N_2O (No $_{To}$ Owies): The Adaptation of Nitrous Oxide at a Community Hospital

Marcus Gabriel, Jr.

Oregon Health & Science University

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Dr. Rana Halabi Najjar

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Author Testimony

Submitting this assignment confirms this is the sole work of the author as required by the student code of conduct

Abstract

Acute painful episodes experienced in hospital settings leads to fear, avoidance of future medical care, and creates gaps in those who suffer from chronic illnesses yet pain continues to be under recognized and undertreated. Nurses often do not practice at the extent of their scope as it relates to treating and addressing pain. The purpose of this project is to develop and implement a policy, education, and demonstration of using nitrous oxide for pain management with pediatric patients undergoing minor painful procedures. Findings from this quality improvement initiative indicate the policy development, education and demonstration of nitrous oxide use with pediatric nurses and pediatricians was effective, but nurses continued to experience hesitancy in using this pain modality. Follow up education and additional PDSA cycles are recommended to ensure patients' pain is mitigated and nurses are practicing to their full scope of practice.

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Pain is often under recognized and under treated in the pediatric population, from infancy to adolescence (Friedrichsdor & Goubert, 2020). Acute painful episodes that are experienced in hospital settings leads to fear and avoidance of future medical care, creating gaps in those who suffer from chronic illnesses as primary care practices are often reminders of underlying fears (Friedrichsdor & Goubert, 2020; Bice et al., 2014; Kennedy et al., 2008). Within the pediatric population there are limited options readily available for pain control, and modalities used to treat pain are commonly associated with painful procedures. These modalities target the treatment of acute pain by pre-medicating with an analgesic, such as acetaminophen, morphine, or lidocaine (Paul et al., 2007). Other modalities work by targeting to treat acute pain by decreasing anxiety with anxiolytic, such as midazolam and fentanyl (Paul et al., 2007).

The use of both analgesia and anxiolysis can cause patients to experience deeper level of sedation and thus are considered to be moderate or deep sedative procedures. In addition, there are incurred costs for the patient for receiving these procedures, such as costs associated with the commitment of additional staff and resources. On the other hand, one such modalities has increasingly shown positive effects in the pediatric population by targeting both pain and anxiety with a combined analgesic and anxiolytic properties, all while being used as a minimally sedative procedure. Nitrous oxide, at appropriate concentrations of 50:50, provides the patient with sufficient analgesic effects to help decrease sensations from minor painful procedures (Kornman et al., 2018; Martin et al., 2018). Moreover, nitrous oxide provides a calming effect due to its anxiolytic and amnestic properties (Roback et al., 2016). A significant benefit to this modality is the device used to deliver this gas can be administered by nurses, does not require

additional resources, and is a minimal sedative procedure (Bice et al., 2014; Bruene & David, 2020).

Nitrous oxide is commonly used in Pediatric Hospital settings, frequently in the emergency department or dental ambulatory settings, where the effectiveness of nitrous has been well-documented (Cravero et al., 2019; Huang et al., 2016; Martin et al., 2018; Tsze et al., 2016). This proposal focuses on implementing a policy to guide healthcare physicians on ordering and nurses on administrating nitrous oxide as a pain treatment modality for patients less than 18 years. The proposal will update the existing pain control policy, to include the use of nitrous oxide, and subsequently implement and evaluate the education delivered to staff on the use of the additional pain control method. This proposal will evaluate the effectiveness of the policy by assessing the education received by staff and utilization of an additional pain control modality to help with pediatric pain control for minor painful procedures. This policy will allow nurses to choose the most appropriate pain control modality while following evidenced based decision making to ensure that pediatric patients have less trauma associated with healthcare, improve their hospital experiences and long-term outcomes.

Literature Review

A literature search was conducted to obtain background information, current recommendations and practices, as well as exploration of utilization of nitrous oxide. Databases searched from June 2020 through September 2020 included the use of *CINAHL*, and *PubMed*. The foundation of the search included key words such as “pain control”, “nitrous oxide” and “child” or “pediatrics” to formulate a base of knowledge. The review was then narrowed by using key words such as “procedural sedation”, “anxiolysis”, “intervention”, “hospital” or “inpatient”. Inclusion criteria for these articles’ studies specifically of the pediatric population,

nitrous oxide used for procedural sedation, peer-reviewed research, and articles published in the past ten years. However, for base knowledge, relevant and frequently cited articles were allowed that were within the past twelve years. Exclusion criteria included research that was published prior to 2010 and was not frequently cited, publication based off of expert opinion, and research using nitrous oxide within an operating room or dental ambulatory clinic. Lastly for comparative analysis, key words such as "midazolam" and "lidocaine" were also used, and relevant studies were cross-examined.

Current Practice

Pediatric pain perception has historically been a controversial topic, which has led to a history of inadequate treatment for pediatric pain (Kennedy et al., 2008; Cummings, 2015). While it has once believed that pain could not be felt by infants, evidence has proven otherwise, and practices have shifted to controlling pain for children of all ages (Bruene et al., 2020; Friedrichsdorf & Goubert, 2020). Despite advances and available options, compared to their adult counterparts, pediatric patients remain undertreated for pain (Bice et al., 2014; Friedrichsdor & Goubert, 2020). Fear of overdosing and causing more harm to the patient are two common reasons for the under treatment of pain in the pediatric population (Emons et al., 2016).

Peripheral venous access has demonstrated one of the most commonly occurring sources of pediatric pain and anxiety related to hospitalization (Kennedy et al., 2008). When this pain is undertreated and managed reactively versus proactively, recurrent episodes have shown a new formation of neuronal circuits that cause the child to become hypersensitive and have an increased behavioral response to noxious stimuli (Kennedy et al., 2008). Furthermore, research from Kennedy et al. (2008) has shown that as this reformation occurs, children who become

hypersensitive can develop needle phobia, "a true medical condition included in the *Diagnostic and Statistical Manual of Mental Disorders*" (p. 131). This subgroup of patients has an increased morbidity and mortality throughout their lives due to their chronic avoidance of medical care that stems from their previous adverse experiences within the hospital setting (Orenius et al., 2018).

There have been a number of modalities that have been used in the pediatric population to reduce experiences of needle-phobia. One introduction to proactively treat procedural pain includes topical lidocaine. Nurses and physicians have consistently used a topical mixture of 1% lidocaine, frequently referred to as EMLA cream, for pediatric patients prior to needle-sticking procedures. Benefits include its quick application, wide use among patient population, and use with minimal to no side effects (Paut et al., 2011; Rogers & Ostrow 2014). Unfortunately, management of pain solely with products such as topical lidocaine does not address the anxiety that some patients feel. Coupled with the pharmacokinetic effects of lidocaine on veins, children may still vasoconstrict prior to needle insertion procedures such as intravenous cannulation. Due to the vasoconstriction, nurses have struggled with the use of EMLA cream prior to intravenous cannulation as nurses occasionally have made multiple attempts for cannulation. This causes an increase in the noxious stimuli to the child and creates greater panic for the patient-family experience (Paut et al., 2011).

Other modalities have been developed to focus on reduction of anxiety related to procedural pain. One specific modality is intranasal midazolam, which does not provide physiologic analgesia, but has been shown reduce pain children experience or perceive during procedures (Roback et al., 2016). Benefits to intranasal midazolam include rapid absorption, amnestic effects, and minimal respiratory effects in healthy children. As a sole anxiolytic, intranasal midazolam has not shown significant effectiveness in deep tissue pain (Roback et al.,

2016). Although no significant respiratory effects, the side effects of intranasal versed are concerning enough that if they occur, the patient does then require continuous monitoring compared to other modalities (Bourke & Mac Giolla, 2018; Roback et al., 2016).

Nitrous oxide, first used in 1844, has increased in popularity and use for the general population (Kornman et al., 2018). In the late 1900s, nitrous oxide was introduced to pediatric dental offices, and has now been used more frequently in children's hospital settings for pain management (Kornman et al., 2018). Nitrous oxide is frequently used in healthcare for minor but painful pediatric procedures. Compared to topical lidocaine, both have been shown to be effective pain management strategies. However, some benefits for nitrous oxide over topical lidocaine include the addition of anxiolytic properties, increased vasodilation for cannulated procedures, rapid onset and excretion (Martin et al., 2018). Although not clinically significant, Paut et al. (2011) demonstrated decreased pain scores for those treated with nitrous oxide compared to topical lidocaine. When comparing to intranasal midazolam, both have been shown to be effective minimally sedative anxiolytics with amnestic effects. However, some benefits for nitrous oxide over midazolam include the additional of analgesic properties and less frequent monitoring following minor side effects (Bourke & Mac Giolla, 2018).

Limitations

Much of the research done with nitrous oxide shows its use in the following settings: emergency department, dental, and operative. Few studies have examined the use of nitrous oxide within inpatient settings; however, due to the benefits of nitrous oxide and the significant decrease in stress, pain, and anxiety children have rated when undergoing minor painful procedures, several studies have recommended increasing the use of nitrous oxide within the pediatric inpatient setting (Kornman et al., 2018; Martin et al., 2018).

There have also been limitations on the number of studies that have directly compared nitrous oxide to other pain modalities. While the use of nitrous oxide in conjunction with agents such as topical lidocaine has been recommended for a child to experience virtually no pain, direct comparative studies are less common (Lee et al., 2012). Moreover, the use of nitrous oxide with other opioids or benzodiazepines has been shown to increase the sedative experience of the application, but does show increased effectiveness (Seiler, Landolt, & Staubli, 2019).

Lastly, several studies have examined nurse driven protocols with the use of nitrous oxide in pediatric care facilities or standalone pediatric hospitals. There are limited studies that have observed the use of nitrous oxide within a community or rural hospital. With the success of nitrous oxide in Pediatric freestanding hospitals, experts recommend the use of nitrous oxide in facilities that care for pediatric populations (Kornman et al., 2018; McCollum et al., 2017; Pederson et al., 2013). Moreover, research has also suggested that nitrous oxide polices can be nurse driven, which can increase the ease and utilization when facilities have administration guidelines that are nurse-driven (McCollum et al., 2017; Risaw et al., 2017).

National Recommendations

The American Academy of Pediatrics (AAP) updated its recommendations and guidelines on managing pediatric procedural pain in 2016. Their recommendations included the use of needle-less pharmacological agents that could provide pain relief for procedures such as intravenous cannulation, lumbar puncture, and bone marrow aspiration with the use of topical, intradermal, or inhaled analgesics (Roback et al., 2016).

The Donabedian framework is conceptual model method that measures outcomes for improvement. This framework utilizes three components: structure, process, and outcome

(Kourtis & Burns, 2019). The Plan-Do-Study-Act (PDSA) process, based on the Donabedian framework will be utilized to implement this quality improvement project.

Purpose & Aims

The purpose of this project was to develop and implement a policy using nitrous oxide for pain management with pediatric patients undergoing minor painful procedures. This project aims were to:

1. Examine best practices for the reduction of pain and anxiety related to painful procedures in a general inpatient pediatric setting and use this information to develop a policy and educational module about nitrous oxide for staff.

2. Implement and educate staff on a pain reduction policy for a general pediatric unit.

3. Evaluate the effectiveness of the educational module using pre/post knowledge assessments and retrospective surveys.

The overall goals of this project were to evaluate pain control modalities compared to use of nitrous oxide in the literature and other facilities by January 2021 as well as to create a policy for the use of nitrous oxide, educate nurses on the developed policy, and evaluate the effectiveness of the education by March 2021.

Methods

Design

The project utilized a PDSA cycle to evaluate the effectiveness of developing and implementing a policy for pain control in pediatric patients. There were multiple stakeholders including the Pediatric Committee, Pediatric Leadership, Director of Patient Safety, and others reviewed, revised, and approved the policy. The intervention included creating online modules to educate nurses and physicians on the policy, pain control modalities, and provide hands-on skill

demonstrations to staff on utilization of pain control methods. Evaluation of the online module and teaching took place after the intervention was implemented.

Setting

The setting of this project took place on a general inpatient pediatric unit located within a rural community hospital, located approximately an hour outside the nearest urban, metropolitan area. The pediatric unit at the hospital has an average daily census of 5.4 patients per day.

Organizational Readiness

The rural community hospital cares for approximately 15,000 pediatric patients a year, and approximately 5% of those patients are located within the inpatient unit. Within the past two years, new policies have been created to help address pain and anxiety for pediatric patients within the facility. These policies have been underutilized by staff due to dissatisfaction with outcome, increasing use of labor in monitoring, or poor effectiveness of the products used. Recent policies have attempted to provide a pain free experience within the pediatric department by introducing intranasal versed, topical lidocaine-tetracaine, or needle-less injectable lidocaine. Staff within the department have verbalized readiness for improved pain control modalities.

Anticipated Facilitators, Barriers, and Challenges

Facilitators of this project included the DNP student as the Project Lead and the Pediatric Unit Decision Making Council, a multi-disciplinary team consisting of a Pediatrician, Nurse manager, Assistant Nurse manager, core pediatric nursing staff, and floating women and children services staff. Adjusting to this current pandemic, many healthcare organizations faced financial challenges due to low patient census or the cancelation of electives surgical cases. An anticipated barrier and challenge to this product was providing a high-quality intervention with the need to obtain costs from capital budgets. A highly recommended delivery device of nitrous oxide for

pediatric populations consists of a continuous flow system (Furuya et al., 2010; Huang & Johnson, 2016; Tzse et al., 2016). The most effective recommendation is the use of a continuous flow system allows children as young as 12 months of age to use the machine. This is compared to a demand flow system in which a child has to be developmentally old enough to self-administer the nitrous oxide and follow instructions for deep inhalation and exhalation. Due to this constraint of costs and remaining within operational budgets, the project required the use of a demand flow system versus a brand-new purchase of a continuous system to use as a trial period.

Participants

Inclusion

A total of N=42 were educated on using the newly developed pain policy. All 42 staff members were evaluated on their understanding of the pain policy. Staff members include all pediatric registered nursing staff providing direct patient care (*n*=12), all women and children services float pool staff (*n*=24), pediatric hospitalists (*n*=6).

Size and Rationale

Pediatric patients are managed under two different groups: in-house pediatricians and outside pediatricians. One focus of the project will be with the Pediatric Hospitalist team, who are the in house physicians. Pediatric nurses who delivery bedside care were the main participants of this education,. Research has supported registered nurses initiating pain management protocol or pathway (Bice et al., 2014) which will underpin the development of this policy. Additionally, McCollum et al. (2017) describes that increased utilization of nitrous oxide occurs when all stakeholders have a sense of shared knowledge and agreement in management.

Floating nurses are more frequently utilized during the high census winter period of the general pediatric unit were responsible for understanding the education. These nurses do not routinely work on the general pediatric floor; therefore, they were only be required to be familiar with reviewing the policy and not the hands-on demonstration.

Recruitment Plan

The pediatric unit council were instrumental in helping to roll out the education to all appropriate bedside nursing staff. The nurse manager assisted in ensuring 100% compliance with the online modules.

Participant Protection

There was no corrective action against any of the staff members regardless of their outcome in post-test scoring and demonstration skills show. The management team can review staff scores and address staff individually who have not mastered pain control concepts. A request for determination was submitted to IRB at OHSU with this project which was deemed as quality improvement with no further submissions required.

Implementation

Implementation Procedures

Nitrous oxide literature review and policies

The first step of this project included a literature review of current evidence of pain control modalities within the pediatric population. Followed by review of the use of nitrous oxide within the pediatric population, and comparative data that demonstrates the use of nitrous oxide and other common pain control modalities – specifically topical lidocaine and midazolam. The information was compiled and prepared to present to the Hospital staff for project approval. A synthesis table was created and analyzed to appraise and summarize the research on best

practices related to pediatric pain control. This table was shared with stakeholders to support the evidence and evolution of the project idea. Additionally, this table was utilized to create an educational module for nursing staff as pivotal points of reference for staff to review for their own edification. The synthesized information was shared with the pediatric unit council as a means to gain approval and buy-in from the unit leaders prior to proceeding with the project.

Once approved, the next step in this project was to review nitrous oxide use and policies from organizations in the State. A further review of nitrous oxide policies was gathered and examined from local, regional, and national facilities. These organizations developed policies on the use of nitrous oxide within the pediatric population, delineating clinical decision-making pathways, emergency department use versus inpatient and outpatient use, inclusion and exclusion criteria, administration steps and monitoring, and equipment used. This information was used as a template for the policy developed.

In addition, to further understand how to implement a new procedure into an unfamiliar setting, expert opinion was sought from a provider with previous experience that had developed staff educational modules and training for the use nitrous oxide in pediatric settings. Conversations occurred with these physicians over email and Zoom meetings, between November 2020 and January 2021.

Policy creation and education dissemination

Development of the policy and educational module occurred after the data was compiled from experts and policies of other organizations and an updated plan was presented and approved by thethe lead pediatric hospitalist, nurse manager of the pediatric unit, the division leader of women and children services, and the division directors from corporate integrity, safety, and risk,

care management, regulatory and patient safety. Similar to the policies of other facilities, the pain policy included background information, supportive data, practice guidelines, safety guidelines, training, administration, inclusion criteria, and exclusion criteria.

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After the policy was approved, a module was developed to educate staff on nitrous oxide. The module contained in-depth evidence to support the use of nitrous oxide with in the pediatric unit, and instructions for staff on setting up the nitrous oxide machine – Nitronox HD.

Education also to consisted safe administration of the inhalant during a procedure, and which patients' signs and symptoms should be monitored.

The hospital utilizes an online education dissemination system called HealthStream, which contains several online learning modules. To ensure that all nursing staff received the same education, and fully understood the information given, the module on nitrous oxide was uploaded and shared electronically with nursing staff. A due date for completion of the educational material was set prior to the March 1st, 2021 "go-live" date for the use of nitrous oxide training. The HealthStream module included a pre/post-test assessment and a nitrous oxide walkthrough PowerPoint presentation with objectives to:

1. Understand the history and goals of nitrous oxide for pediatric patients
2. Identify the implications of poorly managed pain control for pediatric patients
3. Describe how nitrous oxide is used for pediatric patients
4. Distinguish the benefits of nitrous oxide compared to topical lidocaine and intranasal midazolam
5. Understand the inclusion and exclusion criteria for patients to receive nitrous oxide for pain control

6. Follow administration steps to provide nitrous oxide to pediatric patients

A video was included with instructions on setting up the Nitronox HD provided by the manufacturers. Once nursing staff completed the online learning module, including a pre/post-test assessment of their knowledge they received a live hands-on demonstration.

Gathering all eligible participants, with a nursing staff roster, each staff member was required to attend a short 10-15 minute presentation on setting up and using the Nitronox HD. To increase engagement, enhance retention, and promote active learning during the demonstration, staff were assessed on their knowledge of nitrous oxide, the use of Nitronox HD, and patients symptoms to monitor and encouraged to ask questions. After return demonstration each nursing staff member was signed off and considered to competent in their knowledge and use of nitrous oxide in the pediatric population.

All staff were given approximately 45 days to complete the online module from the date the education rolled out, to the go-live date. In order to comply with coronavirus restrictions, hands-on demonstration was done in small groups with no more than two to three healthcare staff members in attendance.

Measures

Data Collection Sources and Procedures

As nurses completed components of the HealthStream education module their responses from assessments and survey was collected. There was an 11 questions pre and post-test knowledge assessment (Appendix A), where healthcare staff were quizzed in a multiple-choice format on information pertaining to nitrous oxide and the policy.

Objective assessment of knowledge on pain - Pre-test. A pre-test was administered to all participants prior to the policy education to assess baseline knowledge of pediatric pain

control and specifically nitrous oxide for pain control. **Post-test.** This was administered to all appropriate participants after completion of the modules to evaluate the effectiveness of the education. Additionally, physicians were provided a knowledge assessment following their in-service training for ease and quick response times. Using pre and post knowledge assessments allow a measurable success in the implementation of any active learning strategy, while improving the focus of study to aim for better performances by the participants (Shivaraju et al., 2017). Pre/post knowledge assessments use an objective measure to assess the impact the intervention and responses were coded dichotomously with either correct or incorrect. A paired t-test was used to determine whether there was a significant difference on knowledge of the use of nitrous oxide before and after the intervention implementation.

Subjective Assessment of Comfort on Policy -Pre/post retrospective survey. This was given to nursing staff after hands-on demonstration to evaluate their perspective on how they would utilize nitrous oxide as a pain control modality. The data obtained by the nurses display their comfort with the process and knowledge of the product they would provide the patient.

This use of this tool gave participants an opportunity to reflect on their previous knowledge to compare to the knowledge gained and provided subjective insight on the efficacy of an intervention (Geldhof et al., 2018).

Open ended questions was be used to assess feedback from nurses after the policy went live and whether nurses were inclined to use the policy, any barriers that prevented the use of the policy, and any increased benefit they perceived from the use of the policy.

Information Systems

Nitrous oxide is currently in use at Salem Hospital in their labor and delivery department. Nurses who implement this pain control are able to provide documentation in the organization's

electronic health record, EPIC, charting system. As this is built-in, the EPIC control team used a similar documentation area to be accessed by pediatric nurses to document their use of nitrous oxide.

Measure Accuracy

Although approximately 20% of the core pediatric nursing staff is on the unit decision making council, those specific nurses were provided with test questions, but they were not given test answers to help increase the validity of their true scores for the education assessment. Retrospective surveys were anonymous to allow nurses to give honest feedback on their comfort and understanding of the policy and education provided on pain control within the pediatric population.

Ethical Considerations

Nurses experience greater satisfaction and provide more quality care for their patients when they feel that they have more control in the treatment of their patients (Bice et al., 2014). With the inclusion of nitrous oxide with other pain control modalities, this will increased nurse autonomy by providing more tools to provide better pain management to patients, thereby improving the nursing quality of care. This policy will also enabled nurses to practice to their full scope of practice, which also increases their autonomy.

As a nurse driven policy, nurses are able to review their current practices and choose a modality that fits their patients' needs. Even if the choice is not always nitrous oxide, when a nurse chooses to use the nitrous oxide policy, they are using their own assessment skills to evaluate what will be effective for their patient. Nurses are trained to critically think and by using these skills, nurses are more likely to experience that autonomy and improve their

satisfaction with a new policy and are more likely to use nitrous oxide for their patients (McCollum et al., 2017).

This project did not collecting any patient names or staff identifiers. Without identifiers and without the possibility of negative consequences, nurses can practice their own veracity in their responses, and recognize their own strength and fidelity from their patients.

Pediatric patients are considered a vulnerable population, and therefore are highly susceptible to adverse events related to healthcare and research. Although this project does not focus on research and seeks to improve the care given to pediatric patients, nitrous oxide is not without its side effects. Well documented events of nausea and vomiting have been noted for patients receiving nitrous oxide, especially for prolonged periods (Tzse et al., 2016). Nurses were instructed to assess beneficence over nonmaleficence when initiating this policy for their patients.

The policy will explicitly suggested limitations for who may benefit from receiving nitrous oxide and those who should be excluded. As nurses seek to provide the best care, they must be aware of the limitations that nitrous oxide provides and use their judgement and assessment skills to provide the best care to their patient with their given knowledge.

Costs

As there is currently a nitrous oxide delivery device located within the labor and delivery department, there was no additional cost to use the machine in pediatrics. Costs attributed to the use of the machine was include in the delivery tubing and pediatric sized masks, estimated to be approximately $10-12 per patient. Costs can be regained with a nursing charge for the use of the machine, dependent upon each organization.

There was not additional costs for the creation of an education module or training on the use of the device and competency of each healthcare staff member. There was no outside sources of funding contributing to this project.

Project Implementation

Project Evolution

Initial meetings with the unit manager and lead pediatric hospitalist led to requests for nitrous policies that are used at nearby facilities and further discussions about the safety and monitoring of nitrous oxide in community hospitals that are not associated with academic facilities. With the coronavirus pandemic there was hesitation on implementing the use of a potentially aerosolizing procedure, and requests for information directly from physicians that routinely use nitrous oxide for their pediatric patients. Through coordinated email efforts, all parties were able to collaborate on best practices for the use of nitrous oxide, and reach a common support and understanding of its continued safety and minimal risk in lieu of the pandemic.

Through literature and policy review, one common recommendation that frequently reoccurred was the use of a continuous inhalation system as opposed to an on-demand system. Unfortunately, there are few studies that have examined a direct comparison of an on-demand system compared to a continuous system for nitrous oxide (Krauss, 2011). General policies related to nitrous oxide utilize continuous systems for pediatric populations and on-demand systems for adults, specifically laboring mothers for its analgesic effects (Pinyan et al., 2017). Regardless of the device system, using nitrous oxide at 50% concentration is the recommendation to achieve analgesic and anxiolytic effects in pediatric populations (Furuya et al., 2013; Risaw et al., 2017; Seiler et al., 2017).

Using the HealthStream system, all nursing staff involved in pediatric bedside nursing care were assigned the nitrous oxide training module. However, due to multiple roles that select nurses work in, such as a lactation nurse who also works in pediatrics, not all staff were assigned at the same time. This required repetitive conversations with the informatics team and nursing education department, to ensure all appropriate staff were assigned the training module.

Unintended Consequences

During the education, there was one impactful positive unintended consequence. The policy newly developed for the use of nitrous oxide in pediatric populations contained the need to obtain verbal consent between the healthcare physicians and the patient prior to the administration of nitrous oxide, as a minimally sedative procedure. While reviewing the key steps of administration with nursing staff and physicians, one physician commented that this inclusion criteria should be a standard met with any patient receiving any degree of anxiolysis, even mild anxiolytics. After review of current policies, no written affirmation for nursing staff to ensure and document verbal consents with mild anxiolytics was found. This realization enabled the pediatric unit council to review and update policies to include verbal consents between physicians and patients highlighting risks and benefits with using anxiolytics. Although it was not a goal, the implementation of this project alerted the healthcare staff to process improvement around other policies that have the potential to impact patient care.

Key Findings

A total of 32 nursing staff members completed the pre/post knowledge assessment and 28 of the 32 completed both the pre/post knowledge assessment and the pre/post retrospective survey. With the 11question knowledge assessment quiz, nurses pre-test score averaged 37.61% compared to their post-test score of 92.29% after the education (Figure 1). A paired samples t-

test showed significant difference in the score before education (M = 37.61, SD = 19.6) and after education (M = 92.29, SD = 7.64); t(27)=14.75, p= <0.01. In addition, the effect size for this analysis (d = 3.68) was found to exceed Cohen's convention for a large effect (d = 0.80).

A total of six pediatric physicians took the assessment quiz and had an average score of 91% after a single initial attempt.

With the pre/post retrospective survey, nurses on all questions expressed an improvement in their comfort, knowledge, and understanding of nitrous oxide. In all seven questions that were assessed, a paired samples t-test revealed that there was a significant (p<0.01) improvement in all areas. This includes the knowledge of nitrous oxide and the policy created, understanding the indications of nitrous oxide, the benefits of nitrous oxide, recommending nitrous oxide, using nitrous oxide, and setting up and administering nitrous oxide (Table 1). Average change scores between pre and post surveys varied from approximately 1-3 points, where the most impactful changes were with knowledge about nitrous oxide (M = 3.07), indications and contraindications for nitrous oxide (M = 2.93), and administration of nitrous oxide (M = 2.86).

In assessing which aspect nurses felt was most helpful to their learning and understanding, nurses felt that that the hands-on demonstration was most impactful (M = 4.93), and although not significantly lower, the policy alone was least impactful (M =4.43).

Missing Data

A total of 32 participants completed the pre/post knowledge assessment, and 28 participants completed both the pre/post knowledge assessment and the pre/post retrospective survey. Part of this discrepancy was due to staff absences from the time of creation to implementation.

Staff working less than full-time, once a week or once every six weeks, did not receive the hands-on demonstration, and they did not have the opportunity to complete the retrospective survey in addition to the knowledge assessment. Therefore, their data was not included in the pre/post retrospective survey. In addition, one staff member went on maternity leave prior to completing the education module and learning, as well as one staff member took a leave of absence during this time.

Project Outcomes

The results of this project met each of the aims initially proposed. The first aim of the project was achieved by reviewing the literature and other facilities pain control modalities as compared to nitrous oxide. The reviewed information facilitated the creation and development of an that was evidenced-based policy and educational modulel. Conducting a literature review and evaluating policies on nitrous oxide was a key in ensuring the success of this intervention. As indicated in the literature, the inclusion of data supporting the use of nitrous oxide for its multivariate properties compiled in the synthesis table facilitated the co-creation of the pain policy and education module (Cravero & Robeck, 2019). The recommendation from the literature of sharing specific information comparing nitrous oxide to other pain control modalities such as intranasal midazolam and topical lidocaine was instrumental in increasing knowledge and understanding of the benefits of using nitrous oxide (Pedersen et al., 2013; Reinoso-Barbero et al., 2016; Kornman et al., 2018). By utilizing the resources from various facilities on their use of nitrous oxide, key components of the administration steps and process had been adapted to fit the context of the facility. As adult learners, nurses benefit from being able to the material through a system that gives them the flexibility to learn at their own pace (Schneider & Good, 2018).

The second aim was achieved by distributing the educational module to staff including the pain control policy, educational module and information on the importance of pain control. The implementation of the intervention was successful as most of the staff was educated on the policy and completed the online module prior to the deadline. The use of multiple pedagogical approaches, including video and hands on demonstrations, helped engage learners, and addressed gaps in knowledge from the pre/post knowledge assessment.

The last aim was to evaluate the effectiveness of the learning strategies which was met by the improvement of mean scores on pre-test knowledge assessments to post-test knowledge assessments, as well as seeing a statistically significant improvement with pre/post retrospective survey responses. The pre/post evaluative tools revealed a significant improvement before and after the education. With the knowledge assessment, mean scores were nearly three times higher after the educational modules. The pre/post retrospective survey revealed that participants felt a dramatic increase in their confidence and comfort with understanding the policy and use of nitrous oxide after the education and demonstration.

The pre and post retrospective survey highlighted a views on how impactful the intervention was to the nurses. Although it may be more subjective view, this objective evaluation gives participants an opportunity to reflect on their previous knowledge to compare with the new knowledge gained. This often creates a self-realization that their knowledge and skill was lower than they realized after an intervention (Geldhof et al., 2018). There was overwhelming agreement by staff that the hands-on demonstration was the most impactful to their understanding and learning.

Implications, Recommendations, and Limitations

Implications

Nursing staff now have the ability to practice to their full scope, allowing them to have options to deliver evidence-based care to patients. Having an additional pain management option that is easily accessible and up to their discretion, allows them to communicate with the provider the needs of the patient and family.

This policy was created with a nursing profession mindset, it was delivered to nurses with the support of a provider with a background in the nursing profession. The policy was created due to a lack of satisfaction in current pain management modalities. The collaboration between the nursing unit council and other stakeholders created a policy that addressed what nurses wanted for their patients. These elements were key in the buy-in of nursing staff, and contributed to the success of the project.

During this current coronavirus pandemic, many organizations are adhering to the recommendations of social distancing, working from home, and discouraging any group settings from more than one household. Many businesses are phasing away with in-person meetings to be held virtually. Although the hands-on training was done in small groups to adhere to organizational distancing requirements, it cannot be stressed enough how essential this component of learning is to understanding a new procedure or policy.

Recommendations

Several lessons were learned during implementation of this project. Recommendations include additional PDSA cycle and utilizing run charts to assess whether nurses are using nitrous oxide, how often, and whether they feel they have appropriate options on managing pediatric pain prior to minor painful procedures.

Nurses were still hesitant to choose nitrous oxide over other pain control modalities; therefore, further research is needed to explore the barriers to using nitrous oxide The lowest

impacted change scores from pre/post retrospective survey was in using nitrous oxide over other modalities and recommending nitrous oxide to other nurses.

A last recommendation is collecting data on demographics, such as age, years of experience, gender, and working department in future quality improvement projects. These demographics can provide information needed to tailor future research, as each unit and department consists of healthcare staff from various backgrounds.

Limitations

There were several limitations to the implementation of this quality improvement project. One significant limitation and barrier faced was due to the COVID-19 pandemic. During initial phases of the project, there was widespread agreement, however during the ebbs and flows of the pandemic, literature on what was considered to be aerosolizing procedures created concern amongst staff and administration for potential contamination and harm from patients to staff. In addition, during this time, the organization faced financial constraints that did not allow investments into new nitrous oxide systems requiring the use of a system that although can be used in pediatric populations, is better utilized in laboring patients. Additionally, physicians and nurses were not delivered the same depth of knowledge and teaching. The implementation of the intervention coincided with the, physicians' annual training which included over 30 HealthStream learning modules. The decision by leadership was made to not add the nitrous oxide module as to not overwhelm physicians. Instead, information was delivered as part of previously arranged virtual meetings.

Summary

Pediatric patients often have pain that is under-treated and undervalued in the healthcare setting. Nitrous oxide is one specific modality that has properties to address analgesia,

anxiolysis, and amnestic components of pain control. A quality improvement project was designed to review the literature and best practices and develop, implement and evaluate education on the use of nitrous oxide for pediatric patients at a local rural community hospital. The success of the project hinged on the collaboration with interdisciplinary members, the policy was created and distributed to staff involved in pediatric care. Education delivered through e-learning modules facilitated and supported the hands-on demonstration. Evaluation of intervention through pre/post knowledge assessment and a retrospective pre/post survey indicated staff's knowledge and confidence of using nitrous oxide dramatically increased. Next steps include additional PDSA cycles with follow up of teaching and expanding this education and service to other areas of the organization outside of the Pediatric Unit.

References

Bice, A. A., Gunther, M., & Wyatt, T. (2014). Increasing nursing treatment for pediatric procedural pain. *Pain Management Nursing*, *15*(1), 365–379. https://doi.org/10.1016/j.pmn.2012.06.004

Bourke, M., & Mac Giolla, C. (2018). Nitrous oxide versus midazolam for paediatrics. *Journal of the Irish Dental Association*, *64*(2), 88–95. https://doi.org//10.2344/anpr-63-03-06

Bruene, D., & Davis, M. B. (2020). Comprehensive strategies to improve the pediatric venipuncture experience. *Pain Management Nursing*, *21*(2), 214. https://doi.org/10.1016/j.pmn.2020.02.036

Chaghari, M., Saffari, M., Ebadi, A., & Ameryoun, A. (2017). Empowering education: A new model for in-service training of nursing staff. *Journal of advances in medical education & professionalism*, *5*(1), 26–32.

Cravero, J.P., & Robeck, M.G. (2019). Pharmacologic agents for pediatric procedural sedation outside of the operating room. *Pediatrics*, *118*(3), 1087–1096. https://doi.org. /10.1542/peds.2006-0313

Cummins, J. A. F. (2015). Pediatric procedural pain: How far have we Come? An ethnographic account. *Pain Management Nursing*, *16*(3), 233–241. https://doi.org/10.1016/j.pmn.2015.06.006

Cummins, J. (2015). Children's procedural pain management in non-children's emergency departments. *Pain Management Nursing*, *27*(8), 124-130. https://doi.org /10.7748/ncyp.27.8.13.s15

Emons, M. I., Petzke, F., Stamer, U. M., Mei*b*ner, W., Koschwitz, R., & Erlenwein, J. (2016). Current practice of acute pain management in children – A national follow-up survey in Germany. *Paediatric Anaesthesia*, *26*(9), 883-890. https://doi.org/10.1111/pan.12947

Friedrichsdorf, S. J., & Goubert, L. (2020). Pediatric pain treatment and prevention for hospitalized children. *PAIN Reports*, *5*(1), 1-13. https://doi.org/10.1097/pr9.0000000000000804

Furuya, A., Ito, M., Fukao, T., Suwa, M., Nishi, M., Horimoto, Y., Sato, H., Okuyama, K., Ishiyama, T., & Matsukawa, T. (2010). The effective time and concentration of nitrous oxide to reduce venipuncture pain in children. *Journal of Clinical Anesthesia*, *21*(3), 190–193. https://doi.org/10.1016/j.jclinane.2008.07.005

Geldhof, G. J., Warner, D. A., Finders, J. K., Thogmartin, A. A., Clark, A., & Longway, K. A. (2018). Revisiting the utility of retrospective pre-post designs: The need for mixed-method pilot data. *Evaluation and program planning*, *70*, 83–89. https://doi.org /10.1016/j.evalprogplan.2018.05.002

Huang, C., & Johnson, N. (2016). Nitrous Oxide, From the Operating Room to the Emergency department. *Current Emergency and Hosptial Medicine Reports*, *4*(1), pp. 11-18. https://doi.org10.1007/s40138-016-0092-3

Kennedy, R. M., Luhmann, J., & Zempsky, W. T. (2008). Clinical implications of unmanaged needle-insertion pain and distress in children. *Pediatrics*, *122*(Supplement 3), S130–S133. https://doi.org/10.1542/peds.2008-1055e

Krauss B. (2011). Continuous-flow nitrous oxide: Searching for the ideal procedural anxiolytic for toddlers. Annals of emergency medicine, 37(1), 61–62. https://doi.org /10.1067/mem.2001.112004

Kornman, K., Wilson, V., Tinsley, P., Watt, J., & Sheppard-Law, S. (2018). Improving the utilisation of nitrous oxide in paediatric patients to manage procedural pain and procedural anxiety. *Comprehensive Child and Adolescent Nursing, 43*(1), 22-34. https://doi.org/10.1080/24694193.2018.1528309

Kourtis, S. A., & Burns, J. P. (2019). Frameworks for quality improvement in pediatric intensive care: A concise review. *Pediatric Investigation, 3*(2), 117-121. https://doi.org/10.1002/ped4.12134

Lee, J. H., Kim, K., Kim, T. Y., Jo, Y. H., Kim, S. H., Rhee, J. E., . . . Eun, S. (2012). A randomized comparison of nitrous oxide versus intravenous ketamine for laceration repair in children. *Pediatric Emergency Care, 28*(12), 1297-1301. https://doi.org/10.1097/pec.0b013e3182768a86

Martin, H. A., Noble, M., & Wodo, N. (2018). The benefits of introducing the use of nitrous oxide in the pediatric emergency department for painful procedures. *Journal of Emergency Nursing*, *44*(4), 331–335. https://doi.org/10.1016/j.jen.2018.02.003

McCollum, N. L., Kamat, P. P., Stockwell, J. A., Travers, C., McCracken, C. E., Thompson, B., & Pettignano, R. (2017). Improving stakeholder satisfaction: Nitrous oxide for peripheral intravenous cannulation for pediatric procedural sedation. *Journal of Radiology Nursing*, *36*(4), 238–241. https://doi.org/10.1016/j.jradnu.2017.07.007

Orenius, T., Säilä, H., Mikola, K., & Ristolainen, L. (2018). Fear of injections and needle phobia among children and adolescents: An overview of psychological, behavioral, and contextual factors. *SAGE Open Nursing*. https://doi.org/10.1177/2377960818759442

Paut O, Calméjane C, Delorme J, Lacroix F, Camboulives J. (2011) EMLA versus nitrous oxide for venous cannulation in children. *Anesthesia Analogs*, *93*(3), pp. 1598-1600 https://doi.org/10.1097/00000539-200109000-00012

Pedersen, R. S., Bayat, A., Steen, N. P., & Jacobsson, M. B. (2013). Nitrous oxide provides safe and effective analgesia for minor paediatric procedures - A systematic review. *Danish Medical Journal*, *60*(6), 1-8. https://doi.org/10.1016/j.jdanmed.2013.11.037

Pinyan, T., Curlee, K., Keever, M., & Baldwin, K. M. (2017). A nurse-directed model for nitrous oxide use during labor. MCN. *The American journal of maternal child nursing*, 42(3), 160–165. https://doi.org/10.1097/NMC.0000000000000336

Risaw, L., Narang, K., Thakur, J. S., Ghai, S., Kaur, S., & Bharti, B. (2017). Efficacy of flippits to reduce pain in children during venipuncture – A randomized controlled trial. *The Indian Journal of Pediatrics*, *84*(8), 597–600. https://doi.org/10.1007/s12098-017-2335-z

Roback, M. G., Carlson, D. W., Babl, F. E., & Kennedy, R. M. (2016). Update on pharmacological management of procedural sedation for children. *Current Opinion in Anaesthesiology, 29*(1), 21-35. https://doi.org/10.1097/aco.0000000000000316

Rogers, T. L., & Ostrow, C. L. (2014). The use of EMLA cream to decrease venipuncture pain in children. *Journal of Pediatric Nursing*, *19*(1), 33–39. https://doi.org/10.1016/j.pedn.2003.09.005

Schneider, M., & Good, S. (2018). Meeting the challenges of nursing staff education. *Nursing*, *48*(8), 16-17. https://doi.org/10.1097/01.nurse.0000541402.97845.2f

Seiler, M., Landolt, M. A., & Staubli, G. (2017). Nitrous oxide 70% for procedural analgosedation in a pediatric emergency department with or without intranasal fentanyl?

Pediatric Emergency Care, Publish Ahead of Print, 755-759. https://doi.org/10.1097/pec.0000000000001213

Shivaraju, P., Manu, G., M, V., & Savkar, M. (2017). Evaluating the effectiveness of pre- and post-test model of learning in a medical school. *National Journal of Physiology, Pharmacy and Pharmacology*, *7*(9), 1. https://doi.org/10.5455/njppp.2017.7.0412802052017

Tsze, D. S., Mallory, M. D., & Cravero, J. P. (2016). Practice patterns and adverse events of nitrous oxide sedation and analgesia: A report from the pediatric sedation research consortium. *The Journal of Pediatrics, 169*, 260-265. https:doi.org/10.1016/j.jpeds.2015.10.019

Appendix A

Questions:

1. The goal of nitrous oxide is to do the following: [Select All That Apply]
    a. Reduce pain
    b. Reduce anxiety
    c. Provide amnestic effects
    d. Modify patient's behavior to allow safe completion of procedures
2. What is the appropriate concentration of N_2O/O_2 to use in the Pediatric setting for *minimal sedation*
    a. 40%/60%
    b. 30%/70%
    c. 50%/50%
    d. 70%/30%
3. Which of the following patients would Nitrous oxide be CONTRAINDICATED for? [Select All That Apply]
    a. A 16 year old whose parents inform you is on a vegan diet, and is getting an IV start
    b. A 12 year old who has a history of Crohn's Disease, who is getting an NG tube for encopresis
    c. A 10 year old who is on a ketogenic diet and undergoing a lumbar puncture
    d. A 8 year old with a history of Celiac disease, who is getting a Foley urinary catheter placed
4. Which of the following patients would Nitrous Oxide be CONTRAINDICATED for? [Select All That Apply]
    a. A 16 year old admitted for respiratory distress following scuba diving exercise who needs an otologic exam
    b. A 12 year old admitted for an SBO who needs an NG tube placed
    c. A 10 year old admitted for asthma exacerbation who needs an IV start for solumedrol
    d. A 8 year old admitted for MRSA infection who needs an I&D of their wound
    e. A 14 year old admitted for shortness of breath following a MVA who needs a laceration repair
5. Some of the side effects of nitrous oxide include: nausea, vomiting and lightheadedness
   To prevent these common side effects it is recommended that patients don't exceed use of N_2O past what time period?
    a. 30 minutes
    b. 45 minutes
    c. 15 minutes
    d. 60 minutes
6. All of the following are true statements about Nitrous Oxide <u>*except*</u>?
    a. Nitrous oxide increases patient compliance without the use of moderate or deep sedation
    b. Nitrous oxide masks are only used once and then discarded after each use for each patient

    c. Nitrous oxide can be administered multiple times per day per patient in short durations (at least 4 hours between usage)
    d. Nitrous oxide provides analgesia, anxiolysis, and amnestic affects
7. Which of the following *cannot* be given within 2 hours of nitrous oxide administration [Select All That Apply]
    a. IV Morphine
    b. Topical Lidocaine
    c. Intranasal Midazolam
    d. PO Oxycodone
    e. IV Acetaminophen
    f. IM Diphenhydramine
8. During the procedure your patient begins to experience a deeper level of sedation to nitrous oxide than anticipated. Your *immediate* next step is to:
    a. Notify the provider
    b. Turn off the nitrous and start the patient on 100% FiO_2
    c. Shake the patient until he/she wakes
    d. Administer a reversal agent
9. Compared to Topical Lidocaine and Intranasal Midazolam, Nitrous Oxide is known to have a rapid onset and a rapid recovery. About how much time to notice desired effects and see patient return to baseline?
    a. 5-10 minutes; 5-10 minutes
    b. 30 seconds-1 minute; 30 seconds-1 minute
    c. 20-30 minutes; 20-30 minutes
    d. 3-5 minutes; 3-5 minutes
10. As a minimally sedative mediation, the following needs to be monitored continuously during the procedure [Select All That Apply]
    a. HR
    b. RR
    c. Temp
    d. BP
    e. O_2
11. An environmental risk of the use of nitrous oxide includes escaping particles into the air. This is mitigated by the use of which part of the machine:
    a. Exhaling Ventilatory System
    b. Scavenging System
    c. Internal Inhalation Driver
    d. N_2O to N_2 Converter

Appendix B

Using Nitrous Oxide for Pediatric Patients At Salem Hospital
An Assessment of Policy Education
Evaluation Form

Thank you for completing all the required training and education materials today. Your feedback about this education is important, so please take a moment to fill out this evaluation. The information will be used to help direct future presentations and workshops. *Please do not write your name on this evaluation form to maintain anonymity*.

Please rate the following answers based on your experience **before** and **after** the workshop today:

1. I feel I have the knowledge to use nitrous oxide in the pediatric setting:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

2. I feel comfortable in knowing the *indications* AND *contraindications* of nitrous oxide:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

3. I feel confident in being able to educate my patient and family about the benefits of nitrous oxide:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

4. I would use nitrous oxide for pain relief for my patients (as appropriate) over other modalities such as topical lidocaine and midazolam:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

5. I feel comfortable administering nitrous oxide:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

6. I feel the hospital policy provides the information I need to use nitrous oxide:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

7. I would recommend nitrous oxide as a pain management strategy to other nurses I work with:

BEFORE the education:	**AFTER** the education:
Strongly disagree 1 2 3 4 5 *Strongly agree*	*Strongly disagree* 1 2 3 4 5 *Strongly agree*

Please rate the following answers based on your experience **during** the workshop today:

8. I found the hospital policy helpful:

Strongly disagree 1 2 3 4 5 *Strongly agree*

9. I found the Healthstream module helpful:

Strongly disagree 1 2 3 4 5 *Strongly agree*

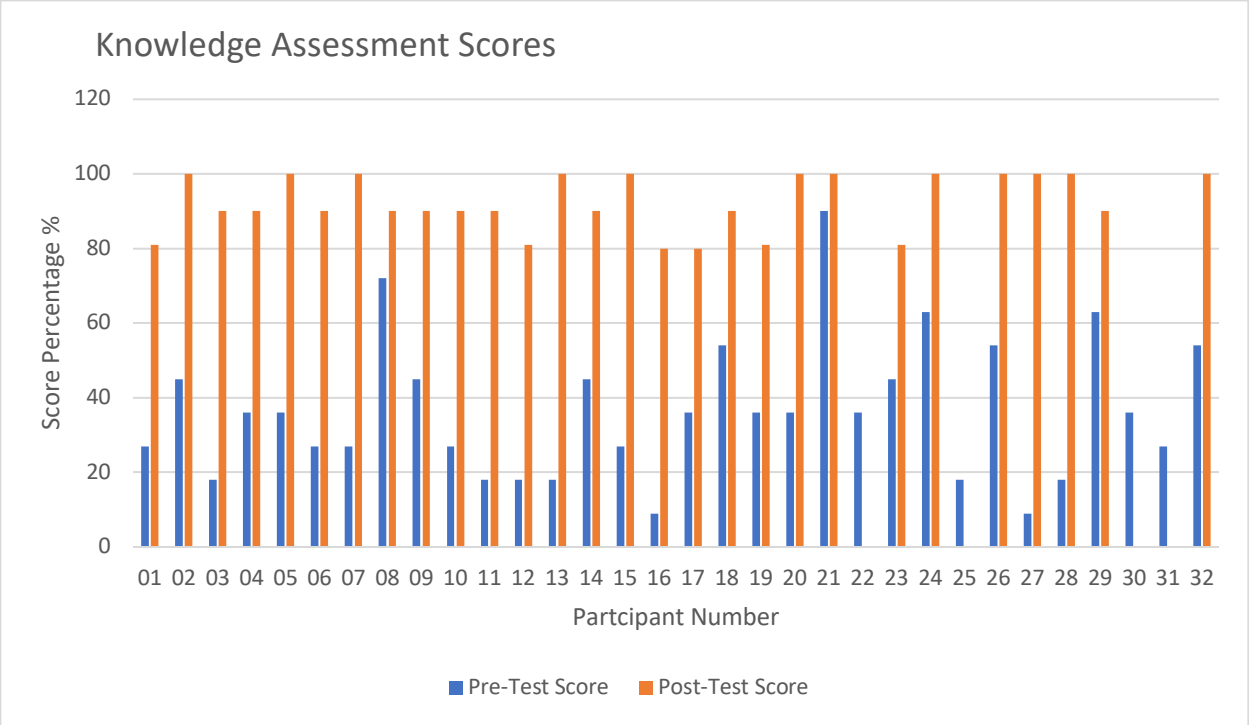
10. I found the hands-on demonstration helpful:

Strongly disagree 1 2 3 4 5 *Strongly agree*

Comments:

Figure 1

Knowledge Assessment Scores



Note. Pre and Post Knowledge assessment scores of nursing staff.

Table 1

Pre/Post Retrospective Survey Responses

Measure	Pre		Post		
	M	*SD*	*M*	*SD*	*p value*
Knowledge	1.43	.63	4.54	.51	<.001
Indications	1.61	.99	4.64	.57	<.001
Benefits	1.64	.87	4.68	.66	<.001
Use	2.11	1.31	4.43	.79	<.001
Admin	1.39	.50	4.32	.61	<.001
Recommend	2.81	1.39	4.56	.51	<.001

Note. (M = mean response score), *p value* relates to significance of intervention between pre and post responses (N=28)