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Toolkit for Implementation of Temporal Artery Thermometers for Neonates

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Walden University
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Abstract

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MSL, Walden University, 2012

MSN, San Francisco State University, 2007

Project Submitted in Partial Fulfillment

of the Requirements for the degree of

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Abstract

Accurate temperature assessment is essential in neonatal patients and allows for prompt recognition of illness. Temperature can be measured by rectum, which is subject to injury, axillary, which is time-consuming, and temporal artery, which is safe and fast. The purpose of this evidence-based practice quality improvement project was to create an educational toolkit for nurses teaching temporal artery thermometers for routine temperature measurement on neonates, to establish the content validity of the toolkit, and to make recommendations for implementation of the toolkit. The format applied was the Kellogg Logic Model that proceeded from the assumption, to planned work, and results. The theoretical framework was Roger's Diffusion of Innovations, which identifies champions as the initial change agents, helps engage the staff, and facilitates the change. The project consisted of a two-phase process. Phase 1 was the development of the toolkit contents by integrating the evidence and applying the framework in the context of working nurses. Phase 2 was the validation of the toolkit by expert nurses and educators with Item-CVI ranging from 0.80 to 1.00 and the scale-CVI at 0.98. The Toolkit for Implementation of Temporal Artery Thermometers for Neonates with three short video presentations was validated. The toolkit is shared on multiple webpages and is available to the public. Adopting the temporal artery thermometer for routine temperature measurement could be a new standard for temperature monitoring that is accurate and fast. Improved family satisfaction would result from a quicker temperature process and a less invasive method resulting in a more comfortable experience for their infant.

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Introduction

Neonatal temperature measurement is essential to evaluate the status of a newborn or premature infant, as the temperature can indicate illness and the need for further intervention (Hofer, Müller, & Resch, 2012; Smith, Usher, Alcock, & Buttner, 2013). Accurate measurements of routine temperatures in a minimally invasive fashion increases infant comfort and decreases nursing time (Carr et al., 2011). The purpose of this project was to develop an educational toolkit to teach neonatal nurses the use of the temporal artery (TA) thermometer for routine temperature measurements, establish the content validity of the toolkit, and make recommendations for its adoption into practice.

Problem Statement

Body temperature is one of the vital signs used to assess basic body functions and the body's ability to maintain thermoregulation. An infant's temperature is critical for assessment and intervention, and is assessed by using a thermometer placed in the rectum, axilla, or over the temporal artery. Rectal measurements are subject to complications such as a tear in the rectal tissue resulting in trauma to the rectum (Smith, Alcock, & Usher, 2013). Electronics have replaced glass mercury thermometers, thus reducing the time required and enhancing comfort while maintaining the accuracy of the measurement (Smith, Alcock, & Usher, 2013). Therefore, placing an electronic thermometer in the axilla for routine temperature measurements in infants is the common practice (Smith, Alcock, & Usher, 2013).

Evidence has demonstrated that taking rectal or axillary temperatures are time-consuming (Carr et al., 2011; Roy et al., 2009). Infants are disrupted with measurements of vital signs that take several minutes, and families are disturbed when their child is irritated (Boxwell, 2010;

Hockenberry & Wilson, 2013). The best thermometer should be accurate, minimally invasive, consistent, quick, and easy to use (Isler, Aydin, Guen, & Guany, 2013). Temporal artery thermometer measurements are faster, less disruptive, and accurate for routine temperature monitoring in infants. This project developed a toolkit to teach nurses the process, rationale, and how to adopt the change of using the TA thermometer in neonates for routine temperature monitoring.

Purpose Statement

The purpose of this EBP quality improvement project was to create an educational toolkit for nurses about using temporal artery thermometers for routine temperature measurement on neonates, to establish the content validity of the toolkit, and to make recommendations regarding the implementation of the toolkit. The guiding questions were (a) what were the essential elements of an educational toolkit; (b) what was the content validity of this toolkit; and (c) what is the process for successfully implementing a change in practice in bedside RNs. This project validated the content validity of a toolkit for implementation of temporal artery thermometers in neonates.

Nature of the Project

Nurses need to recognize evidence-based practice, embrace best practice, and change to new processes when indicated. It is often challenging to nurses when they are required to adopt new practices because change is difficult. One strategy to embracing adoption and enhancing change is to provide the rationale behind the change and a designated, scripted process for the change. Moreover, using change theory to facilitate diffusion of the new practice will smooth the adoption process and allow the practice to be in place much quicker (Rogers, 2010).

The Doctor of Nursing Practice (DNP) translates evidence into practice and facilitates the change adoption. The barriers of bringing EBP to the frontline are many and include (a) lack of knowledge; (b) lack of education; (c) lack of practice or training; (d) resistance to change; (e) lack of support during change process; and (f) lack of outcome monitoring (Melnyk et al., 2004). Recognizing these barriers, there are benefits if the nurse understands the reason for the change, recognizes the significance of the EBP, receives education or training on a new technique, and incorporates this change into their practice (Gerrish et al., 2012). Using the Kellogg (2004) model to identify the steps beginning with assumptions and ending with the outcome helped in creating the toolkit.

This scholarly project focused on the gap the nurses have in the lack of knowledge of the evidence for TA thermometers accuracy, comfort, and time (Carr et al., 2011; Roy et al., 2009). Thus, an educational toolkit was the process to ease the transition from the current practice to the new practice using TA thermometers. Five expert nurse educators validated the content via a questionnaire and using an electronic scoring tool. This project used the Rogers (2010) theory for Diffusion of Innovations (DOI) to determine recommended techniques that can foster adoption. The toolkit developed in this project contains the validated educational content, DOI theory application, and adoption plan.

This project created a toolkit for nurse education and adoption of the best practice change to TA thermometers. The target audience was neonatal nurses for use in routine measurements of temperature in infants. The approach was twofold: first to develop a slide presentation and second to validate the content of the presentation.

The primary slide presentation consists of the process for performing the temperature measurement and a review of the evidence. An additional presentation promotes change adoption by identifying the individuals who should do the training first and champion it to the nursing staff, as well as, how to support the change. Change adoption techniques were included to improve the success of the best practice adoption. A third slide presentation listed pertinent references for the evidence.

Seven nurses who educate hospital nurses and nurses who work with infants and neonates were given the content. Of these, six content experts evaluated the outline for the toolkit and five evaluated the content of the toolkit by scoring them on an online questionnaire. Using content validation processes, the results were evaluated and confirmed content validation. The result of this project was a toolkit designed to facilitate the adoption of TA thermometers in neonates ready for nursing education and implementation.

Significance

In neonates, the measurement of temperature is an indication of wellness or of sickness and illness, and maintaining a constant body temperature is paramount. Hyperthermia and hypothermia both can have adverse effects in the neonatal patient and the temperature measurement should be as close as possible to the actual core temperature measured in the pulmonary artery (Batra, Saha, & Faridi, 2012; Hofer, Müller, & Resch, 2012). Fever in neonates is defined as a rectal temperature $\geq 38.5^{o}$ C (Hofer et al., 2012) or a temperature $\geq 38^{o}$ C (Smith et al., 2013). Hypothermia is defined as a rectal temperature $\leq 36.0^{o}$ C (Hofer et al., 2012). Either hyperthermia or hypothermia can be an indication of early onset sepsis in the newborn (Hofer et al., 2012).

Assessing temperature in the neonate is completed using different techniques. Historically, temperature measurements were done using a mercury thermometer rectally (Pediatric Associates, n.d.; Healio Pediatrics, 2001). The current practice of measuring temperature in neonates remains primarily by rectal using electronic thermometers. While the American Academy of Pediatrics (2013) recommends rectal temperature measurement from birth to three years of age, parents often refuse this method as there is perceived cause of discomfort of the neonate (Carr et al, 2011). Thus, this traditional method of measurement changed as technology and ease of use promoted electronic axillary thermometers. In most hospitals, electronic axillary and rectal thermometers are common, with most nurses and families prefer the less invasive axillary route.

Electronic thermometers provided many benefits over the traditional mercury thermometer. First, the use of electronic thermometers over mercury reduced the risk of releasing mercury, a neurotoxic element, into the environment (US EPA, 2010). Second, newer technology promoted the use of electronic devices as a safer option. Families prefer less invasive techniques to minimize disturbance of the infant and nurses prefer quick, accurate thermometers. Last, the shared electronic thermometers require a single-patient-use disposable probe cover.

Most recently, a new thermometer using the temporal artery (TA) for data was developed and marketed. This noninvasive TA thermometer measures temperatures with an infrared probe that is wanded across the forehead and then placed behind the ear. During this motion, the device rapidly measures skin temperatures, locating the highest temperature. Using a pre-determined calculation, the device can then predict core temperatures (Exergen, 1999).

There are three major benefits to using TA thermometers for routine temperature measurements. First, the TA thermometer is less disruptive to the infant as validated in studies assessing pain scores with the different temperature measurement methods (Lee et al., 2011). Second, the TA thermometer is much faster than either the rectal or the axillary thermometers taking only about six seconds (Carr et al., 2011). Last, the literature has validated the accuracy of the thermometer (Bindu, et al, 2015; Holtzhauer et al., 2009; Lee et al., 2011; Odinaka et al., 2014; Sahin et al., 2012; Titus et al., 2009). Thus, the TA thermometer is a plausible solution for recording routine temperatures of neonates.

As providers, part of nursing care focuses on reducing stimulation to the neonate to promote comfort (Boxwell, 2010). By encompassing the standards of atraumatic care (Boxwell, 2010), nurses tend to touch gently, talk quietly, and keep a calm environment that promotes rest and strengthens the recovery. Neonates in a well-baby or neonatal units frequently have their vital signs taken when awake and hungry, just prior to feedings. Because the TA thermometer is much quicker than axillary or rectal measurements, there is a lesser impact of disturbance to the neonate. Scaled comfort scores measured in neonates fell from 2.22 with rectal to 0.05 with the TA thermometer, thus validating this technique as one that increases comfort (Carr et al., 2011).

Changing to TA thermometers will enhance the comfort of the neonate, improve family satisfaction, as well as, decrease nursing time (Carr et al., 2011). Current policy in many neonatal units requires a rectal temperature immediately after birth, with subsequent temperatures measurements taken by axillary thermometers. If any axillary temperature is outside of normal range, this requires a rectal measurement for confirmation of hyperthermia or hypothermia before initiating a septic workup. Research has demonstrated that temperatures measured in the axilla were equally accurate to those measured in the rectum in premature infants (Moen, Chapman, Sheehan, & Carter, 1987).

Similarly, TA temperatures are also accurate when compared to axillary and rectal temperature for infants (Allegaert, Casteels, van Gorp, & Bogaert, 2014; Bindu et al., 2015; Bahorski et al., 2012; Carr et al., 2011; Haddad, Smith, Phillips, & Heidel, 2012; Holtzhauer, Reith, Sawin, & Yen, 2009; Lee et al., 2011; Odinaka et al., 2014; Sahin et al., 2012; Titus, Hulsey, Heckman, & Losek, 2009). Since accuracy is assured, Carr et al. (2011) and Roy, Chowdhury, Bandhopadhya, and Ghosh (2009) posited that switching from axillary to TA thermometers can save providers nearly 50 seconds of time for measurement, as well as, minimize the perceived discomfort. This can positively influence the nurses' time management by decreasing the length of time for measurement (Carr et al., 2011) and increasing patient comfort.

Last, an additional concern is the threshold for a febrile temperature using the TA thermometer. The current benchmark for febrile is $\geq 38^{o}$ C (Smith et al., 2013); literature shows that the TA thermometer reading of 37.7^{o} C is a better threshold. Changing the threshold from $\geq 38^{o}$ C to 37.7^{o} C would catch almost all febrile infants and children (Odinaka et al., 2014; Schuh et al., 2004; Titus et al., 2009).

Nurses who adopt TA thermometer measurements for routine temperature assessments will benefit from less disruption to the infant, accurate measurements, and an indication of wellness. Moving the threshold assures that all febrile infants will progress to a further workup, thus ensuring that the TA thermometer is accurate for routine measurements. Further, the TA thermometer has the potential to change practice at home for families after they experience the use in hospitals and the recommendation from nurses.

Summary

Temperatures are an important vital sign measurement for newborns as part of the ongoing care of an infant. However, nurses in many organizations continue to take temperatures using traditional methods dependent on axillary thermometers. The literature shows a preponderance of the evidence that supports TA thermometers as being accurate, faster, and more comfortable for the neonate. This gap in knowledge and implementation of EBP for the TA thermometer was reduced by creating a toolkit for education to change nursing practice. Nurses need to see the evidence, learn the new technology, and implement the change successfully. This will give them the satisfaction of following through on EBP change in their environment.

Section Two: Review of Literature and Theoretical and Conceptual Framework

Introduction

This project was to develop an EBP toolkit to educate nurses on the process of TA measurements in neonates, methods to facilitate the change in practice, and to validate the content of the toolkit. This toolkit included the EBP literature for TA thermometer accuracy, time, and comfort. Specifically, the evidence related to neonates and infants was evaluated, in addition to, the accuracy of TA thermometers as compared to other thermometers. Additionally, the literature regarding the time required for different temperature measurements and the comfort of the infant during the temperature assessment was evaluated. Lastly Roger's (2010) Diffusion of Innovation theory was applied to the change process in the implementation plan in the toolkit.

Concepts, Models, and Theories

The framework identified for this project was the Kellogg Logic Model (2004). This model gave a clearly identified projection from the assumptions to the outcomes. The Kellogg Logic Model's six steps were applied to this project (Table 1). The first step was to identify the assumption of the project. In this case, that developing a toolkit can aid in educating nurses with temperature taking for infants. The next two steps included the planned work. The second step was to identify what inputs were necessary: these were EBP, DOI theory, and validation of content. The third step was to delineate the activities to develop the content, validate the content, and identify strategies to enhance adoption and implementation.

The fourth through the sixth steps comprise the results section. For this project, the fourth step identified the output, which included the toolkit with education, EBP rationale, and a process for implementation. The fifth step was to evaluate the outcome; which was fulfilled when the expert-validated toolkit was completed. In addition, the sixth step was to identify the impact; a toolkit, ready-for-distribution, that consists of a standardized EBP temperature measurement modality for routine vital signs in neonates, a plan for education and a format for implementation.

Theoretical Framework

The theoretical framework applied to this EBP was Rogers (2010) change theory entitled Diffusion of Innovation (DOI). The two main parts of this framework are the characteristics of adopters and the critical mass properties of group adoption of a change. The change agents used in this EBP are the peers who motivate the change and influence their peers by discussing the change with them and demonstrating the change (Kaminski, 2011).

Change theory involves understanding change and moving toward adherence to new things or processes. The distinct categories described in DOI help identify the different adopters and how they can facilitate or hinder the transition of change (Rogers, 2010). By engaging the innovators and the early adopters to champion the change, the majority move toward acceptance, and create a tipping point toward overall acceptance, this lessens the time to the overall adoption of change (Rogers, 2010). Therefore, the peer coaches identified for this project are innovators or early adopters who believe in EBP changes.

Rogers (2010) emphasized that facilitating change by creating compatibility and decreasing complexity is possible. Using these techniques to engage the nurses in anticipation of the change in practice and spread the information to others. To accelerate learning, one can decrease the complexity and use a well-designed educational toolkit. This toolkit shares the evidence-based knowledge and can persuade the nurses to adopt the change. The clear concise visual educational slide presentation conveys the pertinent knowledge and engages the learner.

By using DOI to engage the coaches and educating them well, they will champion the change to the rest of the staff thus promoting and advancing the change.

Since the toolkit is for unit use, applying DOI and establishing the commitment, acceptance, and promotion from the peer leaders in the unit facilitates the change adoption in all nurses by speeding the change. This ensures compliance earlier than would natural diffusion of a change (Rogers, 2010; Kaminski, 2011). The inclusion of DOI as a tool within the toolkit should result in a faster adoption of the change by nurses while ensuring that the knowledge and techniques are ingrained.

Relevance to Nursing Practice

Nurses want to use the best tools and techniques for their patients. For infants, the nurses try to minimize noxious stimuli and create a quiet, calm environment. Nurses currently use primarily axillary thermometers to measure temperatures, with rectal being used to validate the axillary. This practice has been in place since the 1970s and nurses have been slow to adopt the TA thermometer for infants.

Using the TA instead of a rectal or axillary thermometer would improve comfort scales and decrease stimulation for the infant (Carr et al., 2011; Holzhauer et al., 2009). Nurses save time with TA measurements (Carr et al, 2011). Hospitals depend on good patient and family satisfaction; reducing irritation in infants can contribute to better family satisfaction.

Implications for Social Change

The Institute of Medicine's (2010) sixth recommendation was that nurses become lifelong learners. Additionally, the second recommendation was for nurses to be the leaders in designing and coordinating collaborative changes to improve practice (IOM, 2010). The IOM asked healthcare organizations to validate competencies and keep them up to date with best practice (IOM, 2010).

A nurse-led project to move toward the least intrusive, safe, and accurate temperature measurement using TA thermometers was a good example that incorporated both recommendations. As a nurse, with the gap identified, the change in practice was designed to include the most up-to-date practice with a toolkit to update the competency of the nurses caring for infants. This can facilitate nurses' lifelong learning by helping them identify best practice changes and adopt the changes.

This toolkit was the first step to a change in practice that benefits infants, families, and nurses. There can be a positive impact on infants and their families after nurses incorporate this practice change into routine practice. This improvement in patient care can result in a reduction in pain or discomfort for the neonates who require routine temperature measurements. This change supports the benefits of atraumatic care by reducing the distress of the infant, as identified by Hockenberry and Wilson (2013) and Boxwell (2010). As families support the process, satisfaction will improve and nursing time will decrease (Carr et al, 2011). A positive impact for babies, families, and nurses will follow this change in practice. The toolkit will be available after this project is complete for use by nurses, educators, and leaders.

Local Background and Context

Neonatal Temperature Measurement. Temperature monitoring in the neonate is essential from the moment the infant is born to the time of hospital discharge. Verklan and Walden (2014) state that hyperthermia or hypothermia are signs of sepsis in the neonate. Moreover, the environment must be adapted to help the infant maintain a normal temperature and reduce the chance of cold stress (Verklan & Walden, 2014). Hypothermia can be fatal

(Hackman, 2001; Placidi, Merusi, & Gagliardi, 2014) and can be caused by evaporation of moisture from the infant body, conduction from cold surfaces, and convection of air drafts (Kumar, Shearer, Kumar, & Darmstadt, 2009). Neonates have a large surface area in relation to body mass and this surface area is higher in low birth weight and premature infants (Kumar et al., 2009). Infants are unable to shiver, which is a physiologic response to cold that increases the core temperature, so hypothermia is hard to recognize in neonates (Kumar et al., 2009). Interventions include bundling, hats, skin-to-skin and maintaining normothermia, all were validated by measuring the neonate's temperature. After birth, using a therapeutic bed with heating elements and monitoring with a skin temperature probe prevents loss of heat by evaporation.

Historically, using the rectal route was the routine temperature measurement in all infants. Moen, Chapman, Sheehan, and Carter (1987) compared rectal mercury thermometer readings to axillary mercury thermometer reading in premature neonates. This seminal work demonstrated a correlation between rectal and axillary measurements in these premature infants (Moen et al., 1987). Practice changed in neonatal units to include the routine use of axillary thermometers; the practice continues today based on recommendations from the American Academy of Pediatrics (2013) and National Association of Neonatal Nurses (Verklan & Walden, 2014). Currently, most temperatures are measured in the axilla, rectum, or on the skin electronically by devices from different manufacturers (Verklan & Walden, 2014).

Temporal Artery Thermometer. The temporal artery thermometer is a minimal contact thermometer that has a smooth tip. The process is to wand the tip across the forehead from the center to the hairline and then place below and behind the ear or in neonates to place the tip behind the ear. The probe displays the highest temperature measured over the temporal artery

(Exergen, 1999). The temperature reading takes approximately six seconds to perform, is portable, and easily cleaned between patients (Carr et al., 2011). This handheld device has no disposable parts and requires only cleaning between patients (Exergen, 1999).

Accuracy. The literature was replete with examples of the accuracy of the TA within 0.5° C as compared to rectal, nasopharyngeal, and axillary (Bindu, et al, 2015; Holtzhauer et al., 2009; Lee et al., 2011; Sahin et al., 2012; Titus et al., 2009). Moreover, four additional studies demonstrated accuracy within a 1° C range when comparing TA to rectal (Hamilton, Marcos, & Secic, 2013; Odinaka et al., 2014; Penning, van der Linden, Tibboel, Evenhuis, 2011; Reynolds et al., 2012). Two specific neonatal-only studies demonstrated accuracy between 0.2 and 0.5° C as compared to axillary and rectal (Bindu, et al., 2015; Lee et al., 2011). Another study of healthy newborns (125 patients) over 35-weeks' gestation resulted in TA temperatures 0.2° C higher than axillary temperatures (Haddad et al., 2012).

While the evidence has examples of TA accuracy, there was evidence of a lack of effectiveness in diagnosing a febrile infant. Hamilton et al. (2013), Holtzhauer et al. (2009), and Penning et al. (2011) reported missed fevers using TA measurements. However, a plausible response to the lack of effectiveness in diagnosing febrile infants using the TA method is changing the parameters. For example, Titus et al. (2009) suggested that providers change the diagnostic criteria from 38° C to 37.7° C, as this would capture 100% of febrile children aged 1-7 years. Odinaka et al. (2014) further iterated that a TA measurement of 37.7° C be considered the cut off for febrile. This change in practice would further promote the TA method for routine measurement as it captures all febrile patients.

The rationale for the need to capture all febrile infants is that a high temperature indicates an infection. In neonates, as in all age brackets, catching the illness at the beginning of the infection allows for (a) early diagnosis; (b) microbe-specific antibiotics; (c) lessens the mortality; and (d) improves the outcome (Yealy et al., 2015). Children and infants have immature immune systems and require immediate identification and antibiotic intervention to fight off sepsis (Yealy et al., 2015). If nurses use a TA thermometer to identify febrile infants over 37.7 ^{o} C instead of 38^{o} C, infants will be identified sooner and receive treatment sooner. This educational toolkit has all the information necessary to teach nurses the rationale and skill for using TA thermometers.

Time and Cost. Carr et al. (2011) demonstrated the time for measurement with a TA thermometer to be significantly shorter than an axillary temperature. The electronic thermometers that measure oral, rectal, or axillary take about 47 (Carr et al., 2011) to 56 seconds (Roy et al., 2009). The TA thermometer uses about 6 seconds to give the reading (Carr et al., 2011). This reduction in time for neonatal patients would be 47-56 seconds per measurement of vital signs. For a patient requiring every four-hour vital signs using a TA thermometer will save five minutes per patient in a 24-hour day.

Comfort. Lee (2011) identified a reduction in discomfort by comparing axillary measurements which took less than a minute of time and demonstrated higher pain scores on the FLACC (faces, legs, activity, cry, consolability) scale than TA thermometers for 6 seconds of time. The FLACC scale was used for infants to determine their level of pain, the data showed a significant correlation with TA FLACC score of 0.5 and rectal temperature FLACC score of 2.22 (p=<0.5) (Carr et al., 2011). Infants were more comfortable with TA modality over rectal or axillary modality.

Families and nurses both want the infants to have little stimulation and they emphasize a quiet, calm, restful environment (Hockenberry & Wilson, 2013; Boxwell, 2010). TA thermometry is faster which results in less disturbance to the infant and the forehead and a touch behind the ear is less intrusive than placing a thermometer under the axilla. Thus, families, nurses, and the infants value the speed and comfort of the TA thermometer.

Context

This toolkit for the implementation of TA thermometers in neonates is designed to be used in hospital settings to educate nurses who care for infants, such as neonatal intensive care, neonatal step-down, and infant care units. The nurse educators, clinical nurse specialists, and managers are the stakeholders to review and accept this curriculum for education. Nurse who care for the infants are the target recipients of the education.

Role of the DNP student

The DNP student was a clinical nurse specialist at a major west-coast hospital for women and children. In this practice, a relationship with a neonatal step-down unit was developed to determine the need for a change in temperature measurement. This unit was used as a model for infant care and the toolkit was developed as a potential means for educating the nurses and supporting the practice change. As this is a toolkit, there is no intervention in a setting. The only DNP student bias is that the TA thermometer for this project was familiar to the student as it was used in other units of the hospital.

Role of the Project Team

A team of educators who are experts in the care of infants was identified and asked to complete surveys to validate the contents of the toolkit. These individuals were provided with an explanation of the project as required by the Institutional Review Board. Two online surveys solicited their scoring as they evaluated the contents of the toolkit. They could add comments for improvement to the DNP student. The time required of each was less than 30 minutes to review the educational toolkit and answer the surveys.

Summary

The purpose of this Evidence-based practice (EBP) quality improvement project was to develop an educational toolkit to educate nurses about using temporal artery thermometers for routine temperature measurement on neonates and establish its content validity. The literature supported the enhancement of comfort of the infant by using TA over axillary or rectal (Carr et al., 2011; Holzhauer et al., 2009) and that there was a reduction in nursing time for the temperature measurement (Carr et al., 2011). Applying Rogers (2010) Diffusion of Innovation theory characteristics to the change engages peer coaches, which enhances and promotes quicker adoption of new technology by providing the knowledge at the right time in the right way. The next section will discuss the approach and method of evaluating the content of the educational toolkit.

Section 3: Approach and Method

Introduction

The purpose of this EBP quality improvement project was to create an educational toolkit designed to educate nurses about using temporal artery thermometers for routine temperature measurement on neonates, establish the content validity of the toolkit and to make recommendations regarding the implementation of the toolkit. The design and method are detailed below and consists of a two-phase process. Phase 1 was the development of the toolkit contents. Phase 2 included the method of validating the content of the toolkit by using expert educators and nurses and added recommendations for implementation. This content validation was evidence based and follows the process for interrater reliability (Polit & Beck, 2013; Polit, Beck, & Owen, 2007; Polit & Beck, 2003). If the interrater reliability was not acceptable, there was a plan to alter the toolkit and resurvey the experts until they validate the content, this was not necessary as the content was validated.

Practice-Focused Questions

What were the essential elements of an educational toolkit and what was the content validity of this toolkit? What is the process for successfully implementing a change in practice in bedside RNs?

Sources of Evidence

The literature search to identify the current evidence for use of TA thermometers was completed by identifying current literature since 1999 (when the TA thermometer came on the market) using the following databases: (a) Walden University Library Search in CINAHL Plus with Full Text, Medline with full text, and Nursing & Allied Health Source; (b) Stanford

Medical Lane Library using the search box; (c) Evidence-based Resources from the Joanna Briggs Institute; and (d) Google web and Google Scholar searches. The terms searched for included: temporal artery thermometers, pediatrics, infants, neonates, and temperature measurement. The search from these terms returned about 1400 individual articles. Title assessment identified articles to include; (a) neonates or infants under three months of age; (b) temporal artery thermometer; (c) the accuracy of measurement or assessment of comfort. Articles excluded after reading the abstracts were; (a) any articles not based in neonatology or with a minimum age of three months; (b) any that did not include temporal artery thermometers; and (c) any that were non-contact temporal artery thermometers. There were sixteen articles identified to be part of the literature review.

These sixteen articles were graded using the AACN (2006) new evidence-leveling system of (a) Level A: meta-analysis or meta-synthesis; (b) Level B: well-designed controlled studies, randomized or non-randomized; and (c) Level C: qualitative studies, descriptive or correlational studies, integrative reviews, systematic reviews, or randomized controlled trials with inconsistent results (Table 2). Fifteen of those studies were rated Level A or B and were included in the evidence (Appendix A). From the literature review, the following themes were identified (a) neonatal temperature monitoring and measurement, (b) temporal artery thermometer accuracy, (c) temporal artery time, (d) cost of temporal artery thermometer measurements, and (e) comfort of the temporal artery thermometer.

The evidence supports the educational content in the toolkit and includes the accuracy, speed, and comfort of the TA thermometer. The theory was applied to the interventions in the toolkit. These two formed the basis for the two phases of the DNP project and the resulting toolkit. Experts validated the toolkit ensuring that all content was accurate and that the toolkit can educate nurses to change practice to the TA thermometer for routine measurements.

Project Plan.

There are two phases to this project. The first was to develop the outline and validate and the second to develop and validate the content of the toolkit.

Phase One. Phase 1 involved the development of the toolkit. The first step was to develop the outline for the educational toolkit by applying the evidence from the current literature. Next, a panel of experts reviewed the outline for content. With six raters, five needed to agree on acceptability for the outline to have a score of 0.83 resulting in approval of the outline for the creation of the toolkit. This validation of 0.83 is above the standard acceptable score of 0.80 (Polit & Beck, 2003; Polit, Beck, Owen, 2007).

The proposed outline (Appendix B) listed a video/slide presentation, a visual representation of the technique, guidelines for the educational and implementation process, and references. Six nurse educators or neonatal/infant nurses validated this outline. After validation of the outline, the content for the toolkit was developed.

The toolkit content included the detailed documents as identified in the outline. The presentation about the TA thermometer (TAT) was 28 animated slides that present as a video taking less than five minutes of time to view. Included in this presentation was the visual representation of a picture demonstrating the correct application of the TA thermometer to the infant to obtain the temperature. An additional animated slide presentation lasted about three minutes and included an implementation plan to spread the change from the current process to the TA thermometer process. This evidence-based educational plan identified the type of staff to engage in the first round of learning, and the process of spreading the new technique to all staff. A third animated slide presentation listed the references for the evidence. The completed toolkit consisted of an electronic package for a unit or clinic ready for a change to TA thermometers. The toolkit's goal is to educate nurses and includes tips to increase adoption of the new technology.

Phase Two. The second phase of the project was to establish the content validity of the toolkit. The content validity index (CVI) is an accepted method of inter-rater evaluation of specific items (Polit & Beck, 2013; Polit & Beck, 2006; Polit, Beck, & Owen, 2007). Following the creation of the toolkit and IRB approval, the five experts validated the content using the item content validity index (I-CVI) and scale content validity index (S-CVI). With five raters, four needed to agree on acceptability for the outline to have a score of 0.80 resulting in approval of the outline for the creation of the toolkit. This rating of 0.80 is the standard acceptable score for content validation (Polit & Beck, 2003; Polit, Beck, Owen, 2007). Each expert received an electronic copy of the toolkit and a scoring tool. They reviewed the toolkit and answered the questions regarding the content on this instrument (Appendix C).

Population and Sampling. The individuals necessary for this EBP project were a panel of expert educators and nurses who validated the outline of the toolkit, ensured that the content was accurate, and conveyed correctly. Experts were identified using the following criteria: (a) a minimum of two years' experience educating hospital nurses via didactic or self-learning modules; (b) knowledge of the variety of thermometers; and (c) neonatal or infant care expert nurses. By using these nurses for content validation, it was recognized that the result was a judgment by the experts (Polit & Beck, 2013). Seven experts were contacted to validate the content and invitations were sent electrically to the individuals to participate in the review. Of the seven that were asked to participate, six experts accepted the invitation to participate. Once agreeing to participate, each expert was sent the outline of the toolkit and a link to an electronic survey for the collection of results.

The experts were asked to review the outline and “approve” or “disprove” its content (Appendix C). After the outline was validated, the toolkit was created based on the topics of the outline and the experts received a copy of the toolkit and a link to an electronic survey for the collection of their results (Appendix D). All survey results were received in a university tool and stored in the password-protected site. All data were collected via the survey and downloaded into an Excel spreadsheet for analysis. The individual project team responses were anonymous.

Analysis and Synthesis

Appendix C. The first instrument consisted of only one question that asked if the outline for education and implementation was appropriate for the topic. The experts were sent a copy of the outline and a link to the survey to respond on a 1 to 4 Likert Scale.

Appendix D. The second tool evaluated the evidence portrayed in the toolkit. This scoring tool questions included the evaluation of seven items and the experts were asked to rank order the items on a 1 to 4 Likert Scale.

Data Analysis

The survey-scoring tool entered data automatically into a spreadsheet to use to calculate the I-CVI and the S-CVI for each section of the toolkit. A Likert scale was used in the evaluation and included four choices (a) 1=strongly disagree; (b) 2=disagree; (c) 3=agree; and (d) 4=strongly agree (Appendix C & D). After obtaining the results the 1’s and 2’s together were dichotomized into 0 (not acceptable) and the 3's and 4's were dichotomized into 1 (acceptable) (Polit & Beck, 2006). A per item analysis was estimated to determine the number of experts who rated an item as acceptable.

With six raters, five needed to agree on acceptability for the item to have a score of 0.83. With five raters, four needed to agree on acceptability for the item to have a score of 0.80. All results were equal to or above the standard acceptable 0.80 (Polit & Beck, 2003; Polit, Beck, Owen, 2007). No items scored below 0.80, therefore, no changes in the content of the toolkit or outline were required.

The evaluation of this EBP project confirmed that all steps of the process are complete. These steps included determining the process of evaluation of the toolkit, identifying the experts, completing the survey validation, and interpreting the results. Six experts were chosen to comprise the panel for content validation of the contents of the toolkit. The instrument to measure content validity was developed and it represents the evidence and content of the proposed toolkit. An online survey tool was utilized to administer the survey to the experts as they evaluated the outline and the toolkit. This project was cost effective and utilized free internet resources.

Summary

The method for validation of the toolkit in detail included the two phases and the expert panel who evaluated the content. The IRB application received approval prior to the recruitment of the expert panel. The data collection process for content validation included an online survey tool with data flowing to a spreadsheet for analysis. The content was deemed acceptable by the analysis of the items on the survey. The experts in the field established content validity for the educational toolkit and confirmed that the contents of the toolkit are relevant and accurate.

Experts validated the toolkit for educating neonatal nurses to integrate the use of the TA thermometer into their practice for routine vital signs. This data used the S-CVI method based on individual I-CVI scores with 80% or higher agreement on each item. This resulted in an implementation-ready toolkit for TA thermometer use for the relevant individuals and units. The next section documents the findings of the project.

Section 4: Findings Discussion, and Implications

Introduction

The purpose of this EBP quality improvement project was to create an educational toolkit for nurses about using temporal artery thermometers for routine temperature measurement on neonates, to establish the content validity of the toolkit, and to make recommendations regarding the implementation of the toolkit. The information in the toolkit was developed using the relevant literature. The content validity process is an accepted process to validate contents (Polit & Beck, 2013; Polit & Beck, 2003; Polit, Beck, & Owen, 2007). The two surveys of experts on the project team determined that the toolkit contents have content validity.

Findings and Implications

Seven experts were identified to evaluate the content of the toolkit; six individuals completed the first survey regarding the outline of the content and five completed the second with the contents of the toolkit. For the first survey, the I-CVI was 0.83 as the experts agreed that the outline of the toolkit was appropriate (Table 3). Based on this, the toolkit was created using the best evidence and included three short presentations: (a) TAT for Neonates; (b) Change Process for TAT; (c) TAT References and Evidence. The results of the second survey (Appendix D) validated the content of the toolkit with the Item-CVI ranging from 0.80 to 1.00. The scale-CVI for the second survey was calculated at 0.98, establishing the content validity of the toolkit.

The experts validated the toolkit and it is now ready for implementation. This toolkit contains the necessary items to educate nurses on the use of the TA thermometer. The implication is that after viewing the videos a nurse can accurately use the TA thermometer.

After completing the educational videos, the nurse will understand the benefits to the infant are an accurate temperature measurement that takes a few seconds and decreases discomfort to the infant.

The simple educational toolkit has three videos lasting less than eight minutes. The main content for nurses is the TAT for Neonates video which is less than five minutes long. The change process video is less than three minutes and contains the information for leaders to facilitate education and adoption of the new technique.

Recommendations

This project consolidated the evidence for using updating practice for measuring temperature in infants. It recommended a change in nursing practice to the use of TA thermometers instead of rectal or axillary thermometers for routine temperature measurements. The benefits were a reduction in nurses' time, increased patient comfort, and a potential for improved parent/family satisfaction with care in the hospital. The expected time saving is ten minutes of nursing time in a 24-hour day. The infant comfort scores were improved with the TA thermometer which can increase parent satisfactions scores. Increased satisfaction scores impact hospital income and is a driving force of many hospitals (Dempsey, Reilly, & Buhlman, 2014; Manary, Boulding, Stalin, & Glickman, 2013).

Additionally, families learn from the nurses who demonstrate care for the infant while in the hospital. Using the TA thermometer with the family present validates the practice. Families receive teaching from the hospital or pediatrician with instructions to measure their infants' temperature rectally. Many are not comfortable with this process and use either axillary or TA thermometer.

Validating the use of the TA thermometer in infants and teaching families to use the TA thermometer can improve family satisfaction with discharge instruction. Additionally, families will be confident that they are providing the best care to their child when the practice of using TA thermometer as recommended by medical personnel.

Proposed Secondary Products. The Toolkit for Implementation of Temporal Artery Thermometers in Neonates is available on a website as well as on the PowToon site. An additional manuscript is planned and will be submitted to a journal focused on nurses and managers. This project will be added to the DNP Scholarly Project site (http://www.doctorsofnursingpractice.org/) of which Walden University is a participant.

Contributions of the Doctoral Project Team

The project team consisted of content experts in the fields of teaching hospital nurses and caring for infants in the hospital. They contributed by viewing the educational content in the toolkit and answering two online surveys. This resulted in the validation of the outline for the toolkit and the three short educational videos. Their validation was a crucial contribution to the project.

Strengths and Limitations of the Project

Strengths. The strength of this EBP project was that the toolkit was validated and contains all the necessary information for nurses to use the TA thermometer. The content experts were essential for the validation. The validated toolkit consists of videos lasting eight minutes in length and can facilitate an evidence-based practice change.

Limitations. There were two limitations for this EBP project. The main limitation of this project was that it creates a toolkit and it does not actually measure the implementation of the toolkit. When evidence dictates a change in practice there is a challenge in accomplishing the change to the new practice. This toolkit is the educational and change tool for nurses and is not a measurement of successful change.

A second limitation is the survey tool for validation of the content of the toolkit. There was no established survey tool to use for this content. The newly developed surveys measured the educational content and the recommendation to enhance change (Appendix C, Appendix D).

Assumptions. There were two assumptions in this project that recognized technology and changes in practice are not stagnant. The first assumption was that the technology cannot be improved or outdated in a short period. There exists the potential for the invention of a better method of measuring temperature that is superior, faster, and more accurate than the TA thermometer.

The second assumption was that creating this EBP toolkit should educate nurses and change their practice in measuring routine temperatures in neonates. Since the toolkit was the product of this project, and there will be no test of the education of nurses, there will be no confirmation of successful adoption of TA thermometers.

Scope and Delimitations. Nurses should follow the evidence and change practice when a better, validated process is available. This project identified the need to change routine temperature measurements in neonates from axillary to TA measurements. Thus, developing the toolkit had two goals; these were to educate the nurse in the rationale and practice of obtaining TA measurements in neonates and to enhance the change process by giving guidelines for orientation and adoption.

The scope of this project was to create the toolkit and have the content validated by experts in the field of education for inpatient nurses or nurses who are working in units with neonates or infants. The scope included (a) educational information about the technique of TA thermometers; (b) the rationale and evidence for using TA over other methods; and (c) recommendations to enhance the change in a workforce. The scope did not include implementation of the toolkit with practicing nurses.

The delimitations included the range of literature and the population selected for content validation. The range of literature was limited to literature since the TA thermometer became available for use in 1999 with an exception from 1987 that validated the current use of axillary thermometers in neonates. The population selected for review of the toolkit content was a mix of educators and nurses who understand and work with neonates. Although seven evaluators were selected based on these criteria, it was possible that the group did not represent all stakeholders. The project was intentionally limited it to nursing and educators instead of interdisciplinary as the project was directed specifically at nursing practice.

Future Projects. Developing a toolkit geared to a change in practice that includes change theory to enhance adoption of the new practice can be generalized to many other practices. The essential educational item in the toolkit is the teaching about the TA thermometer. The critical addition of the change process for TAT includes an EBP theory that improves the actual adoption of a new technique and ensures long-lasting process change.

Summary

The content experts validated the outline for the education, the TAT for Neonates, the Change process for TAT, and the reference animated slide presentations. These individual items together make up the EBP toolkit entitled Educational Toolkit to Teach Nurses about Using Temporal Artery Thermometers for Neonates. The recommendations for nursing practice are to incorporate the TA thermometer into practice for routine vital sign measurements for neonates. When nurses model and teach the TA thermometer, families become comfortable with this accurate modality.

Section Five: Scholarly Project

Dissemination Plan

This scholarly project consists of a toolkit to educate nurses on why and how to implement TA temperatures for routine temperature measurement in neonates. It also addresses how to make change stick and ensure compliance with the process change. The toolkit includes the validated content of three short videos that take less than eight minutes to view.

The contents of the toolkit are accessible on the internet. The site will be shared via professional and social networks such as LinkedIn and Facebook. This project will be added to the DNP Scholarly Project site (http://www.doctorsofnursingpractice.org/) of which Walden University is a participant. This new network will further disseminate the information. A future manuscript is planned for submission to a journal that has a target audience of bedside nurses and mangers.

Thermometers for Neonates Educational Toolkit to Teach Nurses about Using Temporal Artery

Webpage link to all three videos.

Direct links to the content are found in this public Powtoon site.

TAT for Neonates

Change Process for TAT

TAT References and Evidence

Analysis of Self

As a scholar, this project combined two of my passions; first, the desire to influence nurses to embrace the idea of using evidence-based practice at the bedside, and second, my commitment to promoting and validating the adoption of the change at the bedside. Additionally, this project propelled me to explore different educational methods for delivering information to nurses in an adult-learning based methodology. The validation of the project confirmed that the project contains the essential educational aspects and an appropriate method for implementation. The main challenge was motivating the project team to respond to the surveys. This required three emails to improve the number of responses to a relevant amount.

The project manager portion of the project incorporated learning a new system using PowToon to develop short, concise videos that included all the information necessary to learn a new practice. The application of change theory in the toolkit was a unique tool not usually included in an educational kit, and yet is essential for successful adoption of a new process. The ongoing challenge has been to apply an appropriate strategy to enhance adoption and sustain change. This addition will help others facilitate change without having to study the literature. Incorporating this strategy ensures that the project is all-inclusive and compete.

My long-term goals include facilitating change by improving processes and implementing evidence-based practice. A critical aspect of introducing change at the front line is that the new technique itself is not the actual goal. The real goal is achieving change at the bedside; this requires using change theory to promote, teach, support, and monitor process change. This toolkit was a significant accomplishment that cemented some strategies into my brain and processes.

Summary

The purpose of this EBP quality improvement project was to create an educational toolkit for nurses about using temporal artery thermometers for routine temperature measurement on neonates, to establish the content validity of the toolkit, and to make recommendations regarding the implementation of the toolkit. The educational and change adoption toolkit is shared on the internet and can change nursing practice when implemented. The dissemination of the project is important and will be accomplished using different strategies.

Assessing temperature in an infant is an essential measurement that can indicate wellness or sickness. TA thermometers are a less invasive and accurate measurement that can be used for routine vital sign measurements and have the benefit of being less disruptive to the infant. Nurses, managers, and families will appreciate the reduced disturbance to the infant, increased comfort scales, and the accurate measurements using a TA thermometer.

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Table 1.

Using the Kellogg Logic Model (Kellogg, 2004) to Identify the Planned Work and the Intended Results.

Six steps of Kellogg Logic Model					
	Planned Work		Intended Results		
Assumptions	Inputs	Activities	Outputs	Outcomes	Impact
Building a toolkit for educators and leaders to use in neonatal units will facilitate the transition to using temporal artery (TA) thermometers for routine temperature measurement in neonates	Evidence-based practice (EBP) Roger's Diffusion of Innovation (DOI) theory Content validity process	Create a TA thermometer educational toolkit to educate nursing staff Optimize adoption of the new technique Make recommendations for implementation in the organization Establish the content validity of the toolkit.	Toolkit includes: Education on use of TA thermometer EBP rationale for changing to TA thermometers for routine measurements Implementation process based on DOI	A completed validated toolkit with execution, EBP, and implementation process	A ready for implementation toolkit consisting of a standardized EBP temperature measurement education for routine vital signs in neonates that reduces time, reduces infant discomfort, and increases parental satisfaction, references for the EBP, and DOI recommendations for implementation

Table 2.

Strengths and Weaknesses of the Literature Review on Temporal Artery (TA), Rectal (RT), and Axillary (AT) Temperature Measurements in pediatrics.

Strengths	Weaknesses
Accuracy +/- 0.5° C	Accuracy +/- 1° C
TAT and RT, esophageal, bladder, nasopharynx, pulmonary artery -0.2° C (n=3725 in 37 articles) (Geijer et al., 2016)	TA to RT (mercury) Neonates 0.02 ± 0.59°C (n=50) (Odinaka et al., 2014)
TAT and AT no significant difference (n=193) (Bindu et al., 2015)	TA to RT = ± 0.58°C. Children 1-18 (n=205) (Hamilton et al., 2013)
TAT and RT 0°C difference (n=294) (Allegaert et al., 2014)	TA to RT = -0.96-0.04°C (Reynolds et al., 2012).
TA and RT no significant difference. Children 0-36 months (n = 47) (Bahorski et al., 2012)	AT to RT= -1.42- -0.44°C Children < 4 years (n= 52) (Reynolds et al., 2012).
TA and nasopharyngeal no significant difference. Children 1 month – 4 years (n=60, readings done 6 times on each child) (Sahin et al., 2012)	TA to RT = -0.74-0.52°C Children 0-18 years (n=198) (Penning et al., 2011)
TA 0.2°C higher than AT. Healthy newborns > 35 weeks (n=125) (Haddad et al., 2012).	TA to AT = 0.1-.0.8°C Infants in room air or under phototherapy (n=169) (Sim et al., 2016)
TA accurate in comparison to RT and AT: Neonatal (n=34) all within 0.5° (Lee et al., 2011)	
TA and RT 0.03 °C mean difference (n = 450) (Carr et al., 2011)	
RT to TA difference = 0.48°C. Children 3-36 months (n=474) (Holtzhauer et al., 2009)	
RT to TA range of difference – 0.2 to 0.4 °C. Children 1-7 years (n=42) (Titus et al., 2009)	

Strengths	Weaknesses
Redefined Fever	Missed Fevers
TAT 37.7°C equivalent to RT 38° (Odinaka et al., 2014)	TA not a substitute for RT in infants <3 months for febrile screening (Schuh et al., 2016)
By changing the definition of febrile for TA to 37.7°C caught 100% of febrile patients (n=42) (Titus et al., 2009)	TA ineffective as screen for febrile in children (Moore et al., 2015)
	TA missed rectal fevers in 30% of children 3-36 months (n=474) range -1.4 to 0.93°C difference. (Holtzhauer et al., 2009)
	TA missed fever in 27% of children 0-18 years (n = 205). (Hamilton et al., 2013)
	TA missed fever in 33% of children 0-18 years (n=198) (Penning et al., 2011)
Comfort	
Increased comfort with TA as compared to AT as measured by FLACC pain scores (n=169) (Sim et al., 2016)	
Increased comfort with the use of TA as compared to AT as measured by FLACC pain scores. Neonatal (n=34) (Lee et al., 2011)	
Increased comfort TA compared to RT as measured by FLACC pain scores. 3-36 months (n=474) (Carr et al., 2011; Holzhauer et al., 2009	

Table 3.

Outline Content Validation (Appendix C): Item rated 3 or 4 on Point Relevance Scale

Item 1	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Experts in Agreement	Item CVI
1	✓	---	✓	✓	✓	✓	5	.83

Table 4.

Toolkit Content Validation: (Appendix D): Items rated 3 or 4 on Point Relevance Scale

Item 1	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Experts in Agreement	Item CVI
1	✓	✓	✓	✓	✓	6	1.00
2	✓	✓	✓	✓	✓	6	1.00
3	✓	✓	✓	✓	✓	6	1.00
4	✓	✓	✓	✓	✓	6	1.00
5	✓	✓	✓	✓	✓	6	1.00
6	✓	✓	✓	✓	✓	6	1.00
7	✓	---	✓	✓	✓	5	.80
8	✓	✓	✓	✓	✓	6	1.00
9	✓	✓	✓	✓	✓	6	1.00
					Average I-CVI =	.98	
Proportion relevant	1.00	.89	1.00	1.00	1.00		

I-CIV, Item-level content validity index; scale-level content validity index, universal agreement (UA) method (S-CVI/UA) = .70; scale-level content validity index, averaging method (I-CVI/Ave) = .98; average proportion of items judged relevant across 9 experts = .98.

Appendix A: EBP Table Literature Review of Pediatric Temperature Taking

Citation	Main finding	Research method	Strengths of study	Weaknesses	Level of Evidence*
Allegaert, Casteels, van Gorp, Bogaert, 2014.	N = 294 Ages 0.02-17 years (median 3.2 years) Temporal artery thermometer varied from rectal thermometer by 0°C ($p = 0.9288$)	Comparison of RT, TAT, AT	TAT and RT no statistical difference		B
Bahorski, Repasky, Ranner, Fields, Jackson, Moultry, Pierce, & Sandell, 2012.	N = 47 children Ages 3-36 months Rectal temperature (RT) compared to temporal artery temperature (TAT or TA) "The data analysis revealed no statistically significant difference between TAT and RT, $t(25.01) = -1.77$, $p = .089$. Relational analysis revealed a statistically significant relationship between TAT and RT measures using Pearson's r ($r = .85$, $n = 47$, $p = .01$) and Spearman's rho ($\rho = .86$, $n = 47$, $p = .01$)." p. 245	Comparison of RT and TAT	TAT and RT no statistical significant difference		B
Bindu, Jose, Kutty, Menon, Divya, 2015.	N=193, neonates Axillary temperature (AT) to TA ± 0.1°C (*r=0.94*) Infrared reliable and accurate	Prospective comparative. Simultaneous measurements	± 0.1°C		A

Bridges & Thomas, 2009.	Compared literature States that the gold standard of thermometer accuracy is ± 0.5 °C from pulmonary artery	Synthesis of literature	Creates standard of ± 0.5°C accuracy	Compares only to Pulmonary artery (PA) temperature	A
Carr, Wilmoth, Geoglos Eliades, Baker, Shelstak, Heisroth, & Stoner, 2011.	0-24 months febrile (>38°C) 450 paired temps SPSS TA higher than rectal (*r*=.776) Sensitivity 84.7% agreement between TAT and RT Specificity 94.7% differed by 1°C or less FLACC post TAT 0.5 rectal 2.22 (p <.05) Nursing time (450 measurements) 47 seconds rectal 6 seconds TAT	TAT and RT repeated if febrile FLACC	Reduced nursing time by 41 seconds per measurement Less discomfort with TAT	0.03°C mean difference between TAT and RT	B

Haddad, Smith, Phillips, & Heidel, 2012.	125 healthy newborns > 35 weeks AT and TAT paired *t*-test difference normally distributed, ANOVA done for both *p<.05* "Temporal temperatures were significantly higher (M = 36.9◦ C, SD = .59) than axillary temperatures (M = 36.7◦ C, SD = .68), t(112) = 6.74, p< .001. Temporal temperatures ranged from 36.1◦ C to 37.8◦ C." p. 387	AT and TAT	TAT 0.2° C higher than Ax		B
Hamilton, Marcos, & Secic, 2013.	205 children aged 0-18 years TAT to RT: SD = 0.58°C TAT in febrile lower 0.42°C 27.5% febrile misclassified as afebrile (<38°C) TAT sensitivity = 0.726 = 73% TAT specificity = 0.964 = 96%	7 temps per patient, 3 ear, 3 forehead or behind ear, 3 minute rectal or oral as control	TAT	TAT missed 27.5% febrile TAT to RT = ± 0.58°C	B

Holtzhauer, Reith, Sawin, & Yen, 2009.	474 children 3-36 months 201 febrile Mean deviation TAT to RT = 0.48°C Paired t test of FLACC scores -13.73 (p≤.001) Difference -1.44 TAT ability to detect rectal fever was .70 Sensitivity of TAT = 0.70 = 70% Specificity of TAT to detect rectal fever was .96 = 96%	Rectal and TAT	RT to TAT = 0.48°C (within the 0.5°C precision value) FLACC scores 1.44 lower with TAT than RT	No inter-rater reliability – train the trainer teaching for TAT	B

Lee, Flannery-Bergey, Randall-Rollins, Curry, Rowe, Teague, Tuninga, & Schroeder, 2011.	N= 34 neonates aged 32-40 weeks gestation in bassinets “Average temperature differences (bias) SD (precision) for the test thermometers (temporal artery; axillary) compared to the reference standard (rectal) thermometer were -0.30 °C - 0.44 °C for the temporal artery device and-0.28 °C - 0.33 °C for the axillary device” p. 65 TAT and AT without significant difference Precision values for both devices were within the acceptable range of - 0.5 °C or less often cited by experts14,22,35,36 Discomfort scores 41% higher than baseline with ax compared to 9% higher than baseline with TAT		Reduced discomfort with TAT as compared to AT TAT to rectal - 0.30 °C - 0.44 °C (within the 0.5°C precision value)		B
Moen, Chapman, Sheehan, & Carter, 1987.	25 pts. N= 300 temperatures Gestational ages 28-36 weeks High correlation between rectal and axillary (3 minutes) temps Mean difference 0.07 °C (SD= 0.14)	Compare 3, 5, 8 minute temps rectal and axillary in neonates	Seminal study comparing rectal and axillary readings with correlation 0.07 °C	Mercury thermometer s	B

Muth, Statler, Gentile, & Hagle, 2013.	N= 838 children Evaluated records – only 288 were febrile on admission. Recommend using non-invasive temperature measurements				E
Odinaka, K., Edelu, B., Nwolisa, C., Amamilo, I., & Okolo. 2014.	N = 156 Age 0-5 years Nigeria Emergency room assessment for fever TAT 37.8°C ± 1.1°C ($p = 0.001$) Neonates TAT 0.02 ± 0.59 ($p = 0.8100$) TAT 37.7°C equivalent to RT 38°C	TAT first then RT (mercury)		TAT to RT ≤28 days 0.02 ± 0.59 29 d-11 mo 0.42 ± 0.66	B
Penning, C., van der Linden, J.H., Tibboel, D., Evenhuis, 2011.	N= 198 children between 0-18 years. Emergency department and day care. Mean absolute difference between TA and RT was -0.11 ± 0.63 °C. Generally, TAT lower than RT. TAT failed to detect fever in 26 of 81 children – sensitivity = 67.9 specificity = 98.3	RT to TAT within 15 minutes	Correct TAT method taught	TA to RT -0.74-0.52	B

Reynolds, Bonham, Gueck, Hammond, Lowery, Redel, Rodriguez, Smith, Stanton, Sukosd, & Craft, 2012.	52 children < 4 years AT -0.93 ± 0.49 °C compared to RT TA -0.46 ± 0.50 °C compared to RT Bias and precision for the temporal artery and axillary devices were –0.46°C ± 0.50°C and –0.93°C ± 0.49°C, respectively. P. 1 TA less variation than AT		TA less variation than AT	TA to RT -0.96-0.04 AT to RT -1.42- -0.44	B
Sahin, Duran, Sut, Colak, Acunas, & Aksu, 2012.	60 children Ages 1 month – 4 years NP and TA no statistical difference (p< .001) at 15, 30, 45, 60, 90, and 120 minutes, and the completion of surgery. AT lower than NP and TA (p<.001)			NP and TA no difference	B
Titus, Hulsey, Heckman, & Losek, 2009.	42 children Ages 1-7 years RT to TA – 0.2 to 0.4 °C Fever not missed by TAT in any of the 11 patients Comparison of TAT and RT Pearson (*r*=.91, *p*< .0001) TAT febrile should be 37.7 °C as compares to RT 38.3 °C sensitivity 100% specificity 93.5%		By changing definition of febrile for TAT to 37.7°C caught 100% of febrile patients RT to TA – 0.2 to 0.4 °C		B

Note.
*Levels of evidence:
AACN's new evidence-leveling system
Level A: Meta-analysis of multiple controlled studies or meta-synthesis of qualitative studies with results that consistently support a specific action, intervention or treatment

Level B: Well-designed controlled studies, both randomized and nonrandomized, with results that consistently support a specific action, intervention, or treatment
Level C: Qualitative studies, descriptive or correlational studies, integrative reviews, systematic reviews, or randomized controlled trials with inconsistent results
Level D: Peer-reviewed professional organizational standards, with clinical studies to support recommendations
Level E: Theory-based evidence from expert opinion or multiple case reports
Level M: Manufacturers' recommendations only
(Armola et al, 2009)

Appendix B: Outline of the Content of the Toolkit for Implementation of Temporal Artery Thermometers for Neonates

Outline of Content of the Toolkit

1. Powtoon presentation “Temporal Artery Thermometers in Neonates”
    a. Contents include EBP, instructions for use, what to do if out of range
2. Powtoon presentation “Let's apply change theory to nursing practice change”
    a. Using Rogers Diffusion of Innovation theory
3. Powtoon presentation “List of References”
    a. Pertinent references and webpages

Appendix C: Content Validity Survey for Expert Consultant Input on the Educational Toolkit to Teach Nurses about Using Temporal Artery Thermometers for Neonates.

	Strongly Disagree =1	Disagree =2	Agree =3	Strongly Agree =4
1. The outline for education and implementation is appropriate for the topic.				

Appendix D: Content Validity Survey for Expert Consultant Input on the Educational Toolkit to Teach Nurses about Using Temporal Artery Thermometers for Neonates.

	Strongly Disagree =1	Disagree =2	Agree =3	Strongly Agree =4
2. The temporal artery thermometer is accurate for routine temperature measurements.				
3. The temporal artery thermometer takes less time for measurement as compared to axillary measurement.				
4. The temporal artery thermometer takes less time for measurement as compared to rectal measurement.				
5. The infant has less discomfort with the temporal artery measurement as compared to axillary measurement.				
6. The infant has less discomfort with the temporal artery measurement as compared to rectal measurement.				
7. A high or low reading with the temporal artery thermometer should be followed up with a rectal temperature measurement.				
8. All febrile infants will be captured if rectal temperatures are performed for a temporal temperature over 37.7°C.				
9. The visual reference adequately demonstrates the technique for using a temporal artery thermometer.				