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Improving the Accuracy of Temporal Artery Thermometry in Pediatric Direct Care Providers: A Performance Improvement Project

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Abstract

Purpose: The purpose of the project was to improve the accuracy of temporal artery thermometry (TAT) measurements compared to axillary, rectal, and oral thermometry readings on a Pulmonary Pediatric Care Unit.

Design and Methods: A pre-educational and post-educational competency tests and skill performance test of obtaining accurate TAT results with an Exergen 5000 Temporal Scanner were implemented after the pediatric nursing staff participated in a 60-minute educational program. Of the 32 participants, most were RNs (84%) followed by certified nursing assistants (9%) and LPNs. Most participants worked the 12-hour day shift 7a-7p (59%), followed by the 7a-3p shift (38%) and one participant who worked the night shift 11p-7a (3%).

Results: The mean score for the pre-test was 3.5 out of 6, and the post-test score was 5.4 out of 6. A two-tailed paired sample t-test indicated that the mean pre-test score (3.5) is significantly different from the mean post-test score (5.4). Further, a one-tailed test showed that the mean post-test score was significantly higher than the mean pre-test score ($t=6.9$; $p<0.001$). All project participants scored 100% on the skills demonstration tests after receiving the educational intervention; there was no pre-test for the skills demonstration test.

Conclusion: TAT measurements are more precise and accurate when obtained using the appropriate technique. A comparison between competency test performance before and after the TAT educational program suggests that the intervention can help improve the accuracy of TAT measurements performance among pediatric nursing staff.

Implications for Nursing: TAT measurements are more precise and accurate when obtained using the appropriate technique.

Keywords: Thermometry, temporal artery, children

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I would like to thank my family for being loving and understanding as I continued my education at Jacksonville State University. With all the valuable time that I have placed toward my career, I hope that my actions inspired my daughters to reach great life achievements. I love you, always and forever!

Thank you, Jacksonville State University (JSU) Nursing Faculty for providing support and encouraging me to keep moving forward in the doctoral program! The educational experience at JSU has granted me with exceptional leadership competencies to be a great leader. I am excited to continue to apply my leadership proficiencies in my nursing career and create an inspirational impact on community health.

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Introduction

American Academy of Pediatrics (AAP) stated that Temporal Artery Thermometry measurements linked with rectal temperatures better than any other body temperature measurements (Kemp, 2013). TAT measurements have the potential to replace rectal measurement in emergency departments (Kemp, 2013). The nursing staff has been seeking other non-invasive routes of body temperature measurements, which could compare to rectal measurements to improve patient care (Kemp, 2013). TAT devices were the best and preferred routes of pediatricians, parents, and patients (Kemp, 2013; Greenes & Fleisher, 2001; Lee, Flannery-Bergey, Randall-Rollins, Curry, Rowe, Teague, Tuininga, & Schroeder, 2011).

The AAP (2007) stated that average temperature in children is 97.5 degrees Fahrenheit to 99.5 degrees Fahrenheit and recommended rapid work-up of fever (>100.4 degrees Fahrenheit) in infants under three months of age to prevent rapid health decompensations. Inaccurate thermometry can lead to false-positive fever detection and consume significant resources in unnecessary diagnostic work-ups and medical treatments (Zhen, Xia, Long, & Pu, 2014). False-negative detections can delay the diagnosis and treatment of severe illnesses and cause excessive use of medical care and resources (Zhen, Xia, Long, & Pu, 2014).

Among the acute care pediatric population, there was a clinical problem that involved improperly obtaining temporal artery thermometry (TAT) measurements compared to other thermometry devices in a pediatric care unit. TAT is the most common route to obtain body temperature measurements on pediatric patients from the age of three months and 17 years old (Mayo Clinic, 2019). Nurses obtained TAT measurements conveniently, and TAT devices were the most desirable route for patients and families. The clinical issue identified was the incorrect procedure of obtaining TAT measurements by nursing staff and how those results are being

evaluated to implement patient care. The DNP student observed nine out of ten nurses, certified nursing assistants, and nursing assistants utilizing the incorrect technique of obtaining TAT results. The majority of the nurses were observed obtaining the TAT result on one side of the forehead to the other side of the forehead, down the side of the face, then underneath the ear to the mastoid process. After obtaining the TAT results, the nursing staff was noted taking several TAT measurements, which ranged inconsistently with previous measurements. The DNP student observed another technique obtained by the nursing staff. The nursing staff was obtaining the TAT result, but was not going across the hairline to detect the temporal artery, down the side of the face, and underneath the ear. Other techniques were that the nursing staff neglected to touch behind the ear. TAT measurements were an important component of patient care and utilized to implement health care. It was necessary to explore this issue to prevent a clinical crisis, such as declination of health status, misdiagnoses, escalation of care leading to critical care transfers, or death. The clinical problem was specific to the pediatric unit, as TAT measurements were used more in this area and required immediate nursing action to improve patient care and ensure patient safety.

Background

TAT was the preferred technique for obtaining temperature results in a pediatric clinical setting. Obtaining accurate temperature measurements were imperative in evaluating health status and disease processes in children (Harris, DiCorpo, & Merlin, 2017). There was a potential for many problems to occur with unreliable readings, which may lead to inappropriate medical and nursing interventions, misdiagnosing, and treatment negligence. The DNP student identified a clinical issue after observing several of nursing staff obtaining TAT results on the unit. Upon reviewing of the hospital policy, the DNP student determined that the nursing staff

was performing TAT procedures incorrectly, which led to inaccurate TAT results. The TAT method was utilized on the unit more frequently than axillary, rectal, and oral thermometry.

It was expected for the nursing staff to know the required procedure to obtain an accurate measurement. The probe of the device should be gently positioned on the center of the forehead and lightly pressed across the forehead, keeping the sensor in contact with the skin until the hairline was reached while the TAT is measured (Mogensen, Wittenhoff, & Hansen, 2018). If the collection process was not implemented in this systematic manner, the likelihood of obtaining an inaccurate result was high (Mogensen, Wittenhoff, & Hansen, 2018). These nursing actions could decrease TAT device's ability to detect a fever and can lead to delay of treatment (Mogensen, Wittenhoff, & Hansen, 2018). According to Mogensen, Wittenhoff, & Hansen (2018), in the United States (U.S.), TAT measurements were found to be reliable in children with minor temperature differences compared to the rectal temperature measurements, and have sensitivities above 80% to detect fever. Nursing compliance with TAT instructions was an essential component for the device to be reliable as a screening tool to detect temperature instability in a pediatric population (Mogensen, Wittenhoff, & Hansen, 2018).

There were clinical documentation discrepancies of temperature results ranging from normal to abnormal thermometry readings on the pediatric pulmonary unit. Nurses were not aware of inaccurate TAT readings from work shifts to work shifts. Physicians, nurse practitioners (NPs), and other specialty teams utilized this critical assessment to determine if antimicrobial pharmacological therapies were warranted or changes in the plan of care are required. Without an accurate appraisal of thermometry measurements, pediatric pulmonary patients were potentially exposed to life-threatening conditions, such as sepsis, shock, infectious disease process, and hospital-acquired pneumonia. TAT was not sufficiently accurate to replace

one of the reference methods, such as the rectal or other invasive temperatures (Geijer, Udumyan, Lohse, & Nilsagård, 2016). Yet, TAT measurements were used frequently in pediatric hospitals compared to tympanic thermometers measurements because of the ease of use (Kiekkas, Aretha, Almpani, & Stefanopoulos, 2019). It appeared that TAT could replace tympanic thermometers with the limitations that both methods are inaccurate when not obtained with the correct procedure (Geijer, Udumyan, Lohse, & Nilsagård, 2016). Collecting TAT measurements with a poor technique led to inaccurate results, which negatively impacted patient care and well-being. Paik, Henker, Sereika, Alexander, Piotrowski, Appel, Meng, Bircher, and Henkder (2019) found the temporal artery thermometer consistently overestimated core temperature, particularly at lower temperatures. Generally, the study showed that at temperatures less than 98.7 degrees Fahrenheit (37 degrees Celsius) to 100.4 degrees Fahrenheit (38 degrees Celsius), temporal artery thermometers showed a more significant difference from a standard core temperature measurement at lower temperatures. The study findings do not support the use of temporal artery thermometry. If health care providers utilized a temporal artery thermometer in the clinical settings, the proper use of the device, as per the manufacturers' instructions, was essential. Inappropriate use, hair, or bandages over the forehead, and sweating may be interpreted as inaccurate results (Paik et al., 2019). Therefore, TAT devices are sensitive to a systematic approach, which determines the accuracy of body measurements.

Some research studies have found TAT devices not as accurate and desirable as other traditional body measurement devices, similar to rectal, axillary, and oral (Kiekkas, Aretha, Almpani, & Stefanopoulos, 2019; Otto, 2017). A systematic review and meta-analysis revealed that TAT has satisfactory accuracy, precision, and specificity when used in pediatric patients (Kiekkas, Aretha, Almpani, & Stefanopoulos, 2019). Though, due to its low sensitivity, TAT

method does not meet the demands of health care providers for identifying a standard proportion of fever cases and cannot be recommended for the substitution of existing invasive methods of measuring body core temperature in children (Kiekkas, Aretha, Almpani, & Stefanopoulos, 2019). Until improved devices are developed, health care providers should interpret TAT readings with particular caution (Kiekkas, Aretha, Almpani, & Stefanopoulos, 2019). In this study, Otto (2017) compared rectal and temporal artery thermometry. The average distance of a rectal measurement from the mean rectal temperature of 98.3 degrees Fahrenheit was 0.45 degrees Fahrenheit. The second reading of the rectal temperature varied a half a degree or higher from the first taken measurement in the same infant (Otto, 2017). The average distance of TAT from the mean was 0.34 degrees Fahrenheit (Otto, 2017). TAT over-valued temperature measurements by an average of a quarter of a degree, compared with rectal measurements. Therefore, small estimations could lead to unnecessary sepsis work-ups (Otto, 2017).

Several studies have supported the accuracy of TAT devices and the significance of obtaining accurate measurements. Barry, Branco, Kargbo, Venuto, Werfel, Barto, and Glasofer (2016) research hypothesized that TAT measurements have many benefits in the clinical setting. TAT devices are minimally invasive, quick, and safe. Barry et al. (2016) hypothesis inferred that user technique significantly impacts the reliability and validity of TAT measurements. The study results highlighted the importance of the correct method, and it was imperative that nurses understand the impact of incorrect results. Periodically, it may be more appropriate to reevaluate user technique than to question the reliability of the device (Barry et al., 2016).

TAT measurements were found to be as accurate as axillary temperature (AXT) measurements in neonates between 28 and 36-week method (Smith, Keltner, Stickes, Hayes, & Crawford, 2018). In a recent study that compared temperature methods, TAT and AXT were

used to assess temperatures during the day shift and again during the night shift with no significant difference between methods at either time of day (Smith, Keltner, Stickes, Hayes, & Crawford, 2018). Clinical significance to the nursing staff was the convenience of TAT compared with AXT. The temporal region was easily accessed in most neonates without the need to uncover, reposition, or undress the infant. Statistically and clinically significant was the time difference between TAT and AXT body measurements method (Smith, Keltner, Stickes, Hayes, & Crawford, 2018). The time it took to obtain the temperature was significantly shorter for the temporal artery method than the axillary method (Smith, Keltner, Stickes, Hayes, & Crawford, 2018). Reynolds, Bonham, Gueck, Hammond, Lowery, Redel, Rodriguez, Smith, Stanton, Sukosd, & Craft (2014) study suggested that TAT measurements were within the range set by experts to use a noninvasive thermometer as a substitute for invasive body temperature measurements. A noninvasive method for temperature assessment in very young children could decrease physical and psychological discomfort associated with rectal temperature for both the child and parent (Reynolds et al., 2014). Therefore, a TAT device was a great contributor to patient care and nursing staff and its clinical significance compared to AXT and body measurements.

When a TAT method was compared to a rectal method in a clinical setting, rectal temperature measurements were considered as the gold standard of obtaining core temperatures (Kemp, 2013). TAT detected high fevers with 100% sensitivity and specificity. TAT screening for well and ill children has the potential for clinical practice by diminishing rectal measurements in the acute care setting (Moore, Carrigan, Solomon, & Tart, 2015). Rectal temperature measurements caused children complaints, parents' distress, and increased the triage process time. Compared to rectal thermometry results, TAT measurements were painless, and

noninvasive screening methods provided consistent, accurate measurements, increased nurses' and patients' satisfaction, decreased triage time, and overall enhanced the quality of patient care (Hurwitz, Brown & Altmiller, 2015).

Many meta-analyses have been published investigating the accuracy of TAT measurements and other noninvasive methods in approximating core body temperatures (Opersterny, Anderson, Bates, Davenport, Husby, Myking, and Oron, 2017). Geijer, Udumyan, Lohse, and Nilsagard analyzed 37 studies of TAT accuracy. Zhen, Xia, Long, and Pu analyzed 28 studies of tympanic thermometry accuracy (Opersterny et al., 2017). Niven, Gaudet, Laupland, Mrkls, Roberts, and Stelfox analyzed 69 studies of children and adults, examined the accuracy of noninvasive methods, and 20 studies examined the sensitivity of detecting fevers (Opersterny et al., 2017). The meta-analyses studies indicated that no extensive use of non-invasive methods of thermometry achieved the acceptable criterion of remaining within plus or minus 0.5 degrees Celsius of core temperature 95% of the time compared to a TAT device (Operstern et al., 2017).

Although, TAT devices have competitive benefits compared to other temperature devices, inaccurate results can lead to medical complications for the patient and a financial burden of expenditures for the organization. Gates, Horner, Bradley, Sheperd, John, and Higgins (2018) suggested that temporal artery thermometers are an accurate substitute for oral thermometers in normothermic patients; they may not be as precise as predicted with febrile patients. This inaccuracy may have led to false or unknown fever identification and unnecessary delays in clinical interventions, such as antimicrobial therapy, blood cultures, and x-rays.

In pediatric and other clinical settings, a life-threatening condition can be misdiagnosed if TAT measurements are not accurate. Among children, sepsis was the leading cause of death

throughout the world (Randolph & McCulloh, 2014). According to the World Health Organization (2018), three million newborns and 1.2 million children suffer from sepsis globally. An abnormal temperature was defined as a fever (core temperature > 98.5 degrees Fahrenheit) or hypothermia (core temperature < 96.8 degrees Fahrenheit) which is a sign of sepsis or sepsis shock (Randolph & McCulloh, 2014). Sepsis was considered a medical emergency that required immediate medical attention (WHO, 2018). Temperature instability, along with other sepsis signs and symptoms, indicated a child was at risk for sepsis-related disabilities and death (Randolph & McCulloh, 2014). Many of the signs and symptoms of sepsis, such as fever, have made sepsis difficult to diagnose in its early stages, according to the Center for Disease Control and Prevention (CDC, 2018). Therefore it is necessary to obtain accurate temporal artery measurements to prevent sepsis in the pediatric population.

The cost of escalation in care for treating sepsis can place a financial strain on a health care organization. According to Paoli, Reynolds, Shinha, Gitlin, and Crouser (2018), the cost of sepsis management continued to be a significant problem in the United States (U.S.) compared to other health care diagnosis. In 2013, sepsis accounted for more than $24 billion in hospital expenses (Paoli et al., 2018). Over 970,000 sepsis cases per year were admitted to the hospital in the U.S., and the cases continue to increase (Paoli et al., 2018). Sepsis accounted for more than 50% of deaths in the hospital, 10-20% for sepsis, 20-40 for severe sepsis, and 40-80% for septic shock (Paoli et al., 2018). In the U.S. hospitals, septic patients had an average length of stay (LOS) 75% higher than for any other condition (Paoli et al., 2018). If elevated temperatures are not identified and treated promptly, sepsis shock can occur and increase the length of stay (LOS) from a mean of 4.5 to 16.5 days. Septic shock could have an adverse effect on patients' health outcomes (Paoli, 2018).

Problem Statement

The pediatric nursing staff was obtaining inaccurate TAT measurements by incorrectly implementing the TAT procedure according to the hospital policy. Many of the nursing staff did not recognize the wrong technique of obtaining TAT measurement. TAT measurements were utilized to develop the plan of care for patients. Obtaining inaccurate TAT measurements could lead to misdiagnosing, delay of treatment, unnecessary treatment, or death. Due to inaccurate implementation of clinical practice of TAT measurements, the DNP student formulated the acronym, P = Population/ Problem, **I** =Intervention, **C** = Comparison, **O** = Outcome, **T** = Time, in a PICOT question as a DNP project: **In the pediatric nursing staff population, does a TAT educational program improve the accuracy of TAT results versus no educational program?** To help address this clinical problem, the DNP student planned to implement a TAT educational program with the nursing staff to improve the accuracy of TAT results and patient care and safety. All nursing staff who participated in obtaining vital signs in the pediatric care unit was expected to attend a session. The intervention implemented in the project included a pre-educational TAT test, a TAT educational program, a video and demonstration of obtaining an accurate TAT result, and a post-educational TAT test. The DNP student expected that a TAT educational program would facilitate and improve nursing competency and patient care delivery.

Organizational Description of Project Site

The DNP student observed the nursing staff obtaining TAT measurements inaccurately in a pediatric pulmonary care unit. When the TAT results were evaluated, there were variations identified from shift to shift. Inaccurate results were utilized to formulate a plan of care for patients. It was observed that nursing staff continued to obtain TAT measurements inaccurately without being aware of the improper techniques. It was imperative to address this clinical issue

to improve nursing staff competency, patient care, patient outcomes, and patient quality of care. This project was appropriate for this unit due to the on-going problem that required a quality improvement intervention to assist the patient, the nursing staff, and the health organization. Additionally, TAT was the preferred mode of temperature measurements in the pediatric pulmonary unit.

Review of Literature

Selection of the Most Accurate Thermometer Devices for Clinical Practice: Part 1: Meta-Analysis of the Accuracy of Non-core Thermometer Devices Compared to Core Body Temperature.

Wenger, Sims, Patton, and Williamson (2018) systematic review article was identified as having Level I evidence on the Melynk scale. It showed strong evidence that only oral and rectal thermometry should be used to measure individuals' temperature for screening, monitoring, diagnostic, and treatment purposes. Tympanic, temporal artery, axillary thermometry devices should only be used to regulate body temperature for screening purposes. In the clinical setting where the nursing staff was trained to utilize types of thermometry, there were some concerns after the initial training that knowledge begins to deteriorate. Due to a routine usage of the device, a technical understanding of how to properly use the thermometer may have decreased over time. Repeatability became an everyday task for accuracy in obtaining temperature measurements.

Forehead or Ear Temperature Measurement Cannot Replace Rectal Measurements, Except for Screening Purposes

Mogensen, Wittenhoff, Fruerhoj, and Hansen (2018) quantitative study was identified as having Level IV evidence on the Melynk scale. The study provided supportive evidence of

clinical guidelines and everyday clinical practice based on rectal measurements. It was a case-controlled study. The study recommended the rectal device as the gold standard to represent core body temperature. Temporal and tympanic devices could be utilized as a screening tool for temperature measurements. Similarly, Wenger, Sims, Patton, and Williamson (2018), proposed that TAT devices were acceptable as a screening tool. However, if a fever was detected, a rectal thermometry measurement is warranted (Wenger, Sims, Patton, & Williamson, 2018).

Axillary, Tympanic, and Temporal Thermometry Comparison in a Community Hospital Pediatric Unit.

Kurnat-Thoma, Edwards, and Emery (2018) quantitative study represented Level IV evidence on the Melynk scale. The article showed strong evidence and emphasized the proper technique of obtaining a TAT reading is required to facilitate accurate measurements. The TAT device does have variability from the recommended non-invasive standards. When thermometry results were obtained without proper techniques, nursing care and treatment were compromised, which led to risks outweighing benefits. Competency skills evaluation requirements of TAT were needed before being utilized for obtaining patient data. As recommended in the other two previous studies, a TAT device could be used as a screening tool. The accuracy of measurements may require a repeat assessment if a fever is detected.

Based on evidence-based research, the DNP student acknowledged the significance of obtaining accurate TAT measurements compared to other thermometry results in pediatric patients. The DNP student gained knowledge and expanded clinical expertise to improve pediatric nursing clinical practice and patient outcomes by utilizing quality improvement interventions. The DNP student concluded that axillary, rectal, and oral thermometer devices have more supportive evidence of obtaining core body temperature measurements than a TAT

device. However, literature reviews have proven that TAT devices may be utilized as a screening tool to detect temperature instability.

The DNP student appreciated the importance of evaluating temperature measurements to improve patient health outcomes. Monitoring body temperature was one of the most critical vital signs to indicate whether an illness was developing. Patient safety was compromised if an illness is not detected promptly. Nursing compliance in obtaining TAT measurements was critical to ensure accurate body temperature results. Utilizing a TAT device required repetitive monitoring with other evidence-based practice thermometry, and it captured variable readings that were not always reliable. Implementation of the TAT educational program helped address the knowledge deficit of the nursing staff assessment and skills. The TAT educational program promoted high-quality and safe nursing care. Axillary, rectal, and oral thermometry devices provided accurate results which are most important in making sound treatment decisions. However, TAT measurements were mostly utilized in a clinical setting as a screening tool in the pediatric population and should be adequately integrated into nursing staff daily practice to advance the quality of care and to support patient safety.

Evidence-Based Practice: Verification of Chosen Option

The DNP student implemented an evidence-based program, Temporal Artery Thermometry (TAT) Education Program, to improve the accuracy of TAT measurements in pediatric patients on the pulmonary unit. According to Graebe (2019), competency assessment evaluates the achievement of a learner outcome. A 60-minute TAT educational program was implemented by the nursing staff, including competency questions and skills demonstration. Kurnat-Thoma, Edwards, & Emery (2018) recommended evaluating the user's competency and skills prior to obtaining patient data for delivery of care. The DNP student adopted a pre-

educational, post-educational, and skills demonstration test from Exergen Company to improve TAT measurements' accuracy.

Theoretical Framework/Evidence-Based Practice Model

Lewin's Change Theory, created by Kurt Lewin, addressed the clinical issue and the PICO question, which guided the DNP student's project. Change was defined as a concept that is going to occur when the objective of a problem is to show improvement. Lewin's Change Theory was often used in health care and nursing when change is the desired outcome. In Lewin's Change Theory, Lewin described change as a dynamic force within an organization that moves in opposing directions (Butts & Rich, 2018). A driving force motivated the participants toward needing a change, while participants used a resistant method against the change and preferred to operate in their usual manner (Butts & Rich, 2018). Lewin's Change Theory consists of three stages of the change process: Unfreezing, Moving (Change), and Refreezing (Butts & Rich, 2018).

The first stage of Lewin's Change Theory is unfreezing. In this stage, the need for change was identified, and the old behaviors were expected to be discarded or unlearned (Butts & Rich, 2018). The DNP student identified the unfreezing stage of Lewin's Change Theory during observation of inaccurate TAT measurements being obtained by nursing staff. This step required managers and leaders to prepare for change and the DNP student to help others to prepare for change through motivation and education. The DNP student consulted with the unit manager regarding implementing a TAT educational program to improve the accuracy of TAT measurements among pediatric nursing staff. The DNP student established a deadline to implement the TAT educational program. Therefore, the pediatric nursing staff could understand that there is a necessity for a change, and there was a timeline to adhere to (Connelly, 2016).

The DNP student carefully considered the implementation of the TAT educational program in a manner that would result in the least conflict in moving the change of practice forward.

The second stage of the Lewin's Change Theory was Moving (Butts & Rich, 2018), also known as Changing (Connelly, 2016). This stage allowed the participants to move forward with the change and anticipated acceptable behaviors toward the change (Butts & Rich, 2018). The DNP student implemented critical actions to promote change. The pediatric nursing staff received extensive education through the TAT educational program. They were provided with an expectation date to start implementing the correct practice of obtaining accurate TAT measurements. Supportive techniques, such as answering questions, addressing concerns, and providing encouragement, were implemented for nursing staff who may encounter the difficulty in retaining education regarding the change. Necessary alterations to the change strategy were deliberated after constructive feedback from the pediatric nursing staff was composed. After the pediatric nursing staff completed the TAT educational program, the DNP student continued to support the change process and encouraged the staff as the change was being applied. Nursing staff who accepted the change were expected to promote and support their co-workers. The DNP student communicated with the nursing staff by discussing the benefits of implementing the TAT educational program to improve the accuracy of TAT measurements (Connelly, 2016).

Refreezing was the third stage of Lewin's Change Theory (Butts & Rich, 2018). The change has been implemented. Stability was a critical component to change, holding, and refraining from going back to the old way before the change (Connelly, 2016). The DNP student provided support to the nursing staff throughout the implementation of the TAT educational program. The DNP project demonstrated the importance and benefits of providing safe, high-quality nursing care. The nursing staff received consistent collaboration from the DNP student

through their doubts of uncertainty about the change. Those individuals who did not embrace the change received additional support to appreciate the TAT educational program content (Connelly, 2016).

Throughout the DNP project, the DNP student realized that change would not occur immediately and that it would be an on-going process that required time to implement. The change was a slow and supportive process. Reinforcing the importance of the change was necessary among the pediatric nursing staff to facilitate safe nursing care and improve health outcomes.

Goals, Objectives, and Expected Outcomes

The goal of this DNP project was to improve the quality and safety of patient care delivery. To achieve the stated purpose, accurate assessment, screening, and documentation were required interventions to maintain patient safety and improve patient outcomes. Patient care suffered when the nursing staff was not delivering interventions that were required to improve patient outcomes. Nursing assessments significantly impacted patients' health outcomes.

The objectives of this DNP project were to implement the following to address the PICO question: (1) improve nursing assessment skills, (2) educate nurses and nursing staff on how to obtain accurate TAT measurements, (3) improve quality of care, (4) and to improve patients' health outcomes. The implementation of the TAT educational program addressed the clinical issue of improperly obtaining inaccurate TAT results. Through the DNP project, the DNP student provided the educational program in a 60-minute session. The educational session included a pre-educational test, a post-educational test, and a skill demonstration for obtaining an accurate TAT measurement.

The TAT educational program results showed an improvement of post-educational test results compared to pre-educational test results on how to obtain TAT measurements as recommended by hospital protocol and the Exergen 5000 Temporal Scanner. The effectiveness of the implementation of the educational program showed significant improvement and had proven that the nursing staff did show a knowledge deficit of obtaining accurate TAT measurements. The DNP student continued implementing TAT pre-educational and post-educational tests to enhance the quality of care, which improved patient health outcomes. Throughout the quality improvement project, the DNP student monitored the proper technique of obtaining TAT results of the pediatric nursing staff who participated in the educational program. Implementation of the TAT educational program improved the quality of care, improved patients' health outcomes, and facilitated safe patient care.

Project Design

The DNP student implemented a quality improvement project design utilizing the quantitative method design for data collection. A statistician was consulted to analyze the pre-educational TAT test results, post-educational TAT test results, and the accuracy of the TAT skills demonstration. The DNP student measured the improvement of implementing the TAT educational program.

The project site setting was in a metropolitan Children's Hospital in the Southeastern Region. The unit had twenty-four monitored beds and 10-12 nursing staff on every shift. Pediatric patients' ages range from 1 week to 21 years of age. The TAT device, Exergen 5000 Temporal Scanner Series, a hospital-approved device, was utilized in the TAT educational program.

The clinical experience of the nursing staff was categorized from novice to expert. The nursing staff was sorted into millennials, Generation X, and baby-boomers categories. The unit manager was aware and supportive of the DNP project. The unit manager assisted in encouraging the TAT educational program for all nursing staff and encouraged the facilitation of the project as needed to gain staff buy-in. The entire nursing staff was allowed to participate in the project. For the project, the DNP student discussed the nursing hierarchy for the unit. There was a charge nurse for each shift, a unit educator, and 70 nursing staff members. In the Pulmonary Care Unit, respiratory interventions were rendered to patients assigned to the specialty care team. The project was discussed in unit meetings to encourage participation in the TAT educational program.

Setting Facilitators and Barriers

The DNP student utilized the following resources, which facilitated this project was the Exergen Temporal Scanner 5000 Series device, the TAT pre-educational test, the post-educational test, and the skills demonstration. All the necessary resources were critical for obtaining an accurate TAT result. The nursing staff was educated at the time of new nurse hires with plans to initiate an annual unit-based competency evaluation to facilitate accurate TAT measurements (Kurnat-Thoma, Edwards, & Emery, 2018). During the implementation of the DNP project, there were potential internal threats that could have negatively impacted the implementation of the project. A potential constraint could have been if a Children's Hospital Assessment Team (CHAT) event or code occurred on the unit. To overcome the potential limitation, the DNP student had anticipated rescheduling the TAT educational program to another date.

Implementation Plan/ Procedures

Measurement Instruments

To measure the outcomes of the DNP Project, the following instruments were utilized: pre-educational test, post-educational test, and a skills demonstration on how to obtain accurate TAT results. The competency test was generated by the DNP student with the content obtained from Exergen Corporation. A pre-test was administered to evaluate the TAT knowledge, including the hospital policy (see *Appendix B* for TAT pre-test and *Appendix C* for TAT post-test educational program, and *Appendix D* for TAT Skills Test). Utilizing the pre-test and post-test tools allowed the DNP student to measure the amount of knowledge retained on TAT measurement content. The DNP student expected the nursing staff to have great improvement in post-test TAT after receiving education. The post-results proved that the nursing staff had an understanding and knowledge about TAT measurements. If post-test results were unsatisfactory, remedial TAT educational program sessions were re-introduced as needed. The TAT skills demonstration test supported the accuracy of the nursing staff technique.

Data Collection Procedures

The DNP student administered a TAT pre-test competency test to determine the level of knowledge that the nursing staff had before the education. The results were computed by utilizing the Excel program. The DNP student introduced a TAT device demonstration to all nursing staff using the Exergen Corporation video. A comprehensive TAT educational program was presented to all nursing staff. All nursing staff was expected to attend a TAT educational program. The educational program lasted 60-minutes. All the nursing staff received TAT education, and additional educational sessions were scheduled if needed. A post-educational test was administered after obtaining an educational session. The results were computed by utilizing

the Excel program. Pre-educational test and post-educational test data collection results were analyzed by utilizing Excel. The results of the TAT pre-educational test and post-educational test were evaluated. After analyzing the results, the data was presented to all nursing staff and administration. To test the effectiveness of the educational program using a paired sample t-test, one-group pretest-posttest design with $\alpha=0.05$, and medium effect size (Cohen's $d = 0.5$) (Sawilowsky, 2009), 33 participants needed to achieve 80% power for both a two-tailed and a one-tailed test. Thirty-two participants were recruited for a power of 78%.

Data Results

The data was analyzed using an Excel file on one computer, which was encrypted and locked with a unique user name and password. A statistician was consulted to analyze the data and provide pre-educational and post-educational competency test results. The pre-educational and post-educational tests were implemented by using a pencil and paper. Of the 32 participants, most were RNs (84%) followed by certified nursing assistants (9%) and LPNs (6%) (Figure 1). Most participants worked the day shift, either the 7a-7p (22%) or the 7a-3p (37%), followed by the 7p-7a night shift (38%) and one participant who worked the night shift 11p-7a (3%) (Figure 2). The mean score for the pre-test was 3.5 out of 6. After the educational intervention was implemented the mean post-test score was 5.4 out of 6. A two-tailed paired sample t-test indicated that the mean pre-test score (3.5) is significantly different from the mean post-test score (5.4) ($p<0.001$); further, a one-tailed test showed that the mean post-test score is significantly higher than the mean pre-test score ($t=6.9$; $p<0.001$) (Figure 3). An independent group t-test comparing pre-test scores by shift did not indicate a difference in scores between day and night shift workers ($p=0.98$). The same test comparing post-test scores by shift also did not indicate a difference in scores between day and night shift workers ($p=0.40$). Of the 33 project

participants, 100% scored perfectly on the skills demonstration test after receiving the educational intervention (Figure 5); there was no pre-test for the skills demonstration test. Most members of the nursing staff verbally acknowledged that they thought the TAT educational program was beneficial and gave them the confidence to obtain accurate TAT measurements to improve patient care. The nursing staff was encouraged to seek further guidance from the DNP student if they had any inquiries about the TAT educational program.

TAT measurements were more precise when appropriately obtained when using the appropriate technique, according to Exergen Corporation and the hospital policy of the Pulmonary Pediatric Care Unit. A comparison between competency test performance before and after the TAT educational program suggests that the intervention can help improve TAT measurement performance among pediatric nursing staff. There was no statistically significant difference in performance between day and night shift workers. The project's limitation included a lack of demographic variables about participants to provide further context about the project population. This project was not conducted by random sampling and was only performed in one pediatric unit of a hospital in the southeastern United States. Thus, the project results could be generalized to other nursing populations because of the improved TAT measurement performance among pediatric nursing staff. However, future directions for evaluating a TAT device could include testing nurses at multiple pediatric settings around the country and accounting for professional factors such as years of experience or specialized certifications.

Cost-Benefit Analysis/Budget

This program utilized minimal resources with the facility. The unit manager approved the TAT educational program and the cost associated with the nursing staff's wages to attend the program. The Exergen Temporal Scanner 5000 Series device was loaned from the facility at no

cost. The facility covered the TAT video presentation and computer access. The unit manager approved scheduled times for the TAT educational program in the main conference room. Pencils, paper, and printer ink for the pre-educational, post-educational tests, were supplied by the facility at no charge.

Timeline

The DNP student proposed a detailed outline of the project. The actualization of the project included the following: proposal approval, data collection, analysis, and interpretation of outcomes. (*See Appendix E* for Timeline).

Ethical Considerations and Protection of Human Subjects

Approval from Jacksonville State University (JSU) Institutional Review Board (IRB) and the University of Alabama at Birmingham (UAB) IRB were obtained before initiating the DNP project. The DNP student did not anticipate any ethical issues during this project. All participants voluntarily agreed to participate in the project. The DNP student carefully conducted this project following hospital protocols and standards of care. Data collected during this project was obtained by the DNP student and stored securely on a computer with a unique password protection to prevent access by unauthorized users. All data was secured behind closed doors, and others did not see results. The Excel file was locked when not in use by the DNP student. No patient identifiers were involved in this project. Participants' confidentiality was assured by coding the participants using specific identification numbers. The unit manager wrote a permission letter.

Conclusion

The DNP project demonstrated that implementing a Temporal Artery Thermometry (TAT) educational program improved TAT body measurements among pediatric nursing staff. TAT measurements were more precise when appropriately obtained using the appropriate technique, according to Exergen Corporation and the hospital policy of the Pulmonary Pediatric Care Unit. A comparison between competency test performance before and after the TAT educational program suggested that the intervention addressed the clinical issue of improperly obtaining inaccurate TAT results. The effectiveness of the implementation of the educational program showed successful performance and proved that the nursing staff confirmed a knowledge deficit of getting accurate TAT measurements.

The primary purpose of this quality improvement project was to improve the accuracy of TAT measurement in pediatric nursing care. Pediatric nursing staff must utilize proper technique to improve the accuracy of TAT temperature measures. They must understand the significant impact of an improper technique of obtaining TAT measurements have on patient care. Furthermore, having self-awareness can encourage pediatric staff to be responsible for their practice and be mindful of the need for reeducation and revaluation on proper TAT performance when providing patient care. Evidence has proven that user technique significantly impacts the validity and reliability of TAT measurements. It is appropriate to reevaluate user technique rather than questioning the reliability of the TAT device (Barry et al., 2016). According to the DNP student's quality improvement project, TAT measurements are more precise when appropriately obtained using the correct technique.

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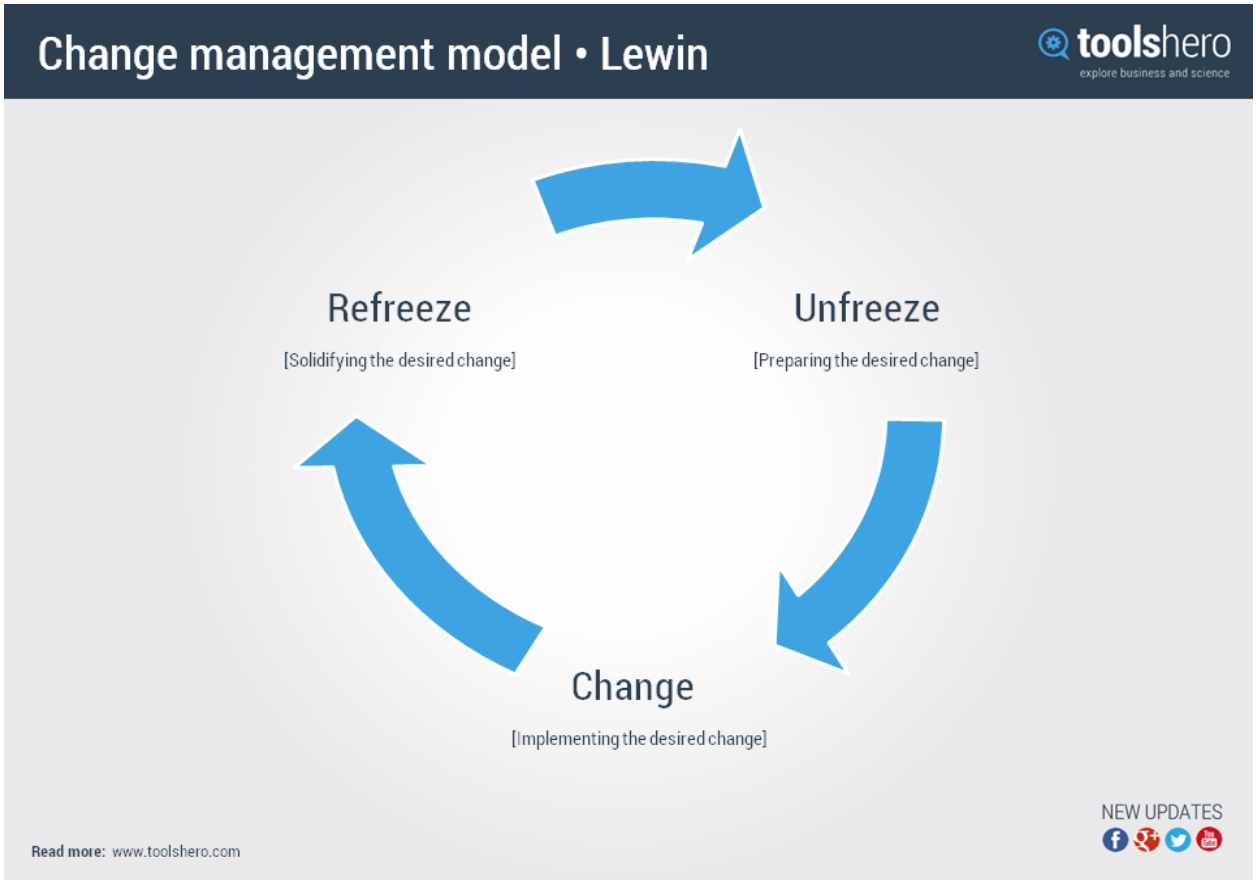
Appendix A

Kurt Lewin's Change Theory



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Appendix B

TAT Pre-Educational Test

Competency Assessment for Exergen TAT

Project participation is voluntary

Participant's Identifier:_____

Title:_____

Work-Shift:_____

Choose the best answer and circle the letter of that answer.

1. Temporal artery thermometers measure the patient's

    a. Ambient air temperature.

    b. Core body temperature.

    c. Skin temperature.

    d. Oral temperature.

2. Core temperature will show a spike in patient temperature:

    a. One to two hours later than rectal temperatures.

    b. At the same time as rectal temperature.

    c. One or two hours sooner than rectal temperature.

3. The temporal artery thermometer measures the temperature of the temporal and carotid arteries, reflecting the core temperature at the heart. In the case of the patient who has been febrile, and the fever is now breaking, the temporal artery scanner may read:

a. Lower than a rectal thermometer because the core temperature will reflect the change more rapidly than the rectum.

b. Higher than a rectal thermometer because the core temperature takes longer that than the rectum to reflect the change.

c. The same because it does not matter how or where temperature is measured.

d. Lower, because environmental factors will always affect core temperature.

4. The temporal artery thermometer may give inaccurate reading if:

1. The lens is dirty.

2. The side of the forehead measured has been resting on the pillow.

3. The patient has just finished drinking iced water.

a. 1 only

b. All the above

c. 1 and 3

d. 1 and 2

e. None of the above

5. Core temperature measurement reflects changes in the body temperature _____ oral or rectal temperature measurement.

a. Slower than

b. The same as

c. More quickly than

6. It is important to clean the lens in the center of the probe with a cotton-tipped stick applicator (Q-Tip) dampened with an alcohol prep pad.

1. Every two weeks
2. After each use
3. When the patient is discharged
4. If lens is not shiny and mirror-like

a. 1 only

b. All of the above

c. 1 and 3

d. 1 and 4

e. None of the above

Appendix C

TAT Post-Educational Test

Competency Assessment for Exergen TAT

Project participation is voluntary

Participant's Identifier:_____

Title:_____

Work-Shift:_____

Choose the best answer and circle the letter of that answer.

1. Temporal artery thermometers measure the patient's

    a. Ambient air temperature.

    b. Core body temperature.

    c. Skin temperature.

    d. Oral temperature.

2. Core temperature will show a spike in patient temperature:

    a. One to two hours later than rectal temperatures.

    b. At the same time as rectal temperature.

    c. One or two hours sooner than rectal temperature.

3. The temporal artery thermometer measures the temperature of the temporal and carotid arteries, reflecting the core temperature at the heart. In the case of the patient who has been febrile, and the fever is now breaking, the temporal artery scanner may read:

a. Lower than a rectal thermometer because the core temperature will reflect the change more rapidly than the rectum.

b. Higher than a rectal thermometer because the core temperature takes longer that than the rectum to reflect the change.

c. The same because it does not matter how or where temperature is measured.

d. Lower, because environmental factors will always affect core temperature.

4. The temporal artery thermometer may give inaccurate reading if:

1. The lens is dirty.

2. The side of the forehead measured has been resting on the pillow.

3. The patient has just finished drinking iced water.

a. 1 only

b. All the above

c. 1 and 3

d. 1 and 2

e. None of the above

5. Core temperature measurement reflects changes in the body temperature _____ oral or rectal temperature measurement.

    a. Slower than

    b. The same as

    c. More quickly than

6. It is important to clean the lens in the center of the probe with a cotton-tipped stick applicator (Q-Tip) dampened with an alcohol prep pad.

1. Every two weeks
2. After each use
3. When the patient is discharged
4. If lens is not shiny and mirror-like

    a. 1 only

    b. All of the above

    c. 1 and 3

    d. 1 and 4

    e. None of the above

Appendix D

TAT Pre-educational and Post-educational Tests

Answer Key

1. b. Core body temperature

2. c. One to two hours sooner than rectal temperature

3. a. Lower than a rectal thermometer because the core temperature will reflect the change more rapidly than the rectum

4. d. 1 and 2

5. c. More quickly than

6. d. 1 and 4 or b. all the above

Appendix E

TAT Skills Performance

Competency Assessment for Exergen TAT

Project participation is voluntary

Participant's Identifier:_____

Title:_____

Work-Shift:_____

SKILL PERFORMANCE	YES	NO
1. Explains procedure to the patient.		
2. Places probe flushed on center of forehead, depresses button, and holds button depressed the entire time.		
3. Slides probe in a **straight** line across the forehead to the hairline.		
4. Lifts probe from forehead and touches half way behind the ear on the mastoid process (or slides behind ear if hair is very short.		
5. Slides probe down to the little soft depression on the neck behind the earlobe.		
6. Releases button and reads temperature.		
7. Records temperature on bedside graphic sheet.		
8. Verbalizes intervention for any abnormal results.		
9. Cleans probe of temporal artery scanner between patients.		
10. Demonstrates cleaning the lens of the temporal artery thermometer.		

Appendix F

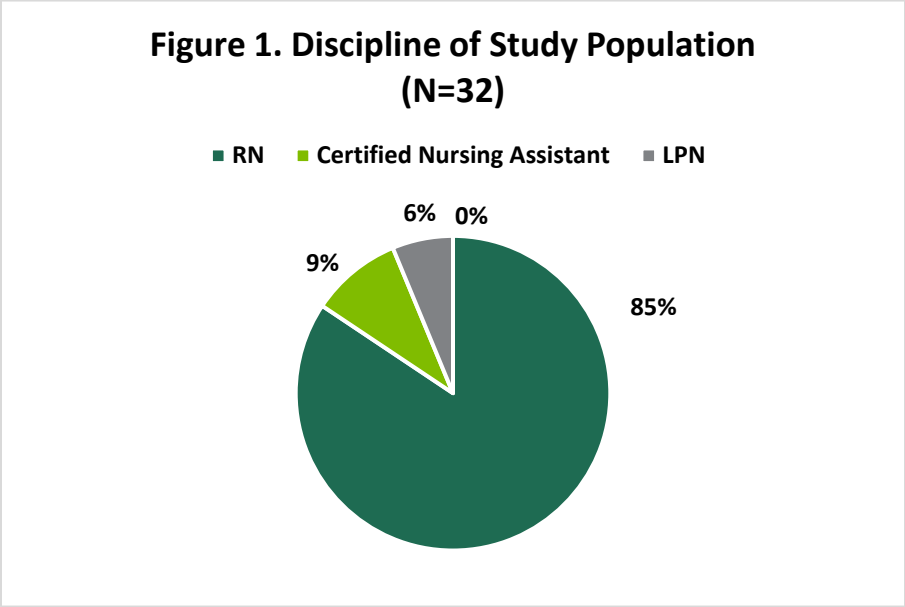
Timeline

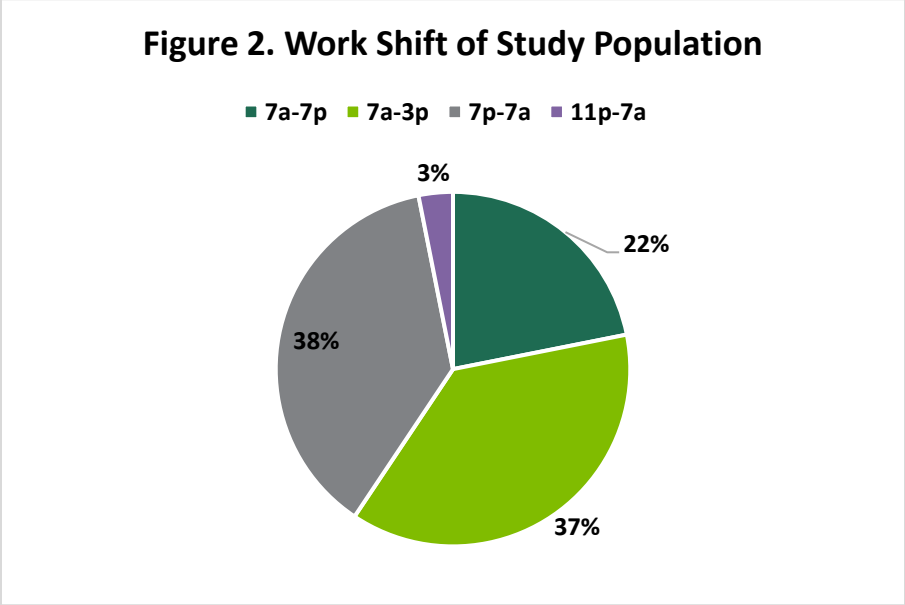
Table 1

Task	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
UAB IRB proposal approval	X							
JSU IRB proposal approval	X							
Recruitment of nursing staff participants		X						
Pre-educational competency test			X	X				
Implement TAT educational program				X	X			
Post-educational competency test					X	X		
Analysis of outcomes; consult Statistician						X		
Evaluation of data							X	
Results presented to nursing staff								X
Results presented to Unit Manager								X

Appendix G

Statistical Analyses





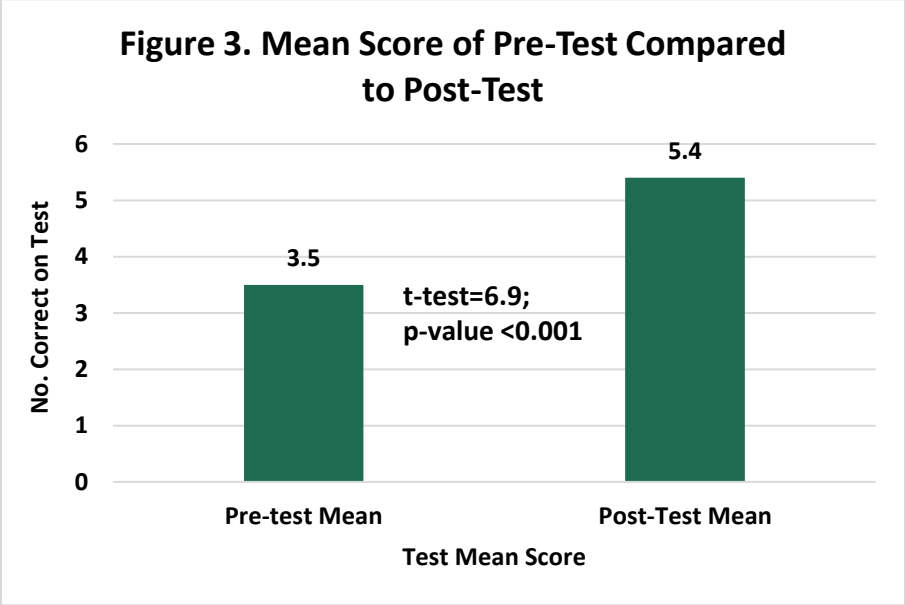


Figure 3. Mean Score of Pre-Test Compared to Post-Test
No. Correct on Test
6
5
4
3
2
1
0
3.5
5.4
t-test=6.9;
p-value <0.001
Pre-test Mean
Post-Test Mean
Test Mean Score

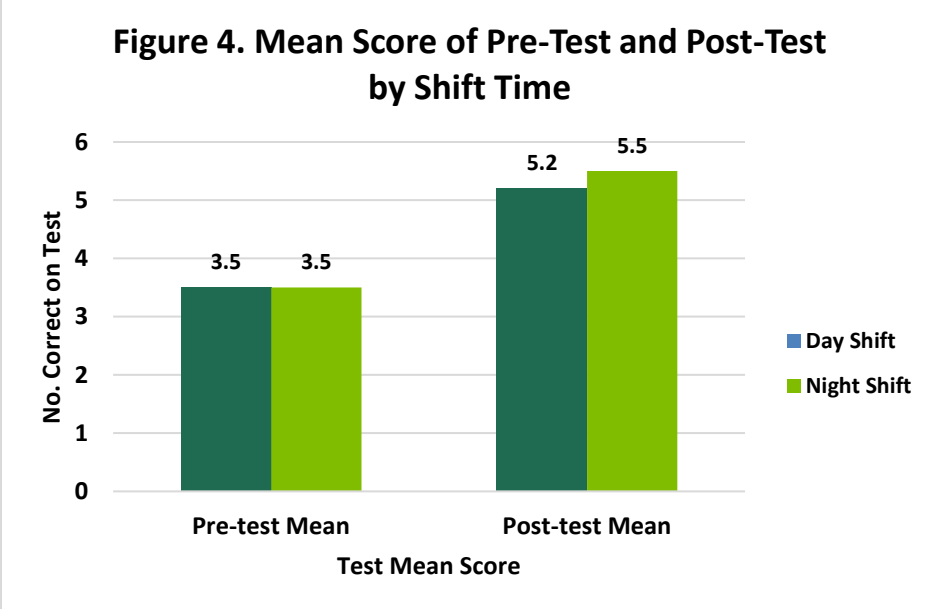


Figure 4. Mean Score of Pre-Test and Post-Test by Shift Time
No. Correct on Test
6
5
4
3
2
1
0
3.5
3.5
5.2
5.5
Day Shift
Night Shift
Pre-test Mean
Post-test Mean
Test Mean Score

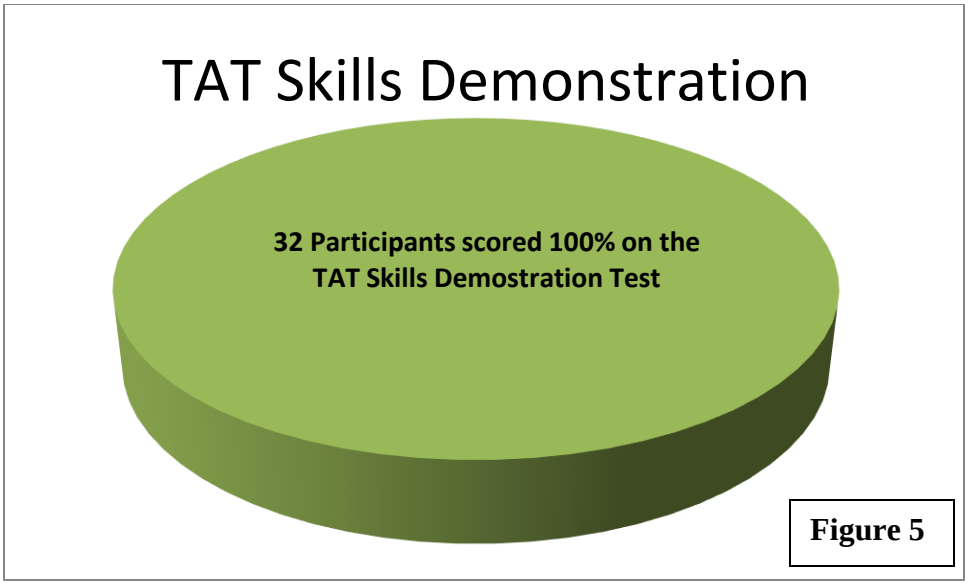

TAT Skills Demonstration
32 Participants scored 100% on the
TAT Skills Demostration Test

Figure 5