thermal environment, finding the optimal body temperature to maintain that neutral environment and promote growth has long been a subject of research. In trying to standardize a guideline for incubator servo control usage it is pertinent to determine what research states to be the ideal air temperature to maintain thermoneutrality for the neonate to serve as a base setting for incubator controls. Early studies in the 1950s and 1960s determined that premature infants with a body temperature of 36˚C or greater for the first 96 hours had a greater chance of surviving (Knobel et al., 2010). More recent researchers found that abdominal temperatures of at least 36.5˚C, rather than lower temperatures closer to 36˚C , kept oxygen consumption to a minimum for preterm infants (Knobel-Dail et al., 2017).

Knobel et al., (2010) completed numerous studies within the neonatal population regarding thermoregulation and is a true pioneer for this topic with multiple published studies spanning across a decade. Their 2010 study aimed to determine the optimal temperature point at which to set the incubator's servo control. Their quasi-experimental study included a sample of 10 infants, born less than 29 weeks gestation and weighing 400-1000 grams. Heart rate and abdominal body temperature were measured at 1-minute intervals for 12 hours. Findings confirmed that hypothermia was associated with abnormal heart rates in transitional ELBW infants, and the determined set point for the incubators servo should be between 36.8˚C and 36.9˚C to optimally control body temperature.

Degorre et al., (2015) were able to determine the most sufficient mean body temperature for the incubated infant that was associated with the lowest energy costs to be 37˚C. They accomplished this through a RCT during which they compared the energy costs of providing incubated preterm infants born before 32 weeks of gestation with maintained normothermia using either the incubator bed's air temperature control (ATC) mode or servo control (SSC) mode. The rigorous study design included close to equal numbers of participants in each group (18 and 20) with similar demographics and sufficient technological methods for data collection. Their in-depth statistical analysis using a *t*-test with ANOVA and ability to quantify hypothermia and hyperthermia episodes into measurable numbers to be compared across incubator environments contributed to the study's level I-A high-quality rating using the JHNEBP scale.

Ideal Location for Skin Temperature Probe Placement

When determining the best way to utilize the infant incubator and its functions for maintaining a neutral thermal environment, the ideal site for skin temperature probe placement is necessary to delineate, and essential for optimum servo control of the temperature. While STPs have been used for decades with both radiant warmers and incubators, either on air temperature control mode or more recently servo control mode, the clinical practice guidelines have varied on information of the proper placement of STPs. The main consensus among current research is to use abdominal skin temperatures for measurement of the infant's overall temperature but with the administration of continuous tube feedings it is difficult to discern if the measurements are completely accurate or skewed by energy in the gastrointestinal tract being directed to digestion (Schafer et al., 2014).

A recent evidence-based practice brief performed by Dr. Rachel Joseph and colleagues in 2017 reviewed twenty different documents where several studies compared sites for random temperature measurement, but few addressed the ideal site for continuous monitoring. Although one Cochrane review found abdominal skin as an ideal site, the majority of the studies they reviewed with STP site comparisons did not find any difference between axillary and abdominal skin temperature measurements (Joseph et al., 2017).

Schafer et al., (2014) performed a randomized control trial with a method-comparison design to evaluate levels of agreement between variable temperature probe placement sites. Their study included 36 hemodynamically stable neonates of postnatal age 15 days or more, birth weight of 750 grams or more, and gestational ages ranging from 29.6 to 36.1 weeks. They tested whether there is a significant difference between skin sensor temperature readings between 3 locations on the neonate as well as which skin sensor locations most accurately reflected the axillary digital thermometer readings. This was a rigorous study with strong methodology including a sample size predetermined using a power analysis and strict inclusion criteria for their infant participants. The findings demonstrated that there were no statistically significant differences found between skin temperature readings obtained from skin sensor temperatures on the abdomen, flank, or axilla regions of the neonate.

Routes Used in Manual Temperature Measurement of the Neonate

In general, the most commonly used sites to record digital thermometer readings of an infant’s temperature are the skin, the axilla, and the rectum (Smith et al., 2013). The length of time it takes to obtain an accurate temperature reading via digital thermometer is not clearly defined in the literature, especially when so many different thermometers are now being used in the neonatal population. However, rapid-response thermometers provide a temperature reading in less than ten seconds (Smith et al., 2013). The difference between rectal and axillary temperatures in the newborn may be influenced by the presence or absence of brown adipose tissue (BAT). As discussed previously, BAT is found within the neck, back, abdomen, armpit, and groin. Mayfield and colleagues noted that premature infants took a shorter time to reach their axillary temperature when compared with the term infant (Mayfield et al., 1984). This could be attributed to the brown fat, which is in the axillary area thus generating heat.

Many clinicians continue to consider rectal temperature measurement as the gold standard because it closely approximates the neonate's core temperature and is not influenced by ambient temperature or age (Smith et al., 2013). However, problems with the rectal approach include trauma to the rectum as well as the potential for infection secondary to perforation with subsequent sepsis and hemorrhage. Rectal temperature measurement is contraindicated if there is bowel disease, especially necrotizing enterocolitis or trauma to the rectum.

In summary, the axillary method of temperature measurement is closely correlated with rectal temperature. It is accurate, easy to access, causes fewer disturbances to the neonate when compared with rectal, and is considered a relatively safe option (Smith et al., 2013). Furthermore, additional studies exploring skin temp probe placement, mentioned previously in this paper, also found no significant differences between skin sensor temperatures and a digital axillary temperature (Schafer et al., 2014); making the axilla temperature check during vital sign collection an appropriate measurement to assess correlation with the thermistor reading.

Discussion and Literature Review Conclusion

With some probing discussions that initiated in the early 1900s, the breadth of evidence presented in this review highlights the utmost importance of thermoregulation for the neonatal population. As already discussed at length, current incubators used to house these vulnerable infants are equipped with state-of-the-art technology, notably the servo control electronic feedback system for infant controlled autoregulation of environmental temperature. The lack of consistency regarding the use of this system within the NICU at the DNP student's practice setting triggered the clinical question central to this paper; how to optimize the use of the servo control function and assure a neutral thermal environment is provided for VLBW and ELBW infants.

Extensive literature review identified several key themes in regard to thermoregulation management for the neonatal incubator, with the most important concept being the usage of the servo control function as the gold standard of care for all infants less than 32 weeks gestation. Implementing the usage of this function requires the important discussions of where best to place the skin temperature probe, what temperature to use as a set point for the servo mode, and which route is best used for manual temperature checks in order to assure the STP is correlating. The National Association of Neonatal Nurses (NANN), a highly regarded governing body for the neonatal field, analyzed all current research on the topic and issued updated guidelines in 2021 for infant thermoregulation. They define normothermia as 36.5-37.5˚C, and as such this should be the targeted temperature immediately after birth for non-asphyxiated infants (NANN, 2021). NANN's new guidelines also conclude there is no statistically significant difference in skin temperature probe readings between axillary and abdominally placed probes, so therefore either location will be sufficient. Axillary temperatures for manual readings taken with electronic machines during vital sign checks have also been found to be the least invasive method for verifying temperature correlation between the STP placed on the infant while in the incubator and the measured core body temperature of the infant (Smith et al., 2013).

Design and Pilot the Practice Change

Based on the findings discussed above, an EBP project was designed to address the clinical question proposed in relation to current thermoregulation methods. The projected goal of the practice change was to reduce variability and standardize the use of the servo control thermoregulation function of the incubators within the NICU at an academic medical center, targeting infants born at or less than 32 weeks gestation.

The practice changes to be implemented based on the NANN guidelines included:

- Placing infants born < 32 weeks on servo control mode with the STP placed either on their abdomen, either flank, or within their axilla.
- Using the Servo control mode until the infant reaches 32 weeks of age or for at least 2 weeks if initiated after 31 weeks gestation.
- Setting incubator environmental temperature to 36.6° C under the servo control setting and therefore permitting the air temperature to adjust on its own to maintain NTE
- Recording air temperature and skin temperature (from the STP) readings into the EMR system hourly. Taking and recording manual infant axillary temperatures in the EMR every 3 or 4 hours with care times to check for correlation with STP.

Setting and Sample

The project took place in an urban academic medical center with a delivery service of approximately 2600 babies/year. The setting is home to a 40-bed, level 4 NICU (among the highest levels of care within the state of Virginia) with 32 private patient rooms, 4 double-patient rooms for multiples (twins), 2 negative pressure rooms, and an in-unit procedure room capable of most surgical procedures. The NICU also provides for developmentally appropriate care spaces within each private patient room allowing for both bedside care team members and family to comfort each infant appropriately for their gestational age. This means dim lighting, warmer ambient temperatures, large and comfortable reclining chairs for mothers to hold their infant's skin to skin even while on respiratory support, and enough space for providers to stand on either side of the infant's incubator simultaneously to provide tactile barriers and comforting touch for the infant during routine cares. The NICU also boasts a family lounge and resource center, overnight accommodations for parents within their infant's room, and a dedicated family shower area. There are approximately 110 registered nurses on staff that work primarily 12-hour shifts.

Based on the literature review, the sample of neonates targeted for this evidence-based project were those born at 32 weeks gestation or less. This population of neonates is identified as needing servo controlled thermoregulation in order to maintain a consistent neutral thermal environment.

Measures and Procedures

The Iowa EBP Model-Revised served as the cornerstone for this project, while the NANN thermoregulation guideline for practice provided the foundation for educating the NICU bedside nursing staff on best practices for managing the neonatal thermal environment. Key points of the education included importance of utilizing the servo mode on the incubator, target temperature parameters, temperature probe placement and troubleshooting challenges to maintaining in-target range. Education was provided through a multimodal approach to reach the greatest number of staff. An email was sent to all staff by the unit's educator notifying them of the upcoming in-service sessions and providing an overview of the thermoregulation topic being covered. Small group in-service sessions consisting of two to six RN's, lasting between 10 to 15 minutes, were held during both day and night shifts in the NICU in an area referred to as the "daylight zone." This spot was an enclave off a main hallway of the unit that had several chairs, a large window, and enough privacy to be conducive to learning as a small group, yet open enough that it was inviting to any staff member that passed by. A large, informative, colored poster on tri-fold material was created and used as the main teaching prop during these small group sessions. Colorful infographic handouts (see figures 6 and 7) were made with easy-to-follow steps on how to initiate and maintain a thermal neutral environment using the servo control function of the neonatal incubator. The main poster included background information about the importance of the topic, the NANN guidelines supporting it, and screenshots of the unit's current electronic health record (EHR) system showing exactly what and where measurements related to the servo control function needed to be charted. The handouts were also placed around the unit for staff to pick up and reference as well as kept in the breakroom with the poster for nurses to view and read outside of the in-service sessions.

In-person staff education via the small group in-service sessions occurred over a two-week period from April 8th to April 22nd, but the poster and handouts remained in the unit beyond this date. Each in-service session consisted of a teaching portion which referenced the key points and guidelines on the poster followed by a demonstration on how to best use the materials currently available in the unit to achieve adequate and effective adherence of the STP to the infant's skin. Proper adherence of the STP is necessary for accurate input to the incubator's temperature feedback regulation system. The education was followed by an opportunity for staff to ask questions and promoted discussion regarding current practices in the NICU.

To evaluate the effectiveness of the educational session, a Likert scale feedback evaluation of five questions regarding the participants' understanding of the servo control thermoregulation topic before and after the in-service sessions was disseminated for staff to complete and return anonymously. The evaluation discussed overall knowledge of the topic before the education and following, including both understanding and confidence on implementing the new guidelines set forth by NANN. The evaluation contained five questions with answers ranging from the lowest measurement of 1 "unfamiliar/unlikely/not confident" to the highest of 5 "very familiar/very likely/very confident."

In appreciation of their attendance, small takeaway items were available for the staff attending the in-service to hold on to as educational reminders. These included miniature sharpie markers for them to hang from their badges with the servo control settings printed on them for easy reference, and various edible treats that were either hot/spicy or cold/minty to match the theme of the thermoregulation discussion.

Following the educational sessions, small laminated 'reminder' placards were also created with the pertinent information needed for the servo control settings of the infant incubator and were placed near the bedside within each patient room of the NICU. In addition, a poster was created with the pertinent information and placed in the staff lounge to reinforce the education but also to reach staff that were unable to attend the educational sessions.

Data Collection and Analysis

Following the staff education, data was collected by auditing the charts of neonates who fit the criteria (gestational age ≤ 32 weeks) for needing servo control thermoregulation within the infant incubator. Two different time periods were evaluated, which will be referred to as Time 1 and Time 2.

Any infant meeting the servo control criteria prior to the in-service educational sessions was recorded in Time 1. The unit was uncharacteristically low in census for the months of February and March, and there were not many neonates requiring servo control during this period. Therefore, to have enough data to support findings, charts were audited back to December of 2021. Of all the infants admitted to the NICU from December 31st, 2021 up until teaching began on April 8th, 2022, five infants were eligible for servo control. Time 2 consisted of all neonates in the NICU eligible for servo control but admitted after the education and implementation had begun. Seven babies starting from April 10th, 2022 through May 3rd, 2022 were admitted and fit the criterion. For all the infants in the Time 1 and Time 2 categories, charts were audited for how the temperature points were documented and managed. Since all the babies across both Time 1 and Time 2 data were at different points in their NICU stay (some born before data was collected and some during) the frequency of vital sign collection and charting of patient data was variable. To be consistent for this chart audit, all points analyzed were taken from the first set of vital signs obtained at the beginning of each nurse's shift over the course of 24 days.

All medical record data was maintained and kept in a locked office in the NICU. Patient medical record numbers (MRN) were recorded on a physical piece of paper and given a corresponding color. This color was then used in an excel spreadsheet to differentiate the data between infants. The spreadsheet was stored on a secure server provided by the University of Virginia. The same data points were audited and documented within the spreadsheet for the infants in both groups, to include:

- The infant's current gestational age at that moment in time of chart audit
- What the skin temperature probe on the infant was reading

- Where the skin temperature probe was located on the infant
- The set temperature of the incubator
- The air temperature of the incubator
- The frequency of charting the temperatures of the incubator and infant (hourly or every 3-4 hours when care time performed)

This data reflects the information provided during the educational sessions. Comparing the measurements from Time 1 to Time 2 provide information about the educational session's effectiveness in reinforcing or optimizing practices to meet the current NANN guidelines. The goal of 95% compliance was set as a target measure for the nursing staff in execution of servo mode with infants in the optimal neutral thermal environment, using the parameters set forth in the NANN guidelines.

Data from the chart audits was then categorized into variable columns within the statistical software platform for data analysis, SPSS® version: 28.0.1.1 (14). Using SPSS®, descriptive and inferential statistics were computed, and comparisons from Time 1 to Time 2 were easily highlighted from the measured data. The data from the completed Likert scale feedback evaluations were recorded into an Excel® spreadsheet for further analysis. Multiple consultations with a statistician from UVA's School of Nursing provided appreciated guidance and assistance with data analysis.

The Iowa Model-Revised highlights vital points of consideration throughout the flow diagram for designing and developing a practice change. Each of these points promote and encourage reflection on the current process while it's being implemented and allow for reassessment and changes to be made, if needed, before moving forward. After a few in-service education sessions occurred, it was clear that one of the newly encouraged thermoregulation tasks, charting infant skin temperatures and incubator air temperatures *hourly*, was felt to be impractical for the nursing staff to execute. The issue was discussed with the nursing staff attending the in-service sessions and, a new goal was developed that was felt to be more attainable. Nurses agreed to take visual note hourly of the infant's servo skin and air temperatures. *IF* they noticed a trend of increasing, decreasing, or generally unstable/labile temperatures, they would then record those numbers hourly in the patient's EMR for reference when discussing medical interventions with other care providers.

Results

Eight 15-minute in-services were conducted during the day and night shifts. Of the 109 RN staff members in the NICU, 52 RNs attended the in-services resulting in 48% of the staff directly educated. The remaining nurses were able to read the information poster used during the in-service sessions, as it was left set up within the unit. All handouts provided during the educational sessions were also disseminated throughout the unit for staff. An email from the unit nurse educator was also sent to all staff with a document summarizing the key points of the education.

Of the 52 nurses who attended the live in-service sessions, 47 returned the evaluations resulting in a 90% return rate. Figure 3 depicts the results of the evaluations. 32% of RNs indicated that before the in-service session they were not familiar at all with the term Neutral Thermal Environment and only 23% were slightly familiar. 40% of all RNs noted themselves to be extremely familiar with the Servo mode function of the incubator, 26% were only moderately familiar, 17% slightly familiar, and 17% not familiar at all. Prior to the education session 43% of RNs said they were not at all likely to place the temperature probe in the axilla and 28% were slightly likely. When asked how confident they were following the in-service teaching session in using the Servo mode function properly 89% said extremely confident, and 9% moderately confident. Most importantly, 96% of RNs felt extremely confident that the teaching session provided new information and met their learning needs.

Four main points were addressed during the education sessions; (1) the set temperature of the infant incubator, (2) location the temperature probe could be placed on the infant's body, (3) the initiation and maintenance of servo control mode for all infants at or less than 32 weeks gestation, and (4) the proper documentation within the EHR system. The results of the data collected indicates the understanding of the education provided and overall compliance with implementing these four points.

When looking at Time 1 data, (infants cared for before education was provided), the set temperature for the incubator was correctly set within the range the NANN guidelines recommend (36.5 ˚C to 37.5 ˚C) only 53.3% of the time (See Figure 4). Time 2 data conversely shows that 86.6% of the time, the incubator set temperature was correct. This reflects a 33.3% increase in accurate set temperature ranges following education. Any set point recorded below 36.5 ˚C was considered not in compliance. Of all the data points in Time 2, 13% of the set temperatures documented were below 36.5 ˚C and thus considered not in compliance. However, 50% of those temperatures were actually correct for the patient at that point in time. While the range of 36.5 ˚C to 37.5˚C is determined to be the best range to set the incubator while using the servo control mode, each individual infant's own medical course and overall weight/growth in relation to their gestational age has to be taken into consideration. Thus, given these unique cases, the overall compliance of temperature documentation in Time 2 was 93.1%.

Time 1 data showed that with respect to where the probe was placed on the infant's body, 100% of the time the audited charting occurred with a probe location of the abdomen (Figure 5).

The educational sessions provided to the nurses discussed how recent research determined that the temp probe can also be placed in the infant's axilla with equal confidence in its readings. In stark contrast, Time 2 data shows 80% of audited infant charts with a temp probe placement documented in the axilla with the remaining 20% having no location documented. This reflects a complete change from using the abdomen as a probe placement site, to not using it at all once learning the axilla was an equally viable option as well as an opportunity to enhance documentation.

Regarding compliance with the third point, maintained servo control for all infants ≤ 32 weeks, data indicates this was 100% met for the audit period. Incubator set temperatures and air temperatures were consistently being documented and all infants were maintained in servo control.

The final measurable point for compliance was that of proper documentation. It was originally proposed that nursing staff chart bed set temperatures and skin temperature readings hourly. Through the reassessment process built into the Iowa Model-Revised and used for this EBP project's framework, this point was modified. For the new parameters, data from Time 2 indicated the nurses were consistently charting the set and skin temperatures and either charting additional temperatures when necessary or providing a rationale for a change in set temperature from a previous care time with the patient.

Discussion

Of the existing frameworks for instituting EBP, the Iowa Model-Revised served this project best in its effort to update current bedside practice within an academic NICU to align with newly published guidelines on neonatal thermoregulation. The ultimate objective of this EBP initiative was to standardize utilization of the servo control mode function of the neonatal incubator to provide an environment for the growing preterm infant that was consistently temperature neutral, thus allowing for optimal growth (NANN, 2021).

One of the key points of the education provided to the nursing staff was, when using the servo control mode function of the infant incubator, the ideal set temperature point for the optimal neutral thermal environment is at least 36.5˚C, preferably 36.6 ˚C (Degorre et al., 2015; NANN, 2021). There will inevitably be a few infants that require a little more than this range as their set temperature as well as those that require a little less to achieve the optimal neutral thermal environment for growth. This point was discussed within each teaching session, and clinical judgement was encouraged for the nursing staff to understand when it would be appropriate to adjust the set temperature of the incubator to better meet an infant's needs. They were asked to then add a comment in the EHR whenever there was a need to alter the set temperature point from the baseline range of 36.5˚C to 37.5 ˚C. These differences in set temperature with appropriate documentation are therefore not considered incorrect and reflect accurate nursing judgement. In addition, this reflects the nurses understanding of the education provided and the incorporation of key points into their practice.

One of the biggest anchors to successful implementation of these new thermoregulation guidelines was the effectiveness of the adhesive covers used to affix the temperature probe from the incubator to the neonate's body. The Giraffe Omnibed (GE Healthcare, 2021) incubators utilized in the NICU of interest for this project used the disposable temperature probe covers manufactured by the same company as the incubator. These 'standard' covers are a sticky piece of foam with reflective backing on the non-adhesive side that protects the probe from potential erroneous readings from the radiant heat source. Throughout the educational sessions, many nurses voiced how these particular covers were suboptimal, at best, and rarely remained stuck to the infant for more than 1-2 hours following application. With the probe cover continually coming loose, the temperature probe would then often be found detached from the infant. This causes faulty temperature feedback from the probe to the incubator and results in the incubator becoming too warm or even too cold. Nurses described using a lower set temperature to compensate for the potential problem of the probe coming detached and the incubator ineffectively maintaining the infant's temperature. Upon closer investigation of the problem, it was discovered that in addition to the probe cover not being very effective, the probe covers had been on back order and were not available in the unit. Therefore, nursing staff were having to create their own ways of getting the temperature probe to adhere to the baby. Multiple different types of adhesive tapes were employed with little success. Not having the correct probe covers greatly impacted the ability of the nursing staff to utilize servo mode effectively and accounted for many of the set temperature points in Time 1 not being at the standard 36.6 ˚C.

Identifying the challenge associated with the temperature probe cover led to working with key individuals in the NICU to obtain the standard stock probe covers and investigate alternative products. A drawback to the standard stock product was its lack of adhesiveness. Newer probes are now made using a hydrogel layer for the adhesive and a mylar layer to insulate the probe from the radiant heat. These hydrogel covers were recommended to replace the current standard stock foam cover.

The Likert scale feedback evaluation given to the nursing staff that attended the in-service sessions provided insight into the session's effectiveness. Several evaluations were returned with comments attached such as, "this was super helpful" and "having better guidelines for managing incubator temperatures has been needed for a while now." After several weeks had passed from the completion of all teaching sessions a few low-key visits were made to the NICU to follow-up on how the nursing staff felt things were going. Many were appreciative, not just for the teaching of new information, but also for the time taken to help troubleshoot how to get the temperature probes to remain adhered to the infants with the materials that were currently available to them. Following completion of the project the unit was able to procure the original standard foam probe covers that had been out of stock. In addition, the new gel probe covers had officially been ordered.

Another factor that was uncovered through candid discussions during the education sessions had to do with documentation in the EHR. The hospital had recently transitioned to a new EHR system. The nursing staff was struggling with documentation and found it difficult to actually locate the appropriate section within the EHR system for documenting the incubator and infant temperature settings. In total, four different measurements were needed to be charted: the set temperature of the incubator, the reading of the skin temperature probe placed on the infant, the air temperature of the incubator, and the location on the infant's body where the STP was placed. Charting required multiple clicks through folders and the results were not readily visible to the providers. Since thermoregulation is a cornerstone of care for premature infants, the documentation for these variables should be populated right by the easily accessible vital signs section within the EHR system. Fortunately, there were technical representatives from the EHR company available to help the staff during the transition period. The charting problem was pointed out to the EHR representatives and with upcoming system updates the temperature documentation will be amended and populated with the vital signs. This is viewed as a positive system improvement and an indirect benefit of this project.

Strengths and Limitations

Perhaps the most impactful part of this EBP initiative was using newly published guidelines (2021) by the National Association of Neonatal Nurses (NANN) to validate the necessity to update and standardize this part of neonatal care. While the literature search performed for this project was extensive and yielded support for the importance of an optimal neutral thermal environment for the growing neonate, the NANN guideline summarizes the evidence and provides clear support for the recommended practices.

As with all clinical practice changes, a key component to success is having buy-in from unit leaders who are responsible for evaluating, implementing, and reinforcing a change in practice. This project had significant support from the unit's neonatal nurse practitioners, several of the neonatologists, unit nurse educator, and many of the RN staff. A seasoned charge nurse and educator served as a mentor and facilitator for implementing this practice change and was pivotal in helping create buy-in from the nurses. She assisted in spreading the word about the in-service sessions, helped encourage attendance and participation, and provided me with constructive feedback.

Many of the nurses voiced confusion over the servo control mode settings and welcomed the educational sessions. There was appreciation for the development of a standard they could reference. Most all the nurses verbalized frustration with not having the temperature probe covers they needed. A strength of this project is having identified barriers to practice and subsequently helping find solutions for the challenges with documentation and with obtaining temperature probe covers.

Now operating in a post-pandemic universe, this practice setting was not immune to the shifting of staff and increase in number of travel nurses. This, however, proved to be a strength for the specifics of this practice change as many of the travel nurses who attended the in-service sessions provided encouragement to the rest of the staff and supported the changes.

The lack of supplies such as the temperature probe cover, highlights the ongoing supply chain issues in many hospitals. While investigating the shortage of probe covers it was discovered that part of the issue was a lack of communication between the staff and the individuals responsible for reordering supplies. Frequent supply shortages have led the staff to assume whenever a product isn't available it is "on back order." Therefore, diminishing supplies were not identified as needing to be reordered per usual. A new system has since been created for keeping track of supplies and when items are needing to be reordered. Having an EBP project proliferate further practice changes in other areas is certainly a strength and positive outcome.

Implementing a new guideline and proposing a change in practice can be a challenging prospect, especially if the unit leaders are not aware a guideline doesn't already exist. Effectively articulating what needed to be implemented and the rationale was also challenging. Through meaningful conversation, sharing of literature review findings along with the newly published NANN guidelines and the physical search through current unit policies and procedures, the unit leadership ultimately recognized the need to move forward, and full support was given to the project.

Obtaining buy-in and support from key leaders in addition to the unit being overwhelmed with a change in the electronic health record (EHR) slowed the progress of the project. The staff needed time to learn an entirely different way of charting and as a result, implementation of the project was delayed. Being familiar with the new EHR, I was able to provide some support to the staff in regard to charting temperatures, however, this delay in implementation impacted the chart audits. Data analysis and chart auditing took place over a period of three weeks, which was not sufficient time to follow the infants until they aged out of the servo mode function. Therefore, data couldn't unequivocally say that all infants were correctly maintained on servo mode for this entire length of time. However, with all infants in Time 2 being kept on servo mode for the duration of data collection, it is likely they were continued in that manner until reaching appropriate age to transition to a lesser mode of thermoregulatory support.

Integrate and Sustain Practice Change

Given the recent publication of thermoregulation guidelines set forth by the respected NANN organization, it is conceivable that the changes implemented through this EBP initiative will continue to occur and be supported as this is considered the standard of care.

Implications for Practice

The NICU highlighted in this practice change is a highly rated and long-standing pillar for neonatal care in its region. They are continually looking towards advancement and for ways to provide the best evidence-based care possible for arguably the most vulnerable population. It has been a goal of theirs for some time now to build a "small baby team" within their unit like other NICUs have done. This would mean creating new policies and procedures that provide specifically for infants born at the edge of viability (22-23 weeks). A key requirement for getting this type of program to succeed effectively is the understanding and management of thermoregulation. Neonatal medicine and its providers worldwide recognize a foundational component to a premature infant's survival being that of consistent and effective temperature control (Philip, 2005). Having a unit of nurses and providers that have become well-versed in the use of the incubator's servo control function will lay the groundwork for the beginnings of this small baby team.

Sustainability Plan

Not only was this EBP initiative fortunate to have a practice mentor to help press forward, a neonatal nurse practitioner within the unit, developed a vested interest in the project's success and expresses desire to help see it through to completion. The new hydrogel-based temperature probe covers that were approved and ordered following the results of this project remain in process and this NNP will follow up to assure they arrive as expected and are then utilized correctly. Fortunately, a few of these products were procured for demonstration purposes during the in-service teaching sessions and many nurses got the chance to see and feel them, but physically putting them to use will require support. Whenever a new product is brought into the NICU environment it is important to monitor its use and obtain feedback from staff. The unit educator and invested NNP agreed to be "champions" of this project and will help with educating the nurses on effective use of the new probe covers.

The work of this project is only a portion of the thermoregulation guideline. The NICU policy and procedure committee will be incorporating the NANN recommendations into a unit-based guideline and utilize the review of literature from this project. The thermoregulation "champion" has met with the committee members to reinforce the key points of this project thus solidifying the changes brought forward.

Conclusion

This evidence-based practice initiative utilized the Iowa Model-Revised as framework for implementing a clinical practice change to standardize the way incubator servo control thermoregulation was utilized within an academic medical center NICU. Thermoregulation remains a cornerstone of care for the neonatal population with direct effect on patient survival and overall outcomes, including growth trajectory and length of NICU stay. (Degorre et al., 2015). The National Association of Neonatal Nurses (NANN) published guidelines in 2021 highlighting the key points for maintaining a neutral thermal environment for premature infants. A practice change was developed to bring an already established NICU up to par with regard to meeting these guidelines. Utilizing the technology available within current neonatal incubators to not only maintain an infant's environment and body temperature but to track and trend thermoregulatory output data is important for assessing an infant's overall health and physiology stability. Having a greater understanding of what the incubator and interfacing skin temperature probe readings are saying for a given patient coupled with overall clinical judgement from the bedside nurse is pivotal for providing the best standard of care for this vulnerable neonatal population.

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Figure 1: PRISMA Flow Diagram

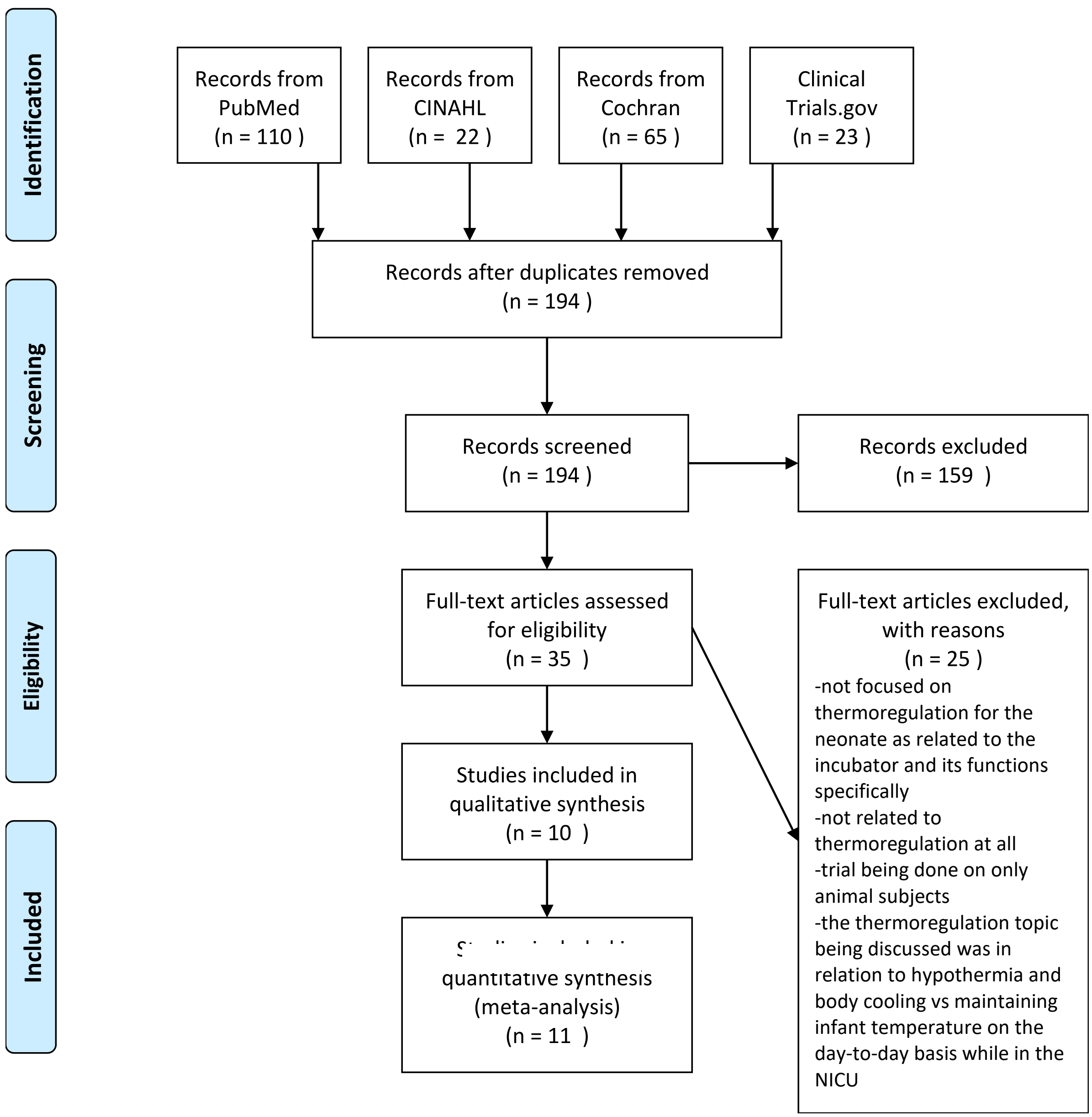

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the systematic literature search process. CINAHL = Cumulative Index to Nursing and Allied Health Literature.

Figure 2: The Iowa Model

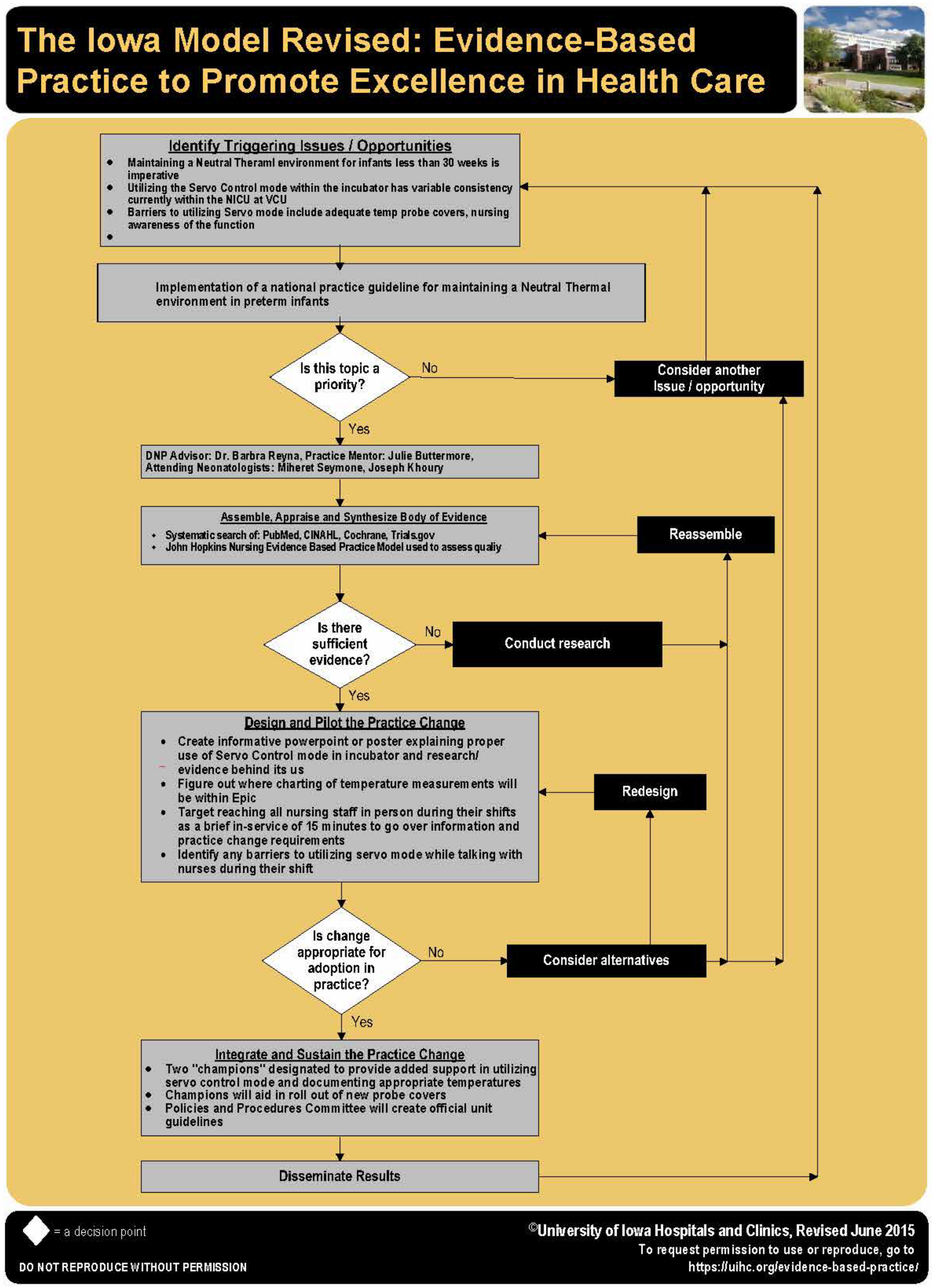

Figure 2. The Iowa Model, Revised. Used for the Promotion and Implementation of Evidenced-Based Practice

Figure 3: Staff In-Service Evaluation Results

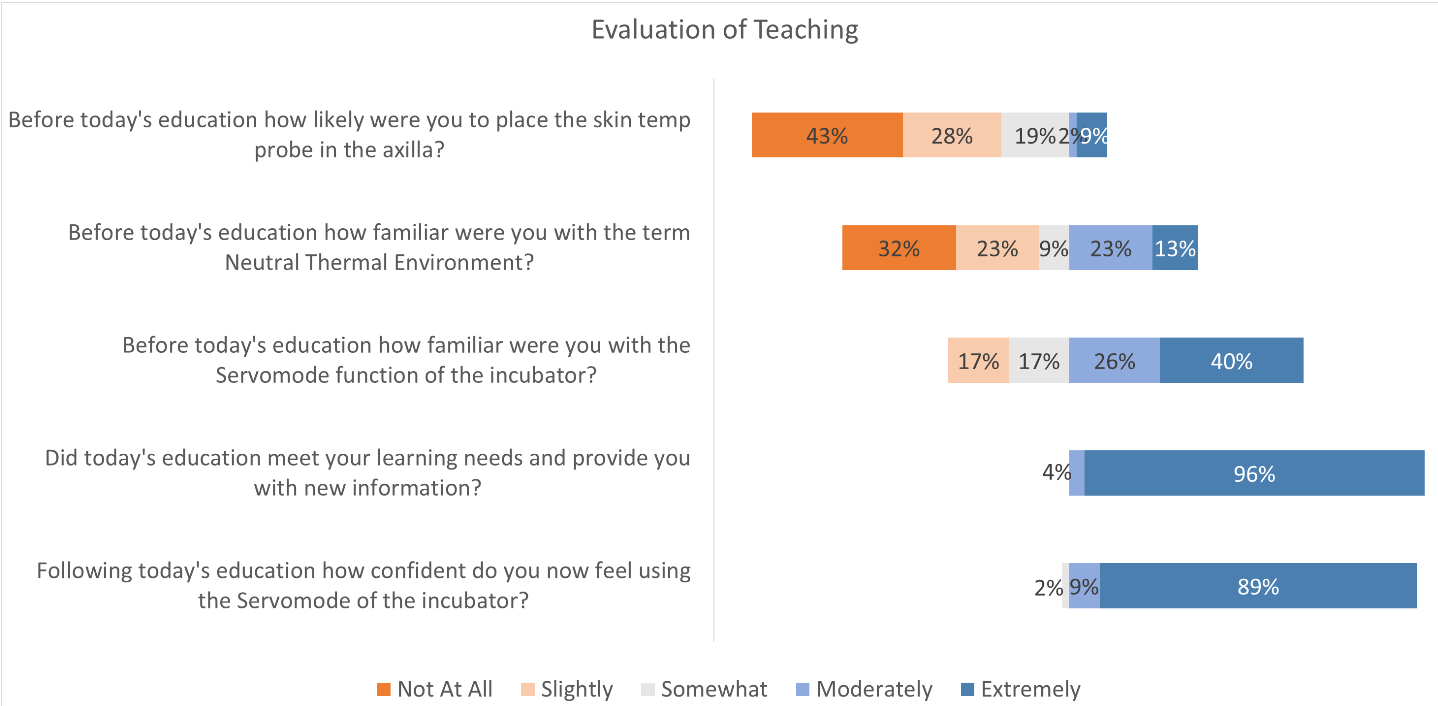

Figure 3. Results of the anonymous evaluation completed by nursing staff following in-service teaching sessions.

Figure 4: Incubator Set Temperatures from Time 1 and Time 2

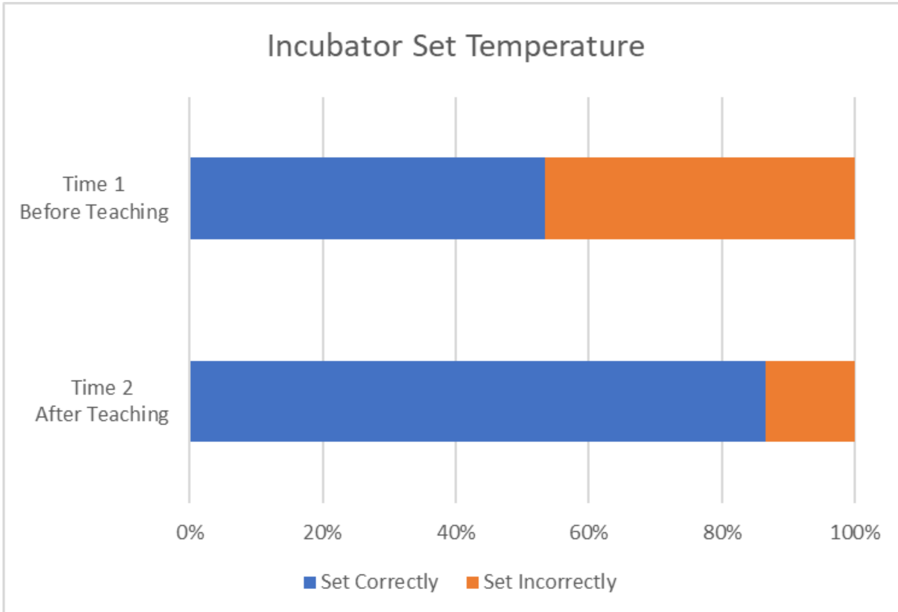

Figure 4. Incubator set temperatures from patient charting before receiving in-service teaching session (Time 1) and after in-service teaching (Time 2).

Figure 5: Location of Temperature Probe

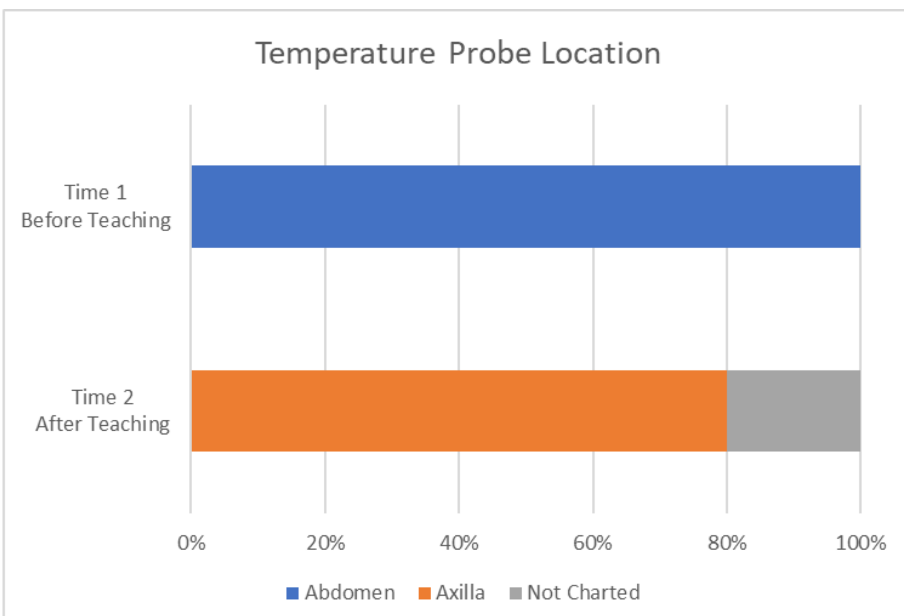

Figure 5. Location of temperature probe placement on infant before receiving in-service teaching session (Time 1) and after in-service teaching (Time 2).

Figure 6: Servo Control vs Air Control Infographic

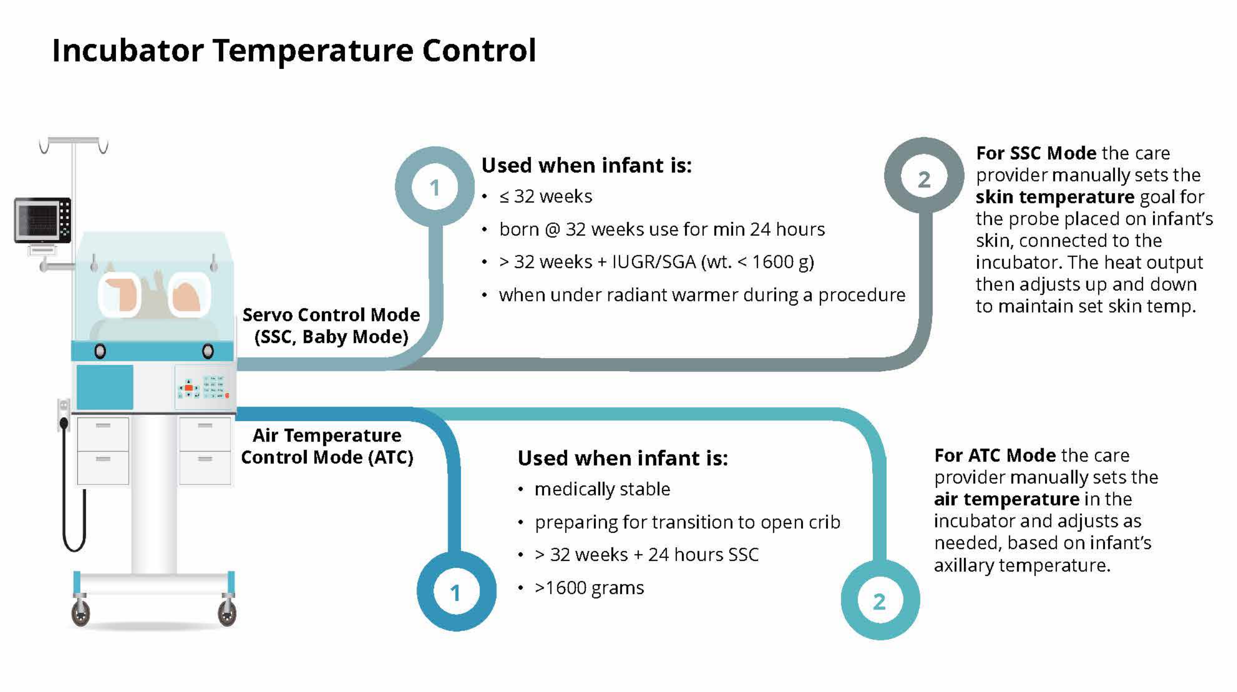

Figure 6. Infographic distributed during educational sessions and to all staff of the NICU.

Figure 7: Servo Control Infographic

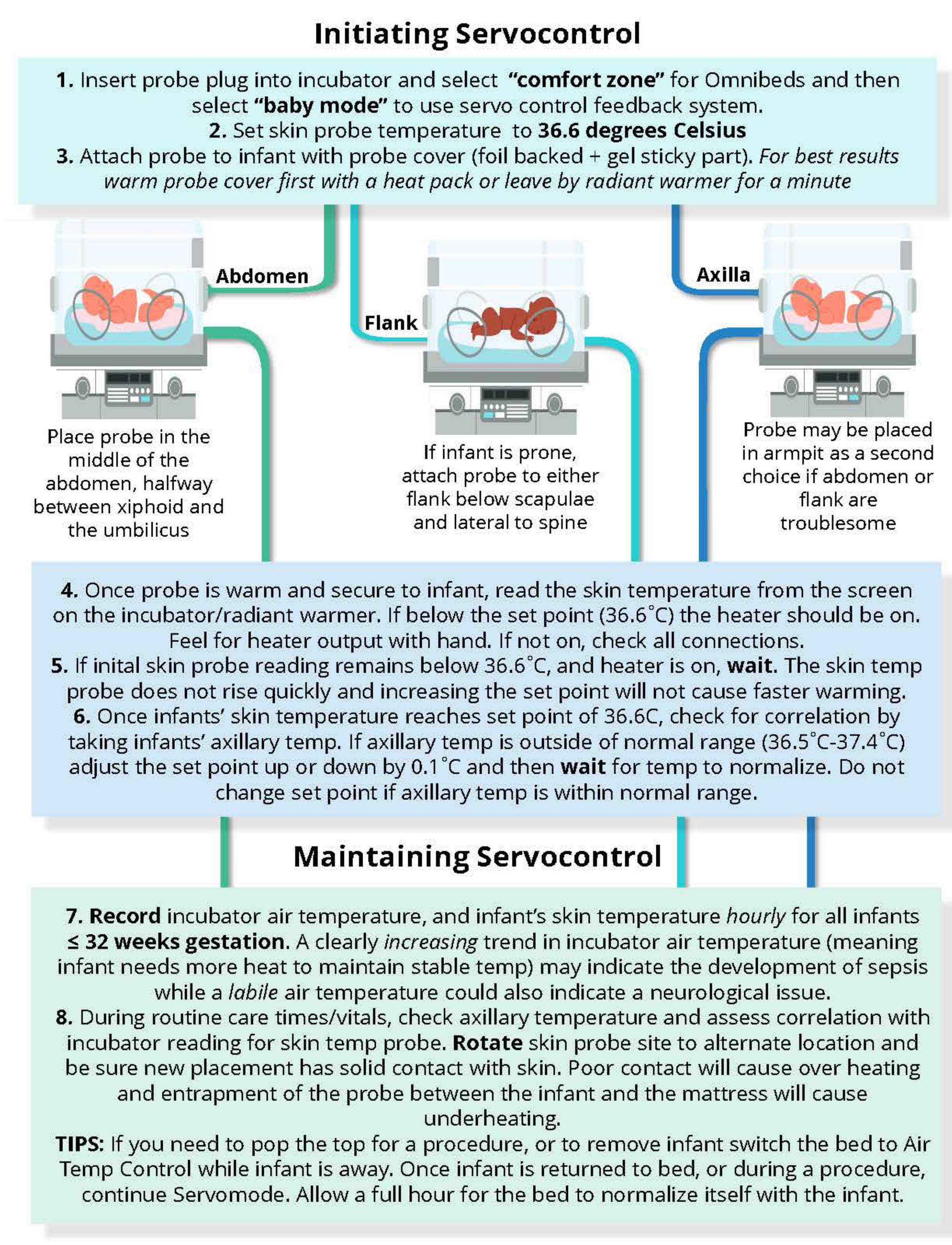

Figure 7. Infographic detailing Servo Control Management. Distributed to all RN staff.

IMPLEMENTATION OF A NATIONAL PRACTICE GUIDELINE FOR MAINTAINING A NEUTRAL THERMAL ENVIRONMENT IN PRETERM INFANTS AT AN ACADEMIC MEDICAL CENTER

Melanie Wallace MSN, RNC, NNP-BC

DNP Proposal Project

Advisor: Dr. Barbara Reyna PhD, RN, NNP-BC
Second Reader: Dr. Beth Quatrara DNP, RN, CMSRN, ACNS-BC
Practice Mentors: Lisa Shaver MS, RNC & Julie Buttermore MSN, RNC
Unit Champion for project sustainability: Emily Ott MSN, NNP-BC
Supporting Unit Neonatologist: Dr. Joseph Khoury MD

Contents

BACKGROUND

BACKGROUND: 1890S

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BACKGROUND: NEONATAL THERMOREGULATION

- Neonates depend on **non-shivering thermogenesis** to avoid hypothermia
- Large body surface area
- Decreased subcutaneous fat and greater water content
- **Metabolic rate vastly increased when cold stressed**
  - ↑ demand for oxygen → hypoxemia and mild respiratory distress
  - ↑ glucose consumption → hypoglycemia

SIGNIFICANCE

SIGNIFICANCE

- Under non cold stress situations (normothermia) neonates dedicate their energy expenditure to:
  - Weight gain
  - Body growth
  - Basal metabolism
  - Maintaining temperature

therefore

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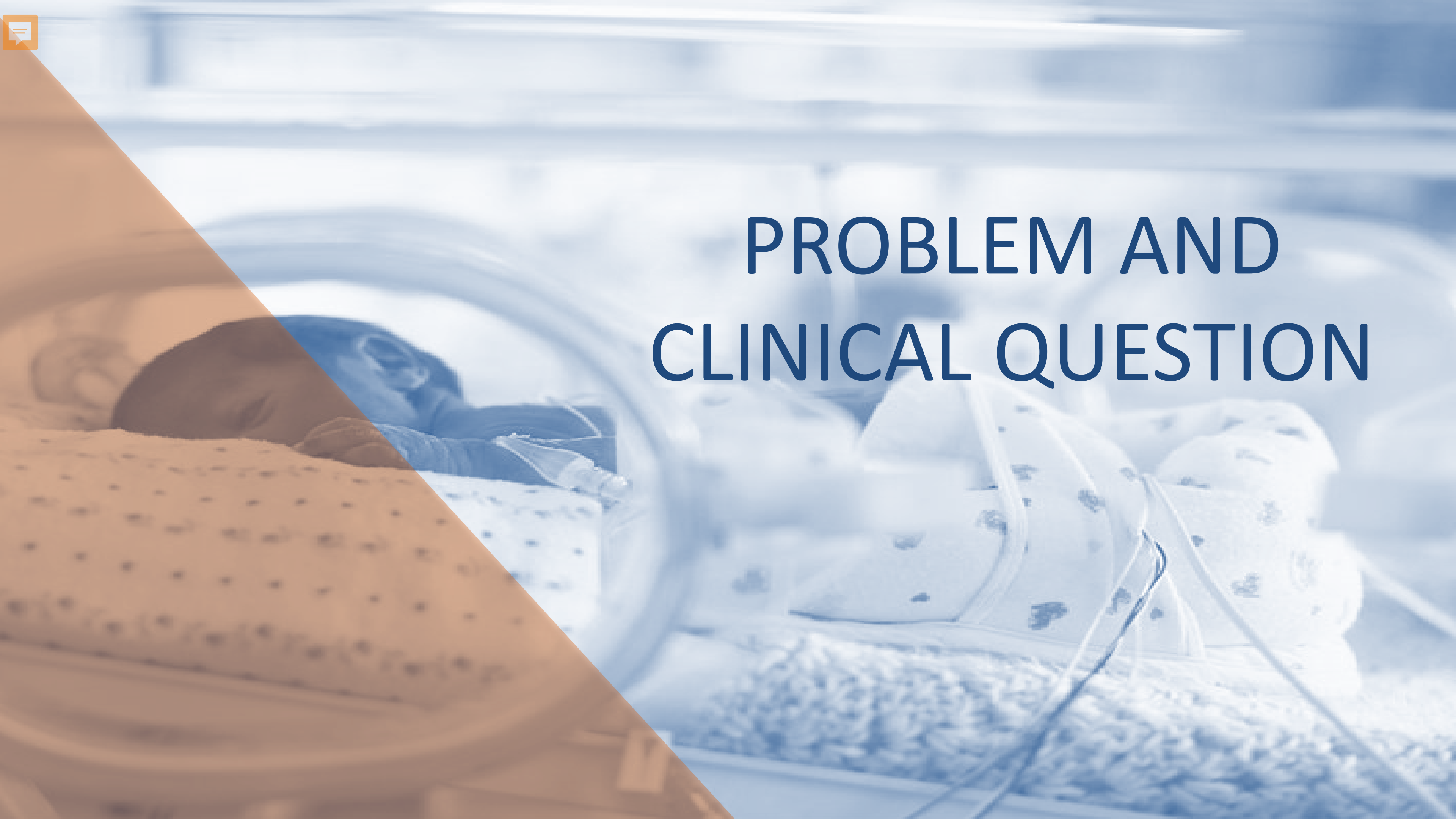
SIGNIFICANCE

- The infant incubator is designed to:
  - Provide a heat source
  - Reduce heat losses from → **radiation, convection, conduction, & evaporation**
- One feature of modern incubators is the ***servo control*** thermal regulation system
  - Specifically aimed at maintaining a neutral thermal environment
  - Requires the RN to have a working knowledge of thermoregulation and understand the intricate capabilities of the incubator


36.8
33.0
37.0
141
95

PROBLEM AND CLINICAL QUESTION



PROBLEM

- A level IV NICU within an Academic Medical Center in Central Virginia currently has up-to-date incubator beds with the latest thermoregulation technology

  → **great variability in the utilization of servo control mode**

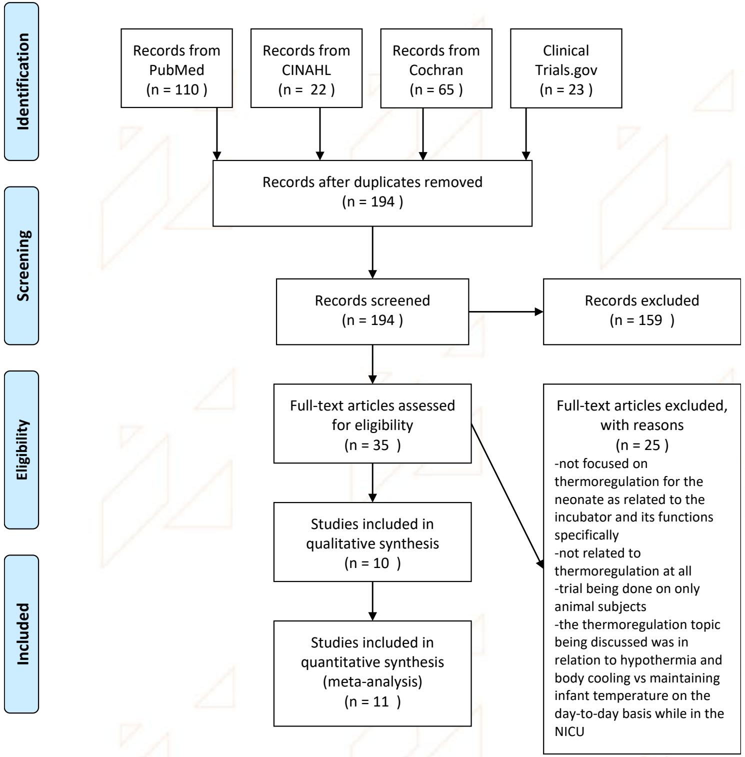
CLINICAL QUESTION AND PURPOSE

How can the use of the servo control function of the infant incubator be optimized and assure a neutral thermal environment in VLBW and ELBW infants within the NICU?

The purpose of this evidence-based practice initiative is to reduce variability and create standardization of the usage of the servo control thermoregulation function for infants less than 32 weeks gestation

REVIEW OF THE LITERATURE

LITERATURE REVIEW FLOW CHART (PRISMA)



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REVIEW OF LITERATURE FINDINGS

- Several reoccurring and **important themes** identified:
  - Skin servo control vs Air temp control
  - Ideal temperature set point for servo control mode
  - Ideal location for skin temperature probe placement
  - Routes used in manual temperature measurement of the neonate
- **NANN**: National Association of Neonatal Nurses → 2021 published "Thermoregulation in the Care of Infants Guideline for Practice"

METHODS AND EBP FRAMEWORK

Identify Triggering Issues/Opportunities

Is this topic a priority?

Assemble, Appraise, and Synthesize Body of Evidence

Is there sufficient evidence?

Design and Pilot the Practice Change

Is change appropriate for adoption in practice?

Integrate and Sustain the Practice Change

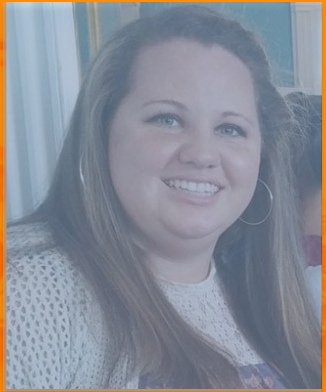
PRACTICE SETTING

- Urban Academic Medical Center with delivery service of approx. 2600 babies/year
- 40-bed level IV NICU
- 32 private patient rooms, 4 double-patient rooms for multiples (twins)
- 2 negative pressure rooms
- In unit procedure suite capable of most surgical procedures and ECMO cannulation
- Family lounge, resource center, and overnight accommodations for parents
- Approx. 110 RN staff working primarily 12 hour shifts

FORM A TEAM

Julie Buttermore
MSN, RNC

Lisa Shaver
MS, RNC



Emily Ott
NNP-BC, RNC

Dr. Joseph Khoury
MD, Neonatology

Dr. Barbara Reyna
PhD, RNC, NNP-BC

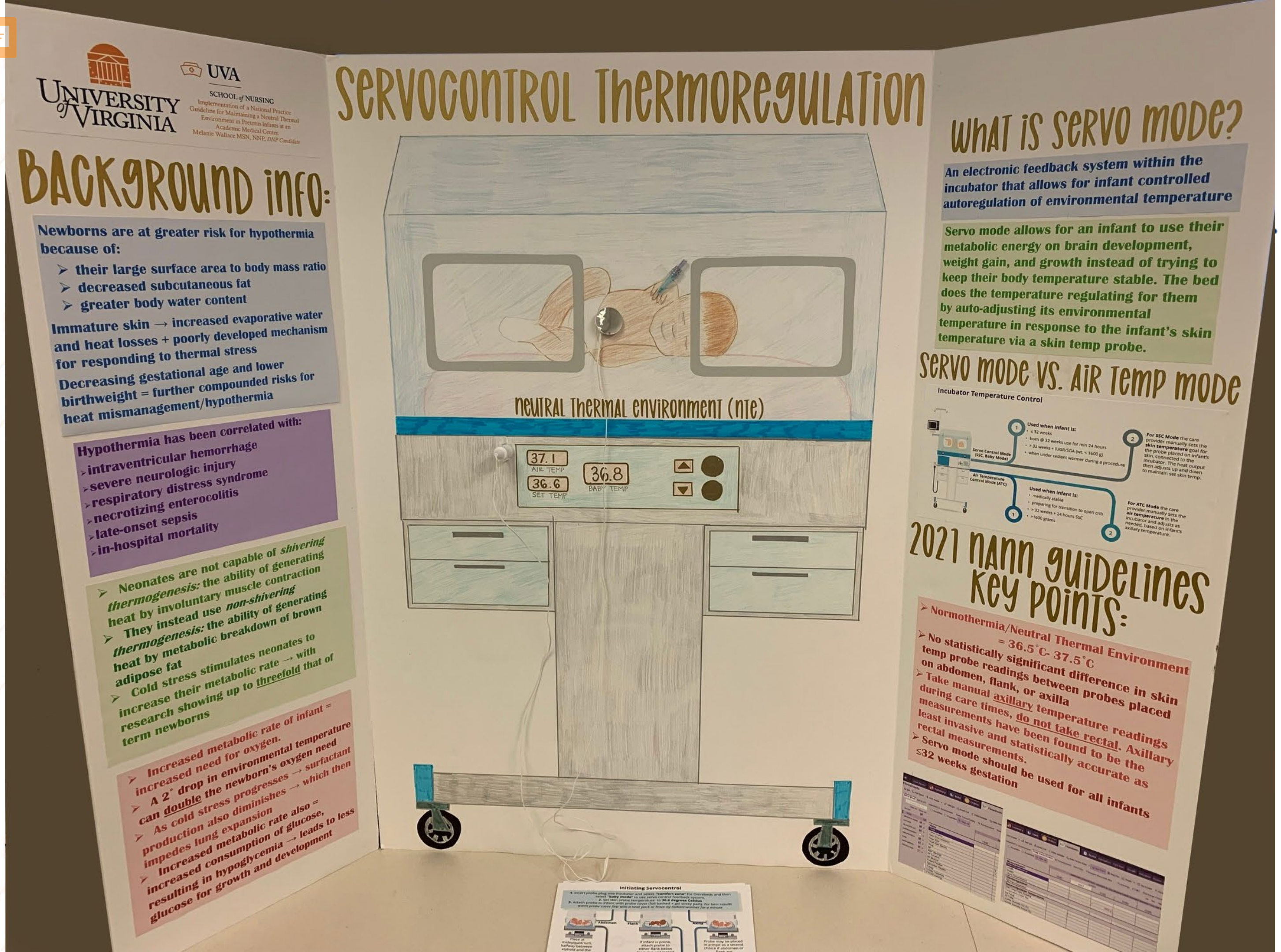
PRACTICE CHANGES BASED ON THE NANN GUIDELINES:

- Infant's born < 32 weeks will be placed on servo control mode with the STP placed either on their abdomen, flank or under their armpit
- Servo control mode will be used until the infant reaches 32 weeks of age or for at least 2 weeks if initiated after 31 weeks gestation
- Incubator environmental temperature will be set between 36.5˚C - 36.6˚C under the servo control setting with air temp adjusting via biofeedback to maintain NTE
- Air temperature and skin temperature (from the STP) readings will be recorded into the EHR system hourly. Manual infant axillary temperatures will be taken and recorded in the EHR every 3 to 4 hours with care times to check for correlation with STP

IMPLEMENT PRACTICE CHANGE

METHODS

- **Small group in-service** education sessions given over two-week period from April 8th to April 22nd. Teaching sessions were 15 minutes, included poster discussion, demonstration of using servo mode on incubator, and open questions from RNs.
- **Evaluation** of teaching effectiveness given at conclusion of each in-service session
- **Informative poster** placed in the nurse break room explaining neutral thermal environment, proper use of servo mode within the infant incubator and the supporting evidence for these practices from the NANN guideline
- **Infographic handouts** given at educational sessions as well as distributed throughout unit and **laminated placards** were placed in each patient room


University of Virginia
UVA School of Nursing
Implementation of a National Practice Guideline for Maintaining a Neutral Thermal Environment in Preterm Infants at an Academic Medical Center.
Melanie Wallace MSN, NNP, DNP Candidate
Servocontrol Thermoregulation
Background info:
Newborns are at greater risk for hypothermia because of:
➢ their large surface area to body mass ratio
➢ decreased subcutaneous fat
➢ greater body water content
Immature skin → increased evaporative water and heat losses + poorly developed mechanism for responding to thermal stress
Decreasing gestational age and lower birthweight = further compounded risks for heat mismanagement/hypothermia
Hypothermia has been correlated with:
- intraventricular hemorrhage
- severe neurologic injury
- respiratory distress syndrome
- necrotizing enterocolitis
- late-onset sepsis
- in-hospital mortality
➢ Neonates are not capable of shivering thermogenesis: the ability of generating heat by involuntary muscle contraction
➢ They instead use non-shivering thermogenesis: the ability of generating heat by metabolic breakdown of brown adipose fat
➢ Cold stress stimulates neonates to increase their metabolic rate → with research showing up to threefold that of term newborns
➢ Increased metabolic rate of infant = increased need for oxygen.
➢ A 2° drop in environmental temperature can double the newborn's oxygen need
➢ As cold stress progresses → surfactant production also diminishes → which then impedes lung expansion
➢ Increased metabolic rate also = increased consumption of glucose, resulting in hypoglycemia → leads to less glucose for growth and development
Neutral Thermal Environment (NTE)
37.1 AIR TEMP
36.6 SET TEMP
36.8 BABY TEMP
What is Servo Mode?
An electronic feedback system within the incubator that allows for infant controlled autoregulation of environmental temperature
Servo mode allows for an infant to use their metabolic energy on brain development, weight gain, and growth instead of trying to keep their body temperature stable. The bed does the temperature regulating for them by auto-adjusting its environmental temperature in response to the infant's skin temperature via a skin temp probe.
Servo Mode vs. Air Temp Mode
Incubator Temperature Control
2021 NANN Guidelines Key Points:
➢ Normothermia/Neutral Thermal Environment = 36.5°C- 37.5°C
➢ No statistically significant difference in skin temp probe readings between probes placed on abdomen, flank, or axilla
➢ Take manual axillary temperature readings during care times, do not take rectal. Axillary measurements have been found to be the least invasive and statistically accurate as rectal measurements.
➢ Servo mode should be used for all infants ≤32 weeks gestation
Initiating Servocontrol

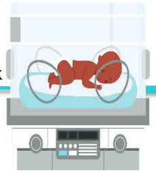
Initiating Servocontrol

1. Insert probe plug into incubator and select **"comfort zone"** for Omnibeds and then select **"baby mode"** to use servo control feedback system.
2. Set skin probe temperature to **36.6 degrees Celsius**
3. Attach probe to infant with probe cover (foil backed + gel sticky part). *For best results warm probe cover first with a heat pack or leave by radiant warmer for a minute*

Abdomen

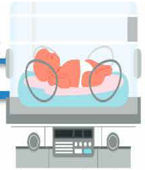
Place probe in the middle of the abdomen, halfway between xiphoid and the umbilicus

Flank



If infant is prone, attach probe to either flank below scapulae and lateral to spine

Axilla



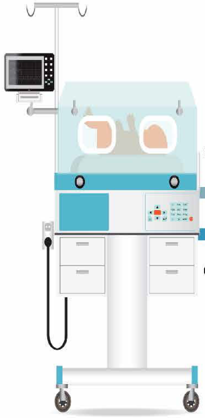
Probe may be placed in armpit as a second choice if abdomen or flank are troublesome

4. Once probe is warm and secure to infant, read the skin temperature from the screen on the incubator/radiant warmer. If below the set point (36.6˚C) the heater should be on. Feel for heater output with hand. If not on, check all connections.
5. If inital skin probe reading remains below 36.6˚C, and heater is on, **wait**. The skin temp probe does not rise quickly and increasing the set point will not cause faster warming.
6. Once infants' skin temperature reaches set point of 36.6C, check for correlation by taking infants' axillary temp. If axillary temp is outside of normal range (36.5˚C-37.4˚C) adjust the set point up or down by 0.1˚C and then **wait** for temp to normalize. Do not change set point if axillary temp is within normal range.

Maintaining Servocontrol

7. Record incubator air temperature, and infant's skin temperature *hourly* for all infants **≤ 32 weeks gestation**. A clearly *increasing* trend in incubator air temperature (meaning infant needs more heat to maintain stable temp) may indicate the development of sepsis while a *labile* air temperature could also indicate a neurological issue.
8. During routine care times/vitals, check axillary temperature and assess correlation with incubator reading for skin temp probe. **Rotate** skin probe site to alternate location and be sure new placement has solid contact with skin. Poor contact will cause over heating and entrapment of the probe between the infant and the mattress will cause underheating.
TIPS: If you need to pop the top for a procedure, or to remove infant switch the bed to Air Temp Control while infant is away. Once infant is returned to bed, or during a procedure, continue Servomode. Allow a full hour for the bed to normalize itself with the infant.

Incubator Temperature Control



Servo Control Mode (SSC, Baby Mode)

1 **Used when infant is:**
- ≤ 32 weeks
- born @ 32 weeks use for min 24 hours
- > 32 weeks + IUGR/SGA (wt. < 1600 g)
- when under radiant warmer during a procedure

2 **For SSC Mode** the care provider manually sets the **skin temperature** goal for the probe placed on infant's skin, connected to the incubator. The heat output then adjusts up and down to maintain set skin temp.

Air Temperature Control Mode (ATC)

1 **Used when infant is:**
- medically stable
- preparing for transition to open crib
- > 32 weeks + 24 hours SSC
- >1600 grams

2 **For ATC Mode** the care provider manually sets the **air temperature** in the incubator and adjusts as needed, based on infant's axillary temperature.

DATA COLLECTION AND ANALYSIS

DATA COLLECTION

- Following staff education sessions, data was collected by **chart audits** of neonates who fit the criteria for servo mode
- Two different time periods were evaluated:
    - Time 1: Infants eligible for servo mode before education sessions to staff
    - Time 2: Infants eligible for servo mode after education sessions to staff
- **Time 1** patient data December 2021 through March 31st - **Five infants qualified**
- **Time 2** patient data April 10th through May 3rd- **Seven infants qualified**
- For all the infants in both groups, charts were audited for how the temperature points were documented and managed.

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DATA COLLECTION CONT.

- All data points analyzed were taken from the first set of vital signs obtained at the beginning of each nurse’s shift over the course of 24 days.
- All medical record data was maintained and kept in a locked office in the NICU
- Data collected during chart audits:
    - Infant’s current gestational age at that moment in time of chart audit
    - Skin temperature probe reading and location
    - Set temperature of incubator and Air temperature of incubator
    - Frequency of charting skin, air, and infant temperatures

DATA ANALYSIS

- Descriptive statistics of averages, means, medians, and ranges were used
- Data was entered into SPSS® statistical analysis software for comparison between Time 1 and Time 2
- IOWA Model encourages reflection on current process during implementation
    - RN feedback during the education sessions was the frequency of the documentation was impractical and a change was made

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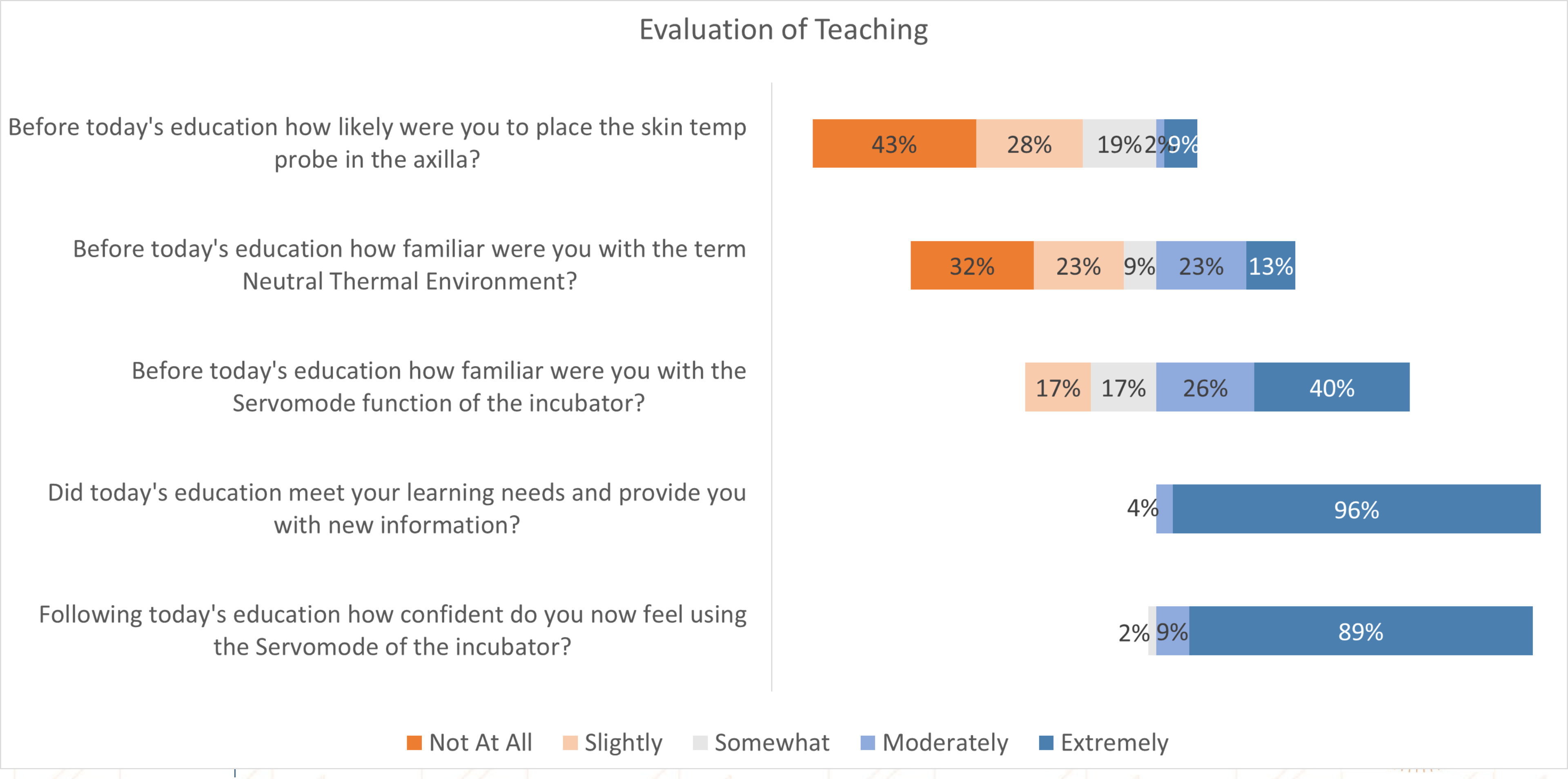
RESULTS

RESULTS: IN PERSON EDUCATION

- Eight 15-minute in-services were conducted during the day and night shifts.
- 52 RNs of the 109 RN staff members in the NICU (48%) attended the in-services
- The information poster used in the in-services remained in the unit for review
- All handouts provided during the educational sessions were also disseminated thought the unit for staff


Evaluation of Teaching
Before today's education how likely were you to place the skin temp probe in the axilla?
43%
28%
19%
2%
9%
Before today's education how familiar were you with the term Neutral Thermal Environment?
32%
23%
9%
23%
13%
Before today's education how familiar were you with the Servomode function of the incubator?
17%
17%
26%
40%
Did today's education meet your learning needs and provide you with new information?
4%
96%
Following today's education how confident do you now feel using the Servomode of the incubator?
2%
9%
89%
Not At All
Slightly
Somewhat
Moderately
Extremely

RESULTS: KEY POINTS IMPLEMENTED

1. The set temperature of the infant incubator
2. Location of temperature probe placement
3. Initiation and maintenance of servo control mode for all infants ≤ 32 weeks
4. Proper documentation within the EHR system

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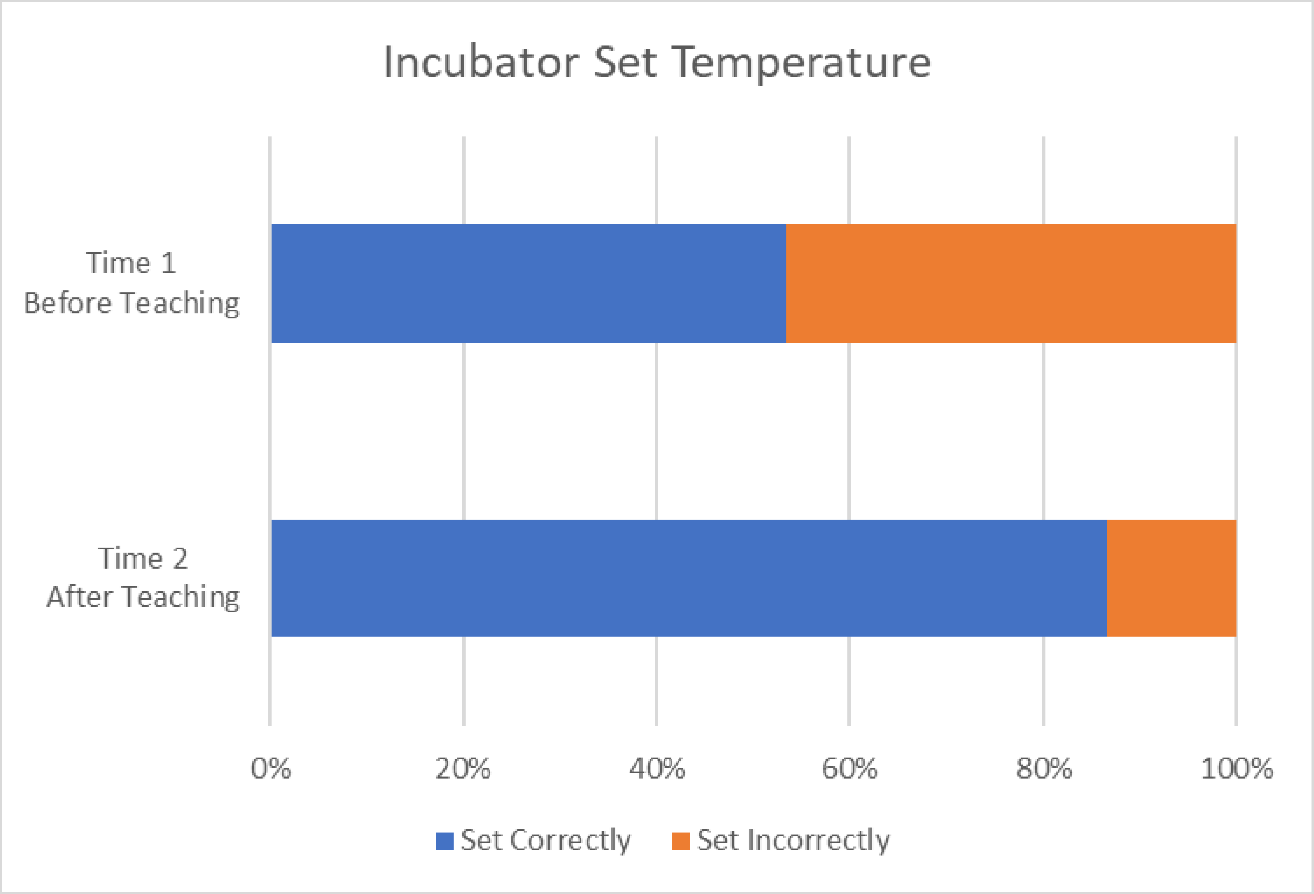

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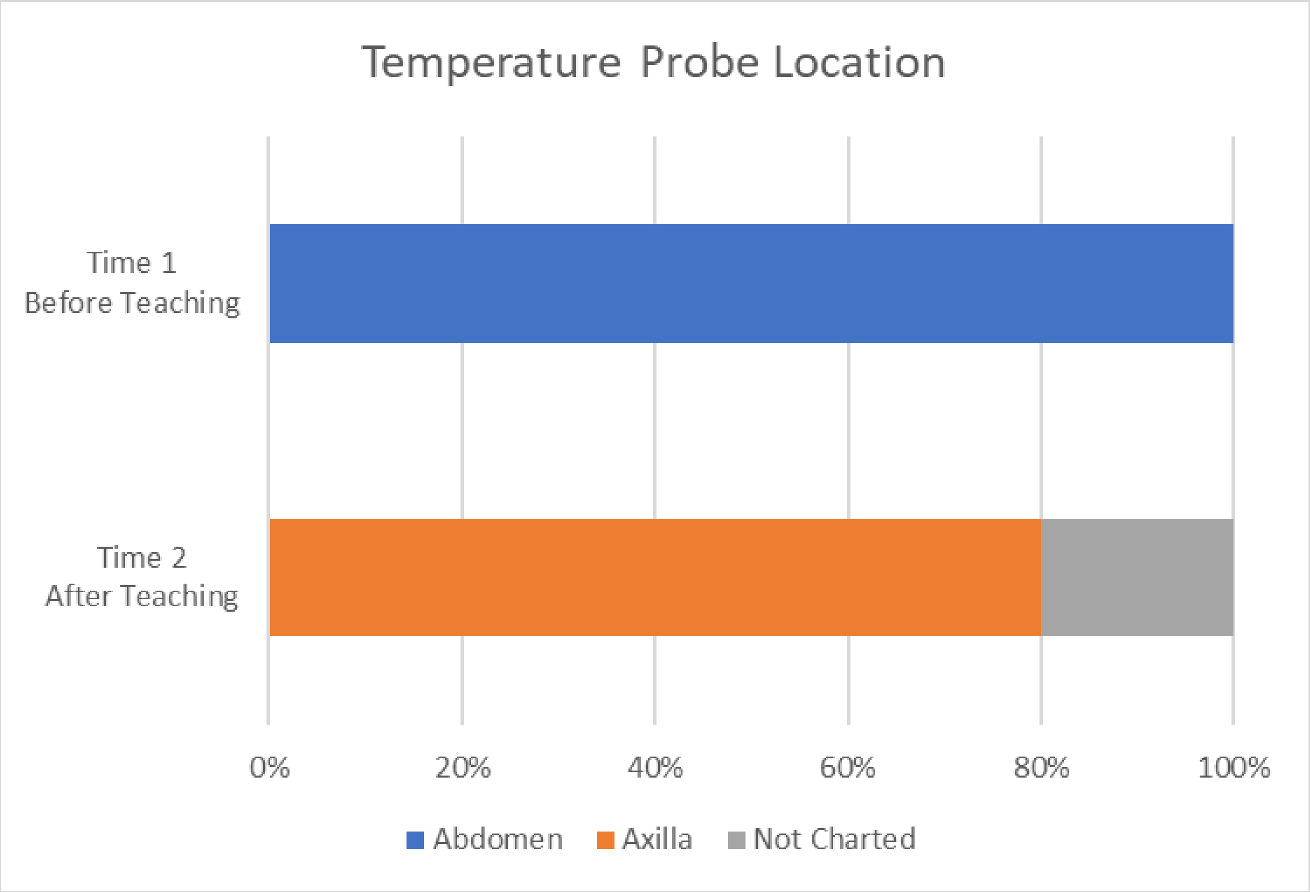

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RESULTS: KEY POINTS IMPLEMENTED

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RESULTS: KEY POINTS IMPLEMENTED

1. The set temperature of the infant incubator
2. Location of temperature probe placement
3. Initiation and maintenance of servo control mode for all infants ≤ 32 weeks
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DISCUSSION

DISCUSSION

- Improved compliance with set temperature point of 36.5/36.6
  - Subset of infants below the set point were appropriate documentation
  - Represents accurate nursing judgement and understanding of the education
- Use of axilla as a site for probe attachment provided nurses with alternative site for placement
- Improved documentation of temperatures

DISCUSSION

standard probe cover

- Temperature probe covers
  - important for the effectiveness of the servo mode
- Current product with poor adhesiveness
  - Lack of availability
- ”work arounds” created by nursing
  - adjusting set point temperature on the incubator
  - use of other products to secure the probe to the skin

newer, hydrogel cover

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STRENGTHS AND LIMITATIONS

STRENGTHS AND LIMITATIONS

- Newly published guidelines by the National Association of Neonatal Nurses (NANN) validating the necessity to update and standardize thermoregulation care
- Buy-in from unit staff and key stakeholders
- Staff changes following pandemic → presence of traveler nurses
- Identification of barriers to practice
    - Probe cover supply
    - Documentation due to change in EHR system

STRENGTHS AND LIMITATIONS

- Staff feedback
  - *"this was super helpful"*
  - *"having better guidelines for managing incubator temperature has been needed for awhile now"*
- Limited time frame for chart audit
  - Ongoing compliance across all RN staff unknown
  - Unable to determine compliance with use of servo control mode until 32 weeks of age or for at least 2 weeks if initiated after 31 weeks gestation
- Lack of an established guideline may limit compliance over time
- Lack of appropriate temperature probe covers

PROJECT SUSTAINABILITY

INTEGRATION AND SUSTAINABILITY

- "Champions" for thermoregulation will help to continue compliance and troubleshoot as needed
- New probe covers arriving from new supplier
- Policies and Procedures Committee within NICU working to formalize an official unit policy on thermoregulation utilizing the guidelines taught through this projects education sessions
- Unit hopes to have a "small baby team" in the future, thermoregulation serves as a cornerstone of care for the tiniest neonates

ACKNOWLEDGMENTS

THIS PROJECT BROUGHT TO YOU BY…

NAPTIME!

ACKNOWLEDGMENTS

Dr. Barbara Reyna

Dr. Beth Quatrara

Julie Buttermore

Lisa Shaver

Emily Ott

Dr. Joseph Khoury

Lori Dippold

Alison Piques

Amy Lynch

NICU Staff

My fellow colleagues and confidants: Elizabeth Kassulke, Susanna Pruangkarn, and Carl Lambert

James and Sonia Safran

Diana Wallace

My village of friends

My dogs

Eric Wallace, ever supportive husband

Naptime


QUESTIONS?

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