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Evidence-Based Interprofessional Education for the Labor and Delivery Team on Nitrous Oxide Anesthesia for Laboring Mothers

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Evidence-Based Interprofessional Education for the Labor and Delivery team on Nitrous

Oxide Anesthesia for Laboring Mothers

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Evidence-Based Interprofessional Education for the Labor and Delivery Team on Nitrous Oxide Anesthesia for Laboring Mothers

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Table of Contents

Abstract

Pain management in the laboring patient continues to arise with challenges of safety, efficacy and comfort. Nitrous oxide is an option for managing laboring women's pain. However, the lack of education for perinatal teams across the United States regarding nitrous oxide administration in the labor patients omits a successful pain management option. The purpose of this Doctor of Nursing Practice project is to create an evidence-and theoretically-based education module for the labor and delivery team, incorporating an instructional video to build knowledge on the use of nitrous oxide in the laboring mother.

Keywords: nitrous oxide, labor pain, anesthesia, education, labor analgesia

Evidence-Based Interprofessional Education for the Labor and Delivery team on Nitrous Oxide Anesthesia for Laboring Mothers

Background

Nitrous oxide (N_2O) is an odorless, colorless, non-flammable gas that can be used for general anesthesia, procedural sedation, and treatment of pain. N_2O has potent analgesic properties that are useful in the birthing process (Knuf & Maani, 2021). N_2O is an inhaled vapor that is self-administered via a face mask to be used intermittently for analgesia (Broughton et al., 2020). When providing sedation and analgesia, a gas blend of 50%-50% of oxygen and N_2O is utilized for safe administration to patients (Migliaccio et al., 2017). Although the mechanism of action of N_2O in reduction of pain is not fully understood, it is believed that it modulates pain perception at the alpha-2 receptors in the dorsal horn of the spinal cord, releases endogenous opioids in the brain, and antagonizes N-methyl-D-aspartate (NMDA) receptors (Broughton et al., 2020).

The experience of childbirth can be difficult for the laboring women without adequate pain relief. In addition to the benefit of decreased pain perception, advantages of N_2O administration include allowing patients to have control since it is non-invasive and self-administered properties that does not require intravenous (IV) access (Vallejo & Zakowski, 2019). Additionally, N_2O can be administered to patients who have a high opioid tolerance, chronic pain, or need enhancement of neuraxial medications. Within the past decade, the rise of opioid use and misuse make it difficult to treat laboring mothers with a high tolerance to opioids. N_2O is an excellent analgesic option for women with a contraindication to IV butorphanol (Stadol) and nalbuphine (Nubain) (Migliaccio et al., 2017). Another advantage to N_2O

administration is the short half-life of the drug allowing the patient to ambulate freely during labor.

Furthermore, many laboring patients cannot receive epidural anesthesia due to progressing labor, contraindications, or personal choice (Collins, 2018). Contraindications include lack of consent, elevated intracranial pressure (ICP), multiple sclerosis (MS), thrombocytopenia, coagulopathies, impaired consciousness, and multiple back surgeries. (Olawin & Das, 2021). Other contraindications include functional impairments that limit the use of the extremities and methionine synthetase deficiency or reduction (Collins, 2018). Due to these factors, patients may experience increased pain. Although N_2O cannot exceed the pain relief efficacy of an epidural block, it can provide significant analgesia as a non-invasive option for the patient who has a contraindication for an epidural. N_2O administration can also be used as a pain reduction adjunct to epidural management to provide pleasure, relaxation, and anxiety relief (Vallejo & Zakowski, 2019).

N_2O analgesia gained popularity in the United States in the last decade, following approval of the Food and Drug Administration in 2012 (Vallejo & Zakowski, 2019). N_2O has been used commonly for greater than 50% of births in Finland, Norway, England, Australia, New Zealand, Sweden, and the United Kingdom (Vallejo & Zakowski, 2019). With increased popularity in the United States, a local implementation team at Baylor University Medical Center in Dallas, Texas performed a systematic needs assessment on implementing N_2O through the intrapartum stage (Houser et al., 2019). The team consisted of a nurse manager, the chief of obstetrics, the chair of obstetrical anesthesia, the safety and quality nurse, and the project director. The team developed a policy for N_2O implementation on eligibility criteria, contraindications, safety concerns, and documentation. Evidence from the literature supported

administration of N_2O to laboring patients to be successful with an interdisciplinary approach. Additionally, choosing N_2O for laboring mothers may increase satisfaction with successful analgesia.

The effectiveness of N_2O use in the laboring patient was reported by Richardson et al. (2017) through a standardized survey conducted over a 34-month period on 6,242 women, post-vaginal birth. Of these women, 19% chose N_2O administration as a single pain management option in early stages of labor. About 50% reported high effectiveness and the remaining reported variable analgesia effectiveness. This evidence supported N_2O administration effective for analgesia alone and as adjunct with other pharmacological measures during labor.

Moreover, after FDA approval of N_2O administration in 2012, larger institutions such as Vanderbilt University and the University of Washington began to offer N_2O to their parturients. Since this time, other institutions have begun to implement the use of N_2O. Broughton et al. (2018), states that more than 500 hospitals and birthing centers have implemented N_2O use across the U.S.

The topic, *Evidence-Based Interprofessional Education for the Labor and Delivery team on Nitrous Oxide Anesthesia for Laboring Mothers,* has been approved by Dr. Kost, Director of the Frank J. Tornetta School of Anesthesia. See Appendix A.

Problem Statement

The experience of becoming a mother is different for all women. For many, it is challenging because pain perception and anxiety levels may differ for each parturient patient. The ability to manage patients' pain and anxiety during labor should be a driving force for obstetrical care (Collins et al., 2018). Providing an additional option such as N_2O administration for analgesic management may improve the overall labor experience, especially for woman

desiring a less invasive birthing option. N_2O administration is an effective and versatile option for mild to moderate pain and has minimal risk of maternal or fetal complications. A lack of interprofessional education within perinatal teams on N_2O administration allows for a disservice to women who cannot receive an epidural placement.

Purpose Statement

The purpose of this Doctor of Nursing Practice project is to create an evidence-and theoretically-based education module for the labor and delivery team through a structured PowerPoint module embedded with an instructional video.

Project Question

What are the elements of an evidence-and-theoretically-based education module that incorporates an instructional video for the labor and delivery team on N_2O analgesia for laboring mothers?

Conceptual Definitions

- N_2O is an odorless, colorless, non-flammable gas that can be used for general and dental anesthesia, procedural sedation, and treatment of pain. N_2O has potent analgesic properties that are useful in the maternal unit and emergency department (Knuf & Maani, 2021).
- Pain management modalities are conceptually defined as an analgesic in which opioid dosage requirement is minimized while providing adequate pain relief and may include epidural placement. This, in turn, promotes recovery during and after labor (Ashburn & Ballantyne, 2009).
- Educational intervention is a teaching session structured by an evidence-and-theoretically-based education module. The knowledge content is based on evidence-based

research and peer-reviewed articles addressing facts, principles, and theories to improve knowledge about N_2O administration during labor (Knowles, 1978).

- An education module is an evidence-and-theoretically-based, that includes: 1) objectives, 2) content, 3) teaching methods/techniques, 4) resources/materials, 5) timeframe, and 6) evaluation method (Knowles, 1978).

Review of Literature

Search Process Methods

The initial search process of nitrous oxide use in the laboring mother within 5 years generated 218 research articles, therefore the search was extended to within 10 years which generated 825 articles from the following six databases: La Salle University's Summon, CINAHL, PubMed, Medline, JSTOR, and Google Scholar (See Table 1). Keyword search terms used during the literature search included: Nitrous oxide, Entonox, labor and delivery, labor analgesia, administration, and maternity with the Boolean operator "AND" for literature searches specific to the topic. Inclusion criteria for research articles included studies published in the English language between 2012-2022, performed internationally, peer reviewed, and full text. Duplicate articles from 2 databases were omitted from Google Scholar and PubMed after initial title review (See Table 2). Following title review, abstract review, and examination, a total of 9 articles met inclusion criteria and were analyzed through a matrix format (See Table 2). Each study was appraised through the Johns Hopkins Evidence Appraisal Tool-C, categorized through Level (I-V), and Quality (A-B-C) guide.

Appraised Studies

Pasha et al. (2012) assessed maternal expectations and experiences of labor analgesia with nitrous oxide use through a prospective randomized control trial (RCT). In a clinical trial in

Babol, Iran from 2008-2009, 540 women were invited to participate in the use of Entonox for labor analgesia. After interviewing the invitees, 98 pregnant women met the inclusion criteria to participate in the study. Of the 98 participants (*N*= 98) 49 women were randomly selected for the intervention group who would receive Entonox (N_2O-O_2) gas during labor and the remaining 49 women were placed in the control group which would not receive Entonox gas during labor. Inclusion criteria consisted of gestational age ranging from 37-42 weeks, being in active phase of labor, cephalic presentation, non-complicated pregnancy, and pregnant for the second time or more. Exclusion criteria consisted of high-risk pregnancies or known maternal mental disease. Written consent was obtained from all patients before administration of the N_2O mixture was initiated. At the active phase of a labor, which is 4 cms of cervix dilatation, randomized participants were instructed on how to use the face mask to breathe in the Entonox gas.

The data gathering tool was a questionnaire given to each participant that included characteristics regarding demographics, pain severity, expectations, experiences, and satisfaction opinions of N_2O mixture usage (Pasha et al., 2012). The questionnaire was completed through an interview by a researcher with each participant before and after the intervention. The expectation levels were divided into three separate groups: weak, medium, and good. The satisfaction rate and severity of labor pain within the intervention group was analyzed through a Five-point Likert Scale criterion including: very good (A), good (B), medium (C), weak (D) and none (E) (Pasha et al., 2012). Descriptive-analytic statistics was performed with SPSS software. Pasha et al., (2012) states:

> "Analyses were performed using t-test (mean age), Chi-squared (i.e., other variables, pain severity, expectations), ANOVA (expectations of intervention group before and after using gas, and efficacy, satisfaction, complication of severity rate, tolerable labor pain,

and awareness of Entonox gas), McNemar test (expectations of intervention group before and after using N_2O mixture) to determine probable significant associations, and a P value of <0.05 was considered significant" (p. 794).

Pain severity was lower in the intervention group who received nitrous oxide, (p= 0.004). The severity of pain in the intervention group was at a moderate level of 49.94% where the control group was at a high level of pain at 55.10%. The mother's experience of very severe pain was rated at 10.20% in the intervention group and 26.53% in the control group. Seventy-eight percent of laboring mothers, 38 out of 49 women, chose medium (C) or higher for the Five-Point Likert scale for satisfaction of Entonox gas. Entonox gas with less labor pain, with only five women choosing no relief (E) after Entonox use. The majority of the intervention group received effective pain management with the use of Entonox citing less labor pain. Five women choose no relief (E) with Entonox use. Levels of expectation started low in both groups, and resulted in higher expectations after gas administration at a p value of <0.001. The findings of this study show Entonox administration having significant effect on labor pains. There was also significant statistical relation between pre-nitrous oxide expectations and labor pain, resulting in higher relief with a more positive expectation. Researchers stated that the negative expectations were related to the lack of information patients received or understanding related to the use of nitrous oxide as a pharmaceutical option for labor relief. No limitations were noted in this study.

Pita et al. (2012) conducted a prospective observational pilot study to analyze the benefits of inhaled analgesia during intrapartum pain while measuring patient satisfaction. The inhaled analgesia consisted of a 50-50% mixture of nitrous oxide and oxygen (N_2O-O_2) using a face-mask and auto-demand valve. The sample consisted of 126 gravidas with a mean age of 21.6 +/- 6.7 years, from January 2011-June 2011 after Institutional Review Board (IRB) approval at a

High-Risk Pregnancy Labor and Delivery Unit in Guayaquil, Ecuador. Inclusion criteria consisted of singleton pregnancies 35 weeks or greater, cephalic presentation, and in active phase of labor. Exclusion criteria consisted of multiple pregnancies, non-cephalic presentation, fetal distress or intrauterine growth restriction, high-risk obstetrical complications such as preeclampsia, and denied consent. Written consent was obtained after providing each woman with a detailed aim of the study. Women were asked to inhale the 50% N_2O/O_2 mixture through the facemask during contractions and to inhale room air between contractions. A data sheet was utilized for each participant to collect baseline information such as maternal age, parity, vital signs, fetal well-being indicators, and pain perception. Each participant had a baseline fetal monitoring tracing before inhaled analgesia was started.

For pain level measurement, a 10-point scoring Visual Analog Scale (VAS) was utilized at baseline, 1 hour after initiation of inhaled analgesia, and during episiotomy repair (Pita et al., 2012). Descriptive-analytic statistics was performed with Statistical Package for the Social Sciences Software (SPSS software). The Kolmogorov-Smirnov test was used to determine normality of data distribution. Chi-squared tests were used to determine significance of data measured, comparing percentages. A p value of <0.05 was concluded, proving statistical significance.

Furthermore, out of n=126, 96% of the gravidas utilized the N_2O-O_2 mixture during the second stage of labor. At the end of the first hour of inhaled N_2O, the 10-point VAS scoring system demonstrated a reduction in pain of 56.2%, with results decreasing from 8.9/10 to 4.9/10 with p= 0.001 (Pita et al., 2012). In addition, a significant increase in cervical dilatation and effacement was also evident. Ninety-three percent of participants achieved optimum analgesia rating the inhaled nitrous oxide as providing “good-excellent” (Pita et al., 2012, p. 629)

analgesia. The lack of a control group within the study may be seen as a limitation, however, the strength of the study revealed much benefit managing labor pain. The most frequent adverse effect was dizziness, which was described as mild and well tolerated. Inhaled intrapartum nitrous oxide provides rapid alleviation of pain while providing efficient and safe pain management throughout labor.

Agah et al. (2014) performed a randomized control trial (RCT) in Iran to determine if there was a difference in obstetric outcomes when N_2O was used continuously compared to intermittently. The study consisted of 100 women that were admitted to the hospital for vaginal deliveries. Inclusion criteria included singleton pregnancy, cephalic presentation, and term gestation. The women were randomly divided into two groups, 50 women in the continuous N_2O group, and 50 women in the intermittent N_2O group. Intermittent use was defined as breathing into the facemask during uterine contractions and removing it from the face in between contractions. The nitrous oxide mixture was started in the active phase of labor (3-4cm dilation) and was stopped at full dilation of cervix. The goal of the study was to determine if there were significant differences in Apgar scores at minute 1 and minute 5, differences in maternal SpO_2, changes to duration of labor, occurrences of hemorrhage, and overall satisfaction with N_2O use.

The study's outcomes were analyzed in two groups by SPSS 17 software, t-test, and Chi^2 with $P < 0.05$ was considered significant (Agah et al., 2014). The results demonstrated that Apgar scores at the first and fifth minute revealed no significant differences with $p = 0.3$. Maternal SpO_2 showed no significant differences with SpO_2 measured at 95% and above in both groups with a p-value of > 0.05. The mean duration of labor slightly varied with the continuous group at 34 minutes and the intermittent group at 30 minutes though this still shows no significant difference with a p-value of 0.3. There was no significant difference noted in regard

to postpartum hemorrhage. Four percent of the intermittent group experienced bleeding due to uterine atony, while the continuous group was 0%, with a p-value of 0.2. Finally, maternal satisfaction was measured by a survey. Scores were noted to be 96% of those in the continuous group were satisfied with the labor experience, while only 70% were satisfied in the intermittent group. This result shows a significant difference with a p-value of <0.0001. This study's results provided a different perspective on N_2O use, and how it can be implemented in more than one way, with relatively similar outcomes. This allows for more options for the laboring mother with positive outcomes. No limitations were noted in this study.

Parsa et al. (2017) completed a randomized control trial (RCT) to evaluate the effects of N_2O for pain relief in laboring patients. The study took place in Hamadan, Iran, where 120 nulliparous women were divided into two groups. The 60 women who were placed in the intervention group received N_2O for labor and the 60 placed in the control group received oxygen therapy. Inclusion criteria was nulliparous women in spontaneous active phase of labor, having reached cervical dilatation of 3-4 cm. Women excluded from the study were those with medical comorbidities or receiving oxytocin or opioids. This study measured nitrous oxide's effects on the differences in duration of labor, women's perception of pain by using the VAS, and any resulting side effects.

The results of the study demonstrated a significant difference between the groups when evaluating the VAS. When pain was measured at hour one, two, three, and four, the difference was found to be significant with a p-value of <0.001 in favor of the intervention group (Parsa et al., 2017). The labor duration was found to be significantly shorter in the intervention group compared to the control group, with times of 64.80 minutes and 98.33 minutes respectively, with a p-value <0.00. The side effects associated with the use of N_2O are nausea, vomiting, lethargy,

and dry mouth. The only significant finding in regard to side effects across the groups was nausea. The intervention group reported more nausea than the control group with a p-value <0.001. Limitations of this study include convenience sampling, self-reporting pain scales, and a single hospital.

Sheyklo et al. (2017) conducted a systematic review and meta-analysis on articles published from databases including Google Scholar, PubMed, Science Direct, Magiran, SID, and Scopus from 2000-2016. After review, 14 articles were deemed eligible for the study's use. The purpose of this study was to evaluate the effects of N_2O on women in labor. These studies provided information based on maternal pain relief and satisfaction with N_2O and its effects on Apgar scoring outcomes. The data was collected using a comprehensive meta-analysis (CMA:2). The results of this study showed that labor pain management with N_2O administration compared to those without N_2O has a standard difference in mean between groups −1.01 (95% CI: −1.59 to −0.43, Q=148.5, df=8, p=0.02, I2= 76). This demonstrated a significant difference favoring N_2O for pain management with a p-value of <0.05.

When evaluating the Apgar scores across the 14 studies selected, the standard difference in mean between the N_2O group versus the comparison was 0.12 (95% CI: 0.01 to 0.23, Q=109.4, df=16, p=0.00, I2= 85.3). The p-value was <0.05 revealing that this difference was significant (Sheyklo et al. 2017). Furthermore, when comparing the differences between groups, the five-minute Apgar was 0.06 (95% CI: −0.06 to 0.17, Q=235.6, df=7, p=0.00, I2= 89.3), demonstrating no significant difference with a p-value >0.05. Moreover, when evaluating the results of mothers' satisfaction rate, 57.6% of mothers in the N_2O group reported a high level of satisfaction rate versus 21.3% of mothers in comparison group. Statistics were shown via funnel plot.

The results of this study confirm that there is a statistically significant benefit to the use of N_2O during labor and delivery in regard to pain relief and overall satisfaction as well as noting that no change in Apgar scores were seen at five minutes. Sheyklo et al. (2017) states that although there is evidence of benefits of N_2O for labor, it is not used worldwide due to lack of knowledge on benefits on N_2O. No limitations were noted in this study.

Houser et al. (2018) conducted an evidence-based practice change to implement the use of N_2O as a pain management option during labor and delivery. This study took place in a tertiary medical center in the southwest region of the United States. This study utilized an evidence-based practice model for change to determine if implementation of N_2O would be feasible and if women would be receptive to N_2O use. Eligibility for N_2O use during labor analgesia included women requiring induction of labor, oxygenation greater than 95% on room air, and category 1 or 2 fetal heart rate tracing. Once those criteria were met, the patient needed to be free from increased intracranial pressure, increased intraocular pressure, pulmonary hypertension, pneumothorax, or recent drug and/or alcohol abuse. Over a two-month period, a total of 550 women met eligibility criteria for N_2O use, 143 women filled out eligibility forms, and 98 women were offered N_2O for labor. Those women that were excluded included the desire to have an epidural, a precipitous delivery, and no need for pain medication. The choice for some patients was based on their obstetric provider approving of N_2O use. Of these women, 55 (56% of final eligibility) used N_2O during the 2-month implementation period.

Participants evaluated the effectiveness of labor analgesia using the N_2O mixture via the completion of a questionnaire (Houser et al., 2018). Of these 55 women, 36 (65%) completed the satisfaction questionnaire. Items on the questionnaire included satisfaction with N_2O use, amount of pain relief, description of pain relief, and if N_2O would be a choice for future labor and

delivery. The results of this study showed that 27 women (75%) “strongly agreed” or “agreed” that they were satisfied with the use of N_2O. In regard to pain perception, 32 (88.9%) of women indicated that they experienced some relief, while only 4 (11.1%) indicated that they had no relief at all. Furthermore, 80.6% of the women responded that they would consider using N_2O for a future labor experience.

This study supported that the implication of N_2O in this setting is feasible. Additionally, this study showed that N_2O should be used as a valid option in labor and delivery units. Limitations of this study include a small sample size and poor compliance by nursing staff with completion of eligibility forms. Houser et al. (2018) stated that this was due to forgetfulness and possibly due to personal perceptions of N_2O. This supports the importance of staff education on the use of N_2O during labor and delivery.

Richardson et al. (2018) conducted a qualitative content analysis in a quality improvement database of women who experienced labor with nitrous oxide as the sole analgesia. The aim of the study was to identify determinants of satisfaction in the labor population and to understand motives for continued nitrous oxide use for labor analgesia. The study started with 6,507 vaginal deliveries over a 34-month period from 2011-2014 utilizing a mix of nitrous oxide, epidural analgesia, or combined spinal and epidural analgesia (CSE) at Vanderbilt University Medical Center. Of these 6,507 women, 1,246 women decided on the sole use of nitrous oxide with no neuraxial analgesia. Of these 1,246 women, 493 converted to neuraxial analgesia while the rest continued to use nitrous oxide analgesia solely.

Postpartum assessments were performed at the beside on the first postpartum day using a 0–10-point VAS to rate the effectiveness of their pain relief during labor along with their overall satisfaction of analgesia (Richardson et al., 2018). During this time, clarifying comments were

solicited and documented by the clinical interviewer either using direct patient quotes or assessor paraphrases. Of the 678 women who solely use nitrous oxide as labor analgesia, 264 clarifying comments were recorded. Two hundred thirty-eight women (90%) reported high satisfaction with a score >8/10. Analgesic effectiveness was reported by 96 (36%) women with a score of >8/10. Participant comments revealed six different consistent themes of patient perceptions and experiences with nitrous oxide use. The six themes were incomplete analgesia, non-analgesic effects that enhanced coping, importance of birth plan, issues related to interaction between parturient and apparatus use, side effects, and superlatives. These six themes were categorized by analyzing all of the clarifying comments of each woman. Richardson et al. (2018) stated "most of the clarifying comments were accompanied by a high score (>8) despite intermediate scores of analgesia (5-7)" (p. 102). Several comments included superlative phrases such as: (1) Nitrous oxide worked perfectly. Could not have done it without N_2O or (2) Loved nitrous oxide. On the contrary, some women believed that nitrous oxide use did not provide complete analgesia but was a good adjunct distraction and eased the pain. One participant commented that the pain didn't go away but it was diminished enough to get through contractions. This qualitative study identified a wide range of perspectives regarding nitrous oxide use for labor analgesia when its administration began to increase within the United States. This study helped to demonstrate the different outcomes N_2O use has on each laboring mother and how its use fits into the six different themes whether it be coping with painful contractions or helping with a specific birth plan by avoiding neuraxial analgesia able to alleviate pain. Women reported benefits such as relaxation, decreased anxiety, and dissociation. The results of this study suggested that the determinants of patient satisfaction are more variable than previously understood, allowing N_2O to be a sufficient analgesic or an efficient adjunct. Researchers suggested limitations regarding

faithfulness of clinical interviewers that summarized postpartum conversations were recorded correctly.

Mukhopadhyay et al. (2021) conducted a prospective randomized control trial (RCT) in a South Asian referral center to evaluate the effect of Entonox on severity of labor pain. The study was completed over two months from May 1, 2020, to June 30, 2020. A total of 200 women were randomly divided into a trial versus a control group by coin toss. The trial group consisted of those who would receive N_2O versus the control group who would receive oxygen. Sample number was determined by a confidence coefficient of 95% and power of 80%. Inclusion criteria encompassed women with a term pregnancy, defined as 37-to-41-week gestation, singleton pregnancy, and without high-risk indicators. The pain assessment tool utilized in the study was the Wong–Baker Faces Pain Rating Scale. This is a pain scoring system that shows different faces varying from a happy face at 0/10, representing without hurt, to a crying face at 10/10, representing the worst kind of pain. The midwife would choose a face from the tool based on the women's faces during labor.

The data compiled for this study was evaluated by using Microsoft Excel and unpaired t-test to determine the significance of study parameters between two groups. Finally, statistical analysis performed by SPSS 17.0 software, unpaired t-test, and Chi-square test while $p < 0.05$ was considered significant. Of the 200 patients in the study, mean scores of the Wong–Baker Faces Pain Rating Scale were taken at 4 cm, 6 cm, and 8 cm dilation, respectively (Mukhopadhyay et al., 2021). The results of the study showed that at 4 cm dilation the N_2O group pain scale was 6.85 compared to 8.00 in the oxygen group. At this stage, there was no statistical significance with a p-value of 0.1158. At 6 cm dilation, the N_2O group pain scale was at 5.86 compared to 8.64 in the oxygen therapy group. This demonstrated a statistical

significance with p-value of 0.01. Finally, at 8 cm dilation, the N_2O group mean pain score was 4.99 compared to 9.08 in the oxygen therapy group. This shows statistical significance with p-value of 0.0000. Furthermore, during the second stage of labor, at full dilatation, the relief of pain was significant in the N_2O group with a mean score of 4.49 compared to 9.13 in the oxygen therapy group.

This study revealed that when comparing the N_2O therapy group to the oxygen therapy group, the mean duration of the active phase of labor was 389.09 minutes in the N_2O group and 413.52 minutes in the oxygen therapy group. This demonstrated that N_2O does not delay the progression of labor with a p-value of 0.2555 (Mukhopadhyay et al., 2021). The conclusion of this study supported that significant pain relief can be achieved with N_2O without increasing maternal complications or prolonging labor progression time while increasing overall maternal satisfaction. No limitations were noted in this study.

Such and Denny (2021) performed a nonexperimental, cross-sectional study on those who received an epidural, N_2O, or natural labor birth. The purpose of this study was to evaluate the comfort and satisfaction of the birthing experience. This study's design was facilitated by Kolcaba's theory of comfort. This study took place in three Midwest hospitals in the United States and was completed from June – October 2019. A total of 84 women participated in the study. Criteria for the study included vaginal births at term gestation defined as greater than 37 weeks, at least 18 years of age, first pregnancy, and no current complications associated with pregnancy. The women were placed into their respective group according to their chosen birth plan, i.e., natural, N_2O, or epidural. Of these women, 28 used N_2O only, 28 had an epidural, and 28 had no analgesia management.

Data was collected within six hours of birth via the Birth Satisfaction Scale-Revised (BSS-R) and the Childbirth Comfort Questionnaire (MCCQ). The BSS-R includes 10 Likert-type questions that are used to quantify birth satisfaction based on how the women perceived the stress experienced during labor, quality of care, and coping skills (Such & Denny, 2021). The MCCQ is used to measure overall comfort during labor and delivery. The MCCQ was developed to evaluate comfort for nulliparous women during the latent and active phases of labor. Included in the MCCQ is a 14 Likert-type items that are scored from 1-5 (Such & Denny, 2021). Scores ranged from 36 to 66. The higher the scores, the more pain relief and comfort the patient reported.

Such and Denny (2021) found no statistically significant differences in comfort during childbirth when comparing the MCCQ of those who used N_2O, those who had an epidural, and those who chose no pain relief modalities. Mean scores remained within 1 point across the groups. Furthermore, the researchers conducted a between-groups ANOVA, which indicated no significant differences in MCCQ scores across groups, $p = .34$, $\eta 2 = .027$.

Scores on the BSS-R ranged from 15 to 40, with a mean score of 30.79 and SD of 4.88. The mean score for the N_2O group was 30.54 making that the lowest, while the mean score for the epidural group was the highest with a mean score of 31.07. In order to evaluate the effect of the self-directed option for pain management on a satisfaction scale, the researchers performed a between-groups ANOVA, which indicated no significant differences in satisfaction across groups, $p = .92$, $\eta 2 = .002$ (Such & Denny, 2021). This study shows by having no significant differences in satisfaction scores, that each woman experiences pain through a multidimensional view point where many different factors may contribute to the overall birthing experience. The small sample size is mentioned as a limitation to this study.

Related Literature

Migliaccio et al. (2017) published a brief report in the Journal of Midwifery & Women's Health about the utilization of nitrous oxide during intrapartum labor. The brief report describes the integration of N_2O into practice at the University of New Mexico (UNMH), along with challenges that occurred during the process. The initial step in the implementation was the development of a written policy and procedure guideline formulated from current literature and policies from other institutions. After many revisions and input from representatives at UNMH, the approved policy and procedure guideline included, 1) equipment and safety, 2) monitoring, 3) nursing administration of N_2O, 4) use by women with opioid dependence, and 5) financial considerations. The UNMH guideline included indications of labor pain, difficult intravenous placement, external cephalic version, intracervical balloon placement, postpartum laceration repair, and manual removal of placenta. Contraindications within the UNMH guideline included excessive sedation or the inability to hold the facemask, unstable hemodynamics, vitamin B_{12} deficiency, head trauma within the past 2 weeks, recent pneumothorax, gastric bypass surgery or inner ear surgery and/or category III fetal heart rate pattern.

The safety of N_2O exposure can be measured by providers wearing N_2O dosimeter badges, which are tested annually per the National Institute for Occupational Safety and Health (NIOSH) standards (Migliaccio et al., 2017). Since the beginning of testing N_2O readings, the amount has never exceeded 25 parts per million which is the national guidelines limit of exposure to N_2O. It was reported that during the first four months of implementation, a total of seven incident reports, both formal and informal, were submitted stating the smell of a sweet odor with the complaints of headaches and jaw tightening. Biomedical engineering examined the equipment finding no leak of gases, only minor eroding of the rubber washers between the tank

and device. As a result, the rubber washer was changed with each use and there has been no further incident reports. As for the sweet odor, N_2O is an odorless gas, so this complaint was related to the new plastic smell released with the opening of the breathing face mask and circuit during each use.

Migliaccio et al. (2017) stated minimal literature was available on recommendations for care and monitoring of the woman and the fetus when exposed to N_2O. The UNMH guideline recommends intermittent versus continuous fetal monitoring during the use of N_2O, depending on fetal status on admission. In regards to education, UMNH implemented suggestions from Vanderbilt University Medical Center. The suggestions included that "well-developed staff education and proof of competency are key components in establishing N_2O availability" (p. 360). Sharing literature, providing ongoing education, hands on experience, and annual competencies helped ensure an increase in understanding and support for N_2O availability. UNMH allows registered nurses to administer N_2O to the laboring mother entailing education, initiation, and observation. Collaboration between providers, nursing staff, and other hospital departments such as anesthesia was involved in the implementation of N_2O for laboring mothers.

Collins (2018) published an informational article in AWHONN recommending nitrous oxide to be a vital component in maternity care while addressing each step from initiation to management in the laboring mother. Examination of research studies to support the information as well including an RCT and a systemized review. Richardson et al. (2017), cited in Table 2, compared the relationship between analgesic effectiveness and patient satisfaction. Results concluded similar satisfaction rates between N_2O anesthesia and neuraxial anesthesia. The systemized review by Likis et al. (2012) encountered limitations with poor quality studies, concluding less effective pain relief compared to epidural analgesia and insufficient findings

when compared to nonepidural labor pain methods. The published date on the systemized review relates to poor outcomes, as more recent research has sufficient results.

As for indications, it has been found that nitrous oxide has many uses within childbirth. The most prominent studied use of nitrous oxide is the promotion of pain relief during labor but it can also be used during external cephalic version, placement of IV lines, procedures for cervical ripening, manual removal of the placenta and laceration repair. Nitrous oxide can also be used with other analgesia methods such as hydrotherapy, massage, acupuncture or even used during the placement of neuraxial anesthesia. N_2O is safely administered through an approved obstetrics apparatus, different than the apparatus used for dental procedures. The obstetrics apparatus does not allow for a change in the dial of gas percentages so there will always be an exact 50% O_2-50% N_2O mixture. In addition to administration safety, the obstetrics apparatus delivers gas on inhalation via a demand valve within the mask or mouthpiece, whereas the dental apparatus provides continuous delivery of gas. On exhalation, the flow of gas stops completely while a scavenging interface connected to the breathing circuit allows the exhaled N_2O to be vented out of the facility. Advantages of N_2O analgesia include:

- noninvasive
- women retain mobility; bed rest is not required
- no IV access required
- fast onset and fast elimination
- viable option for procedures when regional anesthesia is not in use
- no adverse effects on uterine activity, contractions or fetus
- control of administration
- substantial anxiolytic

- decreased cost compared to regional anesthesia

On the contrary, disadvantages are listed as variability in efficacy and the chance of side effects during use like nausea and vertigo. Contraindications for N_2O use include conditions in which a collection of gas can be harmful such as a recent pneumothorax, gastric bypass surgery, or an inner ear surgery. Medical conditions including extreme B_{12} deficiency, pernicious anemia, and impaired consciousness are also contraindications for N_2O use.

Education is required for the patient, family members/visitors, and staff. This education will provide safety for the laboring mother, support persons, and medical team. Women should be instructed on how to achieve an adequate seal from the mouthpiece or mask when inhaling the N_2O. An adequate mask seal is critical in order to open the demand valve Collins (2018) recommends that women be instructed on inhaling 30 seconds prior to a contraction for optimal efficacy. It is important to make family members or visitors aware that only the laboring mother can utilize the breathing circuit and no one is to assist her. Collins (2018) states, "Staff education to ensure broad understanding of N_2O use is a necessary component of a successful program" (p. 197). Appropriate training for staff allows for a safer environment of N_2O use for everyone. N_2O administration can be taught to registered nurses, obstetricians, and anesthesia personnel. Collins (2018) suggests the idea of an extended team to be primarily focused on future implementation programs.

Rollins et al., (2018) created an informational review via the American Society of Anesthesiologists. The authors state that although pain relief is a large component of the labor experience, there are other components that contribute to the experience as well. These factors include the ability to cope with pain and having a sense of control over the experience. This concept of the labor experience favors the use of N_2O. N_2O produces a sense of dissociation and

euphoria which could improve the perception of pain. For example, the authors reviewed a study completed by Richardson et al. (2017) that evaluated N_2O for labor pain. The study revealed that although women reported poor analgesic efficacy, they still provided high satisfaction ratings with their pain management care. These results offer the opinion that the primary beneficial effects of N_2O in labor may be due to its anxiolytic effect and impact on the woman's sense of control with self-administration.

According to Rollins et al. (2018) the process of implementing a N_2O policy for the labor and delivery unit has many requirements that must be met. These requirements include that the administration of N2O must comply with the sedation policies developed at the individual institution's Department of Anesthesiology and should be in accordance with the Centers for Medicare and Medicaid Services (CMS) guidelines for anesthesia care. The administration of N_2O should be performed in health care facilities that have written protocols for use of N2O, pulse oximetry, and gas scavenging systems availability.

Furthermore, the authors stated that N_2O protocols can allow for nursing implementation with provider order. Before the protocol can be implemented, perinatal teams need training and education on N_2O administration, importance of the scavenging system, patient monitoring, and potential for exposure to health care workers. Depending on the policy, staff may wear dosimetry badges to determine the level of environmental exposure. National Institute of Occupational Safety and Health (NIOSH) in 1994 recommended that a maximal time-weighted average level of N_2O exposure to 25 ppm per procedure over an 8-hour period (Rollins et al., 2018).

Theoretical Framework

The theoretical framework, andragogy theory on adult education, developed by Malcom Knowles (1978) describes a process through which the adult learner becomes aware of the goal

objectives to be taught. Andragogy is defined as the methods and principles of helping adults to learn (Knowles, 1978). Knowles's framework will be used to orient the evidence-and-theoretically-based education module for administration of N_2O to the labor and delivery team.

The key concepts of the Malcom Knowles andragogy theory (1978) include: changes in self-concept, the rule of experience, readiness to learn, orientation to learning, and motivation to learn are described as (p. 45-47).

- Changes in self-concept is when a person matures, moving from total dependency to a more self-directed human being.
- The rule of experience assumes that as the individual endures personal experience it allows for a resource of learning.
- Readiness to learn assumes that as a person matures, their ability to learn is based on current social roles instead of biological development. Perspective on time changes to immediate application versus previous application.
- Orientation to learning as one matures shifts from specific subjects to a whole-centered focus.
- Motivation to learn increases the persons motivation to absorbing new information (p. 45-47).

This theoretical framework regarding adult education by Knowles (1978) connects to the conceptual definition of educational intervention, education module on N_2O anesthesia, and evaluation method. Incorporating this framework into the project matches the classification of labor and delivery nurses as adult learners. During the education session, it is anticipated that they incorporate this new information and exhibit interest in learning.

Andragogy theory on adult education by Knowles (1978) will be a successful guide for completing an education module on N_2O administration. According to Knowles, adults learn best through doing rather than memorization. Effective teaching focuses on specific tasks to be done and can be achieved when a teaching process is performed. Adult learners have an increased chance of success if specific tasks are fully explained and not just demonstrated (Corley, 2008). Due to N_2O being underutilized in the last decade, the labor and delivery team may have limited education about N_2O as an option for labor pain management.

Method

Design and Procedure for Data Collection

This DNP scholarly project validates the need for an evidence-based educational module regarding nitrous oxide use for the laboring mother. The evidence-based educational module is presented through a PowerPoint module embedded with educational videos to enhance the level of knowledge and skills to the perinatal team. This can be categorized as a quality improvement project with a focus on professional education. Quality improvement (QI) is a "systematic, formal approach to the analysis of practice and efforts to improve performance" (AAFP, 2022). Goals of the design included 1) validated topics to be included in an evidence-based education module focused on N_2O use in the laboring mother as a pain management option, 2) improved labor and delivery teams' knowledge and self-efficacy related to N_2O use in the laboring mother, and 3) with this improved knowledge, labor and delivery teams may advocate for mothers to use N_2O analgesia who choose not to receive neuraxial analgesia or for who neuraxial analgesia is contraindicated.

A directed content analysis (Table 3) provided classification, tabulation, and evaluation of key themes in order to attain a probable effect (Krippendorff, 2019). The qualitative results

from the content analysis provided a foundation for the proposed evidence-based education module.

Sample and Setting

The evidence-based literature identified in the directed content analysis is the primary sample for the development of our teaching module on the administration of N_2O in labor and delivery. The directed content analysis served as the foundation for the educational module and the embedded videos. The educational videos were filmed in an obstetric room at Einstein Medical Center Montgomery in Norristown, Pennsylvania. Expert reviewers were sent a Qualtrics Survey that assisted in validating our program. Those who met criteria of an expert reviewer pertaining to the topic included certified registered nurse anesthetics (CRNAs), anesthesiologists, and registered nurses (RNs) with expertise in labor and delivery.

The role of each expert was to complete a Qualtrics survey to provide feedback. With the combination of these experts, all aspects of our project were appropriately addressed with their experience and input. Recommendations from the expert panel were taken and revisions to the educational module were made. After completion of the revised module, the educational PowerPoint was distributed to the labor and delivery unit, including anesthesia personnel. The education module summary is displayed in Table 4. The Qualtrics Survey received 20 responses from RNs with labor and delivery expertise, anesthesiologists, and CRNAs. The survey included two demographic questions including profession and clinical experience followed by clinically relevant questions related to N_2O use in the labor and delivery setting.

Ethical Considerations

This project has been granted exemption from Albert Einstein Healthcare Network's IRB (Appendix B) given there are no human subjects involved in the quality improvement project. La

Salle University acknowledges and accepts Einstein's IRB approval and does not require the submission of a formal IRB proposal (Appendix C).

Instrumentation

The instruments used for this project included the directed content analysis (Table 3) and the Expert Content Validity Form (Table 5) that illustrate how the expert reviewers rated the QI education module. The Qualtrics survey was designed utilizing a Likert scale for experts to rank the relevance on different aspects of N_2O administration in the laboring patient. A content validity index (CVI) was calculated based on the survey responses to evaluate the need for education in labor and delivery nurses, anesthesiologists, and CRNAs on the use of N_2O in the laboring mother. The results of the CVI were calculated based on the provider experience by asking, “In your clinical practice, have you ever provided N_2O as an analgesic for the laboring patient?”. The results of this CVI were 0.85.

Discussion

Findings

Although there were 22 total responders, two of the responders only answered the demographic questions and did not complete the survey. Because of this, we were unable to determine what types of practitioners did not complete the survey. Of those who completed the survey, the results determined that only three of the 20 responders have used N_2O in their practice. The survey results indicated that the majority of the respondents stated that they have never received any formal education on N_2O use. Respondents stated that the highest priority of N_2O use in the laboring patient was addressing contraindications and patient monitoring specifics. The survey included an open-ended section for the respondent to offer any additional feedback they felt should be included. In this section it was noted that COVID-19 effects and

staff exposure to N_2O waste be addressed. Finally, the survey included a section for open ended responses on barriers to implementing N_2O in clinical practice. The results of this question demonstrated that the leading barriers included administrative support, budget constraints, and health care provider cooperation. A Likert-style question from the survey results is attached as Figure 1.

The results of this survey demonstrated that there is a need for further education on N_2O in the laboring patient. As the leaders of this QI project, we plan to address the concerns of the labor and delivery teams. For example, the effects of wasted gas, contraindications, and specific monitoring are included within the PowerPoint with embedded video. Furthermore, we intend to break down barriers by increasing education with the PowerPoint with embedded video. It may be plausible to offer this information to the hospital staff as well as the clinic, OB/GYN office staff, and prenatal classes.

Limitations

Limitations of this survey included that no research was completed during COVID-19 on N_2O administration to the laboring mother due to isolation effects of masks. Hospitals suspended the use of N_2O at this time to reduce the risk of transmission from aerosolization of the vapors (Froessler et al., 2022). Because of the pandemic, there is a gap in the literature on N_2O use in the laboring mother. Another limitation included that the survey did not include “risks to mother and baby” in the Likert scale, yet it was written once in the open-ended section. We have addressed this within the paper stating that there are no adverse effects on uterine activity, contractions, or fetal well-being and we have added the information to our voice over PowerPoint with embedded video.

Implications/Future Plans

This evidence-based education module with embedded videos on the administration of N_2O to the laboring mother can be used as a foundation for future hospital orientation and annual staff education. The data collected can be added to future research, strengthening the significance for N_2O administration as a pain relief adjunct in the laboring mother. The gap in research on the effects of COVID-19 should be addressed to assist in eliminating fears regarding its administration. Future SRNA's interested in this topic should implement a pre and posttest survey for evaluation of the educational module to providers' learning. Successful implementation and evaluation of the program includes working with all team members involved in caring for the patient. These members include Obstetricians, Anesthesiologists, Nurse Anesthetists, Labor and Delivery RNs, Neonatal Intensive Care RNs, Mom/baby RNs, Risk Management, Biomed and Facilities.

Conclusion

In the United States, less than 1% of labor and delivery units utilize N_2O, while in Australia it is the most common analgesic agent with use at 53% (Froessler et al., 2022). This demonstrates the profound need for education on the use of N_2O in the laboring mother. A lack of education provides a disservice to women who wish to have a less invasive labor experience. Broughton et al. (2020) states that N_2O offers a safe alternative for many laboring patients who desire a greater sense of control and mobility. Our goal is to increase education by providing a clear, concise, and easily accessible voiceover PowerPoint with embedded videos that the learner can use as a reference tool for N_2O administration. The intended outcome is to increase the overall knowledge and comfort of the provider of N_2O use in the laboring mother and therefore provide another analgesic option to laboring mothers.

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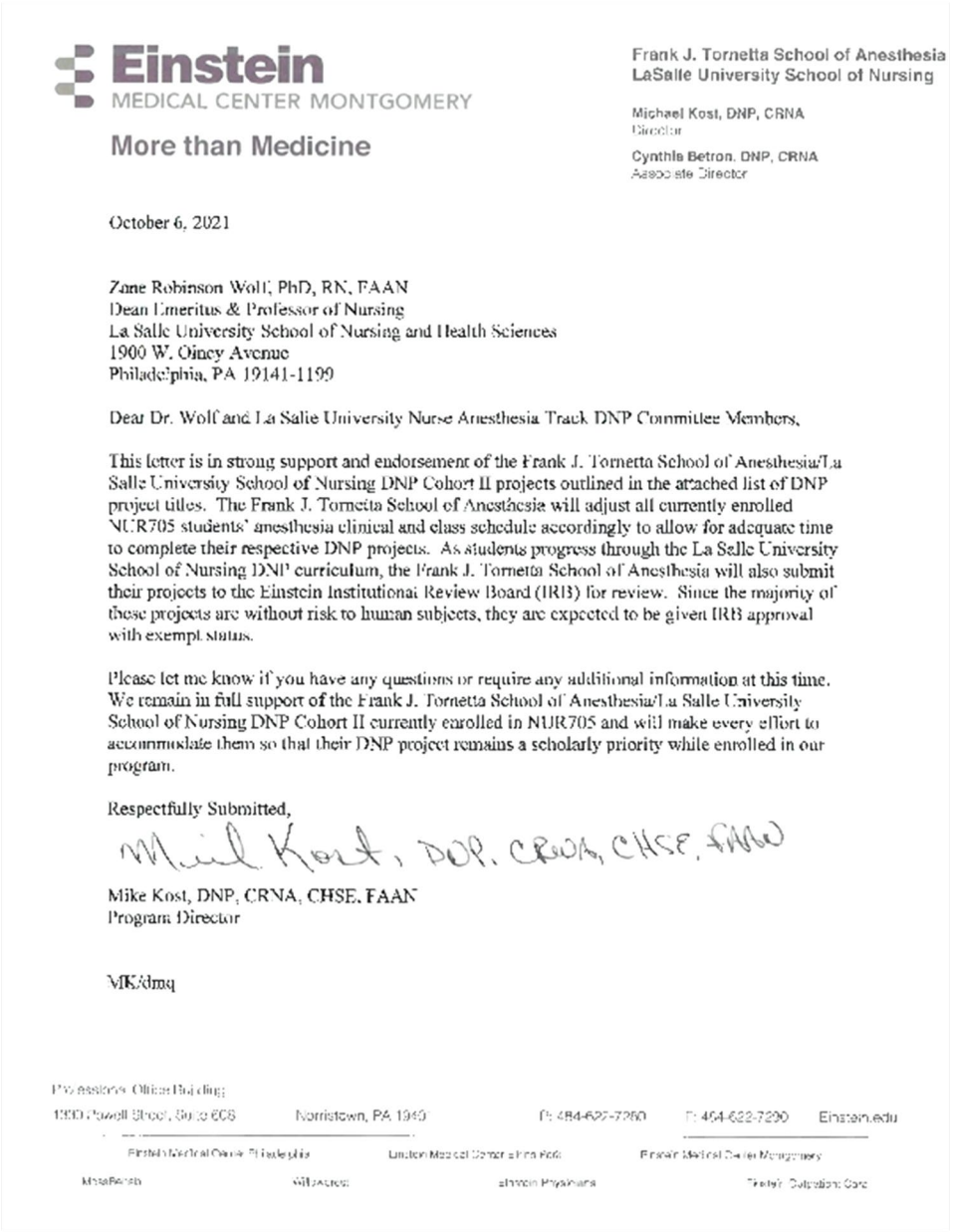
Appendix A

Project Support Letter



Einstein
MEDICAL CENTER MONTGOMERY
More than Medicine

Frank J. Tornetta School of Anesthesia
LaSalle University School of Nursing

Michael Kost, DNP, CRNA
Director

Cynthia Betron, DNP, CRNA
Associate Director

October 6, 2021

Zane Robinson Wolf, PhD, RN, FAAN
Dean Emeritus & Professor of Nursing
La Salle University School of Nursing and Health Sciences
1900 W. Olney Avenue
Philadelphia, PA 19141-1199

Dear Dr. Wolf and La Salle University Nurse Anesthesia Track DNP Committee Members,

This letter is in strong support and endorsement of the Frank J. Tornetta School of Anesthesia/La Salle University School of Nursing DNP Cohort II projects outlined in the attached list of DNP project titles. The Frank J. Tornetta School of Anesthesia will adjust all currently enrolled NUR705 students' anesthesia clinical and class schedule accordingly to allow for adequate time to complete their respective DNP projects. As students progress through the La Salle University School of Nursing DNP curriculum, the Frank J. Tornetta School of Anesthesia will also submit their projects to the Einstein Institutional Review Board (IRB) for review. Since the majority of these projects are without risk to human subjects, they are expected to be given IRB approval with exempt status.

Please let me know if you have any questions or require any additional information at this time. We remain in full support of the Frank J. Tornetta School of Anesthesia/La Salle University School of Nursing DNP Cohort II currently enrolled in NUR705 and will make every effort to accommodate them so that their DNP project remains a scholarly priority while enrolled in our program.

Respectfully Submitted,

Mike Kost, DNP, CRNA, CHSE, FAAN
Program Director

MK/dmq

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Einstein Medical Center Philadelphia | Einstein Medical Center Elkins Park | Einstein Medical Center Montgomery
MossRehab | Willowcrest | Einstein Physicians | Einstein Outpatient Care

Appendix B

Einstein HEALTHCARE NETWORK
More than Medicine

Human Subjects Research Determination

October 19, 2022

Type of Review: Initial
Project Title: Evidence-Based Interprofessional Education for the Labor and Delivery team on Nitrous Oxide Anesthesia for Laboring Mothers
Investigator: Cynthia Betron
IRB ID: IRB-2023-1015

Dear Cynthia Betron ,

The planned activity noted above was reviewed by a member of the EHN IRB and determined not to be human subjects research. This decision only applies to the planned activity described in the materials provided to the IRB. As the person accountable for the conduct of the activity, you are responsible for ensuring that it is conducted as described in the materials provided.

Before this project can be initiated, you **must** email Derrick Crump, the Chief Privacy Officer, the following to confirm all HIPAA regulations will be followed:

- The activity description
- The plan for data use (Who will have access to the data? Will data be shared outside of Einstein? How long will it be stored?)
- The plan for data protection (e.g. limited access, where and how data will data be stored, data coded, deidentification, password protection, etc.)
- Any materials submitted within this determination and that will be used to carry out your planned activity:
  - Any surveys/questionnaires
  - Data collection sheet(s)
  - Master/Linking sheet
  - Description of recruitment activities including invitations (if applicable)
- Other relevant information not listed above

If any data that is being collected for this project will be used for student requirements to earn a degree for an external school or institution (ie, doing the study and collecting data for your dissertation, Master's Degree, etc, you must contact Tahirah Harrigan to confirm that all student requirements have been met and Derrick Crump, the Chief Privacy Officer, to confirm that a data sharing agreement is needed and/or signed.

Please note that any data collected for this activity cannot be analyzed and presented for another purpose, unless an updated project description and analysis plan is approved by the IRB. Although much can be learned from these types of activities and sharing your findings is strongly encouraged, this activity as currently described cannot be referred to as "human subject research" when discussed in publications and presentations. Innovative Programs (IP) and Quality Improvement (QI) projects should not be described or analyzed as a "study" or "research" in publications or presentations, but should be clearly identified as a "program", "program evaluation" or "QI project". An acceptable statement that could be included in the manuscript would be, "This project was reviewed and determined not to meet the definition of human subject research by the EHN IRB."

If you wish to analyze and present the data collected for your project/program as part of a human subject research study, please call the IRB Office at 215-456-7217 to discuss whether a new application must be submitted to the IRB for review prior to initiating this activity.

Sincerely,
Beth Lynch, CIP
Senior IRB Analyst

Appendix C

18 February 2022

TO: Patricia Dillon, PhD, RN
Chair of Graduate, RN to BSN and RN to MSN Nursing Programs

FROM: Susan C. Borkowski, Ph.D.
Chair, Institutional Review Board

RE: Post BSN - DNP Anesthesia Students' Projects

The La Salle University Institutional Review Board [IRB] accepts Einstein Hospital's IRB assessment of the Post BSN - DNP Anesthesia Students' Projects as non-human research.

These projects focus on quality improvement and do not involve human subjects. Based on the Einstein determination, La Salle's IRB does not require the submission of a formal IRB proposal.

Appendix D

Table 1

Search Process Review of Literature

Database	Total Articles	Articles Remaining After Title Review	Articles Remaining After Abstract Review	Articles Retrieved and Examined	Articles that fit Inclusion Criteria
LaSalle Summons	220	6	5	5	3
CINAHL	11	0	0	0	0
PubMed	46	6	6	6	4
Medline	5	0	0	0	0
JSTOR	72	0	0	0	0
Google Scholar	471	10	9	9	2

**Duplicate studies omitted (2)*

Table 2

Review of Literature Matrix Systematized Review

Database # Article First Author, Year (full citation in References)	Purpose of Study Major Variables (IV, DV) or Phenomenon	Theory or Conceptual Framework	Design	Measurement Major Variables (Instrument)	Data Analysis (Name of Statistics, descriptive, Inferential and Results)	Findings	Evidence Level of Research & Quality Johns Hopkins Nursing Evidence-Based Practice
La Salle University Summon #1 Pita, C.P., 2012	To analyze the benefits of an inhaled analgesia procedure over intrapartum pain and the degree of satisfaction. DV- Pain (VAS scores), maternal hemodynamics, cervical dilatation (cm), cervical effacement (%), reassuring fetal heart monitoring tracings (%), clear amniotic fluid (%).	None	Prospective observational pilot study.	The study ran from January 2011-June 2011 at a High-Risk Pregnancy Labor and Delivery Unit in Ecuador. Baseline fetal heart monitoring (FHR); baseline data sheet; 10-point scoring Visual Analog Scale (VAS) at baseline, 1hr after initiation, and during episiotomy repair.	Descriptive-analytic statistics was performed with SPSS software. The Kolmogorov-Smirnov test was used to determine normality of data distribution. Chi-squared tests were used to determine significance of data measured, comparing percentages.	A total of 126 gravidas participated in the study. The effect of N_20 mixture for pain according to the VAS scale concluded a reduction of 56.2% (8.9-4.9, *p* value <0.001). An increase in cervical dilation and effacement by 28.4% and 21.7%. There were no significant differences in	III-B

					A *p* value of <0.05 was concluded, proving statistical significance.	maternal blood pressure and pulse.	
La Salle Summon #2 Gareh Sheyklo, S., 2017	The aim of this study was to systematically review studies addressing the effect of Entonox for pain management in labor. IV- Nitrous oxide use DV- perception of labor pain relief, APGAR score	None	Systematic Review and Meta-analysis study	CONSORT 2010 includes 37 items for evaluating 6 main parts of clinical trial studies. This includes: • title • abstract • introduction • materials and methods • results • discussion Forest plot diagrams were used with 95 percent for each study. For evaluation of heterogeneity among the studies' results, Q statistic and	Pain relief standard difference in mean between-groups was −1.01 (95% CI: −1.59 to −0.43, Q=148.5, df=8, p=0.02, I^2=76) this difference was significant (p<0.05). The overall Apgar score standard difference in mean between-groups (N_2O vs. comparison) was 0.12	Showing clinical significant (p<0.05). The results of mothers' satisfaction rate show that mothers in N_2O group had a high level of satisfaction rate.	II-A

				I^2 indicator were used.	(95% CI: 0.01 to 0.23, Q=109.4, df=16, p=0.00, I^2=85.3).		
La Salle Summon #3 Richardson, G., 2018	The aim of the study was to identify determinants of satisfaction in the labor population and to understand motives for continued nitrous oxide use for labor analgesia.	None	Qualitative content analysis	Postpartum assessments were performed at beside on the first postpartum day using a 0–10-point verbal analog scale to rate the effectiveness of their pain relief during labor along with their overall satisfaction of analgesia.	Of the 678 women who solely use nitrous oxide as labor analgesia, 264 clarifying comments were recorded (Richardson et al., 2018). 238 women (90%) reported high satisfaction with a score >8/10. As for analgesic effectiveness, 96 (36%) women reported a score of >8/10	In conclusion, this qualitative study identified a wide range of perspective on nitrous oxide during the decade in which N_20 administration during labor began to increase in use within the United States compared to other countries. Researchers suggest limitations regarding faithfulness of clinical	III-C

					(Richardson et al., 2018). Differences in comments provided six different consistent themes of patient perception and experience with nitrous oxide. Richardson et al., (2018) states "most of the clarifying comments were accompanied by a high score (>8) despite intermediate scores of analgesia (5-7)" (p. 102).	interviewers that summarized postpartum conversations were recorded correctly.	
PubMed #1 Pasha, H., 2012	To assess maternal expectations and experiences of labor	None	Prospective Randomized Control Study (RCT)	The study was conducted in a maternity ward Babol, Iran	Descriptive-analytic statistics was performed	Pain severity was lower in patients in the intervention	I-A

	analgesia with nitrous oxide. IV- Nitrous oxide use during labor. DV- Expectations and experiences gathered through a self-taken questionnaire.			from 2008-2009. 49 women were placed in the control group and 49 women were placed in the intervention group. The data gathering tool was a questionnaire concluding patient expectation and experiences including severity of pain, and any related complications.	with SPSS software. Analyses were performed using t-test, Chi-squared, ANOVA, and a McNemar test. A *p* value of <0.05 was concluded, proving statistical significance.	group (*p*= 0.004). The severity of pain in the intervention group was at a moderate level of 49.94% where the control group was at a high level of pain at 55.10%. The majority of the intervention group received efficacy of Entonox gas with less labor pain, only 2 women were unsatisfied. Levels of expectation started low in both groups, and resulted in higher expectations	

						after gas administration at a *p* value of <0.001.	
Pub Med #2 Houser, T., 2019	To evaluate if the implementation of nitrous oxide as a pain management option during labor and to examine women's satisfaction with that option. IV- Nitrous oxide use. DV- Perception/satisfaction of mother.	None	Quality Improvement Project (QI)	Assembling an implementation team, developing and approving of a policy for nitrous oxide use in labor and delivery**,** staff education sessions**,** strategies to inform women about the availability of nitrous oxide**,** initiation of the policy. 5-question eligibility form for staff to complete first If N_2O was chosen: Questionnaire of women's satisfaction	During the 2-month data collection period: of the n=55, 36 (65%) completed satisfaction survey.	N= 32 (88.9%) = some relief N= 4 (11.1%) = no relief 80.6% of women responded that they would consider using N_2O again.	V-A

				with N_2O (7 questions).			
Pub Med #3 Agah, J., 2014	To determine if there was a difference in obstetric outcomes when N_2O was used continuously compared to intermittent use of N_2O. IV: N_2O intermittent use, N_2O continuous use DV: difference in minute 1 and minute 5 Apgar score, maternal SpO_2, duration of labor, occurrence of hemorrhage, satisfaction with N_2O use.	None	Randomized Control Trial (RCT)	N= 100 50 women in continuous N_2O group 50 women in intermittent N_2O group Apgar score system SpO_2 was measured via pulse oximetry Duration was measured via time Hemorrhage was measured by presence of uterine atony Maternal satisfaction was	Results were analyzed in two groups by using SPSS 17 software, t-test, and Chi^2 $P < 0.05$ was considered statistically significant	The results revealed that Apgar scores and the 1st and 5th minute showed no significant differences $p = 0.3$. Maternal SpO_2 revealed no significant differences with SpO_2 measured at 95% and above in both groups p-value of > 0.05. The mean duration of labor in the continuous group was 34	I-A

				measured via post-survey		minutes and the intermittent group was 30 minutes. P= 0.3. Hemorrhage showed that 4% of the intermittent group experienced bleeding due to uterine atony versus continuous group 0% p-value = 0.2 maternal satisfaction scores were 96% satisfied with experience 70% satisfied in the intermittent group. p-value= <0.0001	

Pub Med #4 Parsa, P., 2017	To evaluate the effects of N_2O for pain relief for laboring patients. IV= Nitrous Oxide use, Oxygen use DV= perception of pain, labor duration, and side effects noted	None	Randomized Control Trial (RCT)	120 women total were randomly assigned to control O2 therapy (N=60) and intervention group N_2O therapy (N=60) Perception of pain by using the Visual Analog Scale (VAS) measured at hour 1, 2, 3, 4. Labor duration was measured in minutes. Side effects measured included, nausea, vomiting, lethargy, and dry mouth	Results were analyzed using SPSS version 20.0 data analysis and descriptive statistics, chi-square test, independent t-test were used with significant level considered at p-value <0.05	Pain was measured at hour one, two, three, and four, the difference was found to be significant p-value = <0.001 Labor duration was 64.80 minutes in intervention group compared to 98.33 minutes in the control group p-value =<0.001 The only significant finding in regard to side effects was nausea. The intervention group reported more nausea than the control group p-value= <0.001.	I-A

Google Scholar #1 Mukhopadhyay, I., 2021	To assess if N_2O was more effective for pain control during labor compared to oxygen therapy. IV- Nitrous Oxide use during labor and oxygen therapy during labor. DV- Wong-Baker Faces Pain Rating Scale	None	Prospective Randomized Control Trial (RCT)	The Wong–Baker Faces Pain Rating Scale. The scale shows faces varying from a happy face at 0, which represents "without hurt," to a crying face at 10, which represents "hurts like the worst kind of pain." Based on the faces and written descriptions, the midwife chooses the face that best describes their level of pain.	Unpaired T-tests Chi Square	The mean pain score at 6 cm of cervical dilatation in the N_2O group was 5.86 as compared to 8.64 in the oxygen group. This was statistically significant (*p*-value of 0.00 00). At 8 cm of cervical dilatation in the Entonox group, the mean score of pain was 4.99 as compared to 9.08 in the oxygen group. The intensity of labor pain measured by Wong-Baker Faces Pain score was significantly lower in the N_2O group than that in the oxygen group (*p*-value <0.001)	I-A

Google Scholar #2 Such & Denny, 2021	To determine if comfort and satisfaction with the birth experience differed among women who used N_2O, epidural, or no analgesia during the labor and delivery process IV: N_2O, epidural, no analgesia DV: comfort and satisfaction scores	Kolcaba's Theory of Comfort	Non-experimental, cross-sectional study	The study was completed on 84 women having vaginal births. N= 28 (N_2O) N=28 (epidural) N=28 (no analgesia) 6 hours post-delivery the Birth Satisfaction Scale–Revised and the researcher-modified Childbirth Comfort Questionnaire were taken by patients.	ANOVA with the level of significance set at $p <$ 0.05 (two-tailed) followed by post Hoc comparisons to evaluate for significant *F* values.	No statistically significant differences shown related to comfort among women who used N_2O only, epidural analgesia, or no analgesia during labor and birth, $F(2, 81) = 1.11$, $p = .34$ Birth satisfaction: showed no statistical differences $F(2, 81) = .084$, $p = .92$. Between-groups ANOVA, which indicated no significant differences in satisfaction across groups, p = .92, η2 = .002.	III-B

Table 3

Directed Content Analysis

Code/Theme	Citation (full citation in references)	Educational Component
Nitrous Oxide (N_2O)	Knuf & Maani, 2021 Broughton et al., 2020 Migliaccio et al., 2017 Vallejo & Zakowski, 2019	• N_2O is an odorless, colorless, non-flammable gas that can be used for general anesthesia, procedural sedation and treatment of pain. N_2O has potent analgesic properties that are useful in the maternal unit (Knuf & Maani, 2021). • N_2O is an inhaled vapor that is self-administered via a face mask that can be intermittently used for analgesia (Broughton et al., 2020). • A gas blend of 50%-50% of oxygen and N_2O is composed to safely administer to patients, providing sedation and analgesia (Migliaccio et al., 2017). • Although the mechanism of action of N_2O is not fully understood in reduction of pain, it is believed that N_2O modulates pain perception at the alpha-2 receptors in the dorsal horn of the spinal cord, releases endogenous opioids in the brain and antagonizes N-methyl-D-aspartate receptors (Broughton et al., 2020). • Advantages of N_2O administration allows patient to have control due to its non-invasive self-administered properties, and does not require IV access (Vallejo & Zakowski, 2019). • N_2O analgesia gained popularity in the United States in the last decade, following approval of the Food and Drug Administration in 2012 (Vallejo & Zakowski, 2019). • N_2O has been used commonly in other countries for greater than 50% of births in Finland, Norway, England, Australia, New Zealand, Sweden and the United Kingdom (Vallejo & Zakowski, 2019).

Lack of education on N_2O	Knowles, 1978 Migliaccio et al., 2017 Collins et al., 2018	• Educational intervention is a teaching session structured by an evidence-and-theoretically-based education module. The knowledge content is based on evidence-based research and peer-reviewed articles addressing facts, principles, and theories to improve knowledge about N_2O administration during labor (Knowles, 1978). • Migliaccio et al. (2017) states minimal literature on recommendations for care and monitoring of woman and a fetus when exposed to N_2O. • The suggestions include that "well-developed staff education and proof of competency are key components in establishing N_2O availability" (Migliaccio et al., 2017). • Collins (2018) states, "Staff education to ensure broad understanding of N_2O use is a necessary component of a successful program" (p. 197).
Pain relief	Rollins et al,. 2018	• Rollins et al., (2018) created an informational review via the American Society of Anesthesiologists. The authors state that although pain relief is a large component of labor experience, there are other components that contribute to the labor experience. • Although, N_2O cannot exceed the pain relief efficacy of an epidural block, it can provide significant analgesia as a non-invasive option for the patient who is contraindicated of an epidural. In contrary, N_2O administration can also be used as a pain reduction adjunct to epidural management to provide pleasure, relaxation, and anxiety relief (Vallejo & Zakowski, 2019).
N_2O implementation	Rollins et al., 2018	• According to Rollins et al. (2018) the process of implementing a N_2O policy for the labor and delivery unit has many requirements that must be met. These requirements include that the administration of N2O must comply with the sedation policies developed at the individual institution's Department of

		Anesthesiology and should be in accordance with the Centers for Medicare and Medicaid Services (CMS) guidelines for anesthesia care. • Furthermore, the authors state that N_2O protocols can be allow for nursing implementation with provider order. In order for a policy to be implemented, labor and delivery staff need training and education on N_2O use, proper administration, importance of scavenging, patient monitoring, and potential for exposure of health care workers (Rollins et al., 2018)
Education module	Knowles, 1978	• An education module is an evidence-and-theoretically-based, that includes: 1) objectives, 2) content, 3) teaching methods/techniques, 4) resources/materials, 5) timeframe, 6) evaluation method (Knowles, 1978).
Maternal satisfaction is high with the use of N_2O as an adjunct	Agah et al., 2014 Sheyklo et al., 2017 Houser et al., 2018 Richardson et al., 2018	• Maternal satisfaction was measured by survey. Scores were noted to be 96% of those in the continuous group were satisfied with the labor experience, while 70% were satisfied in the intermittent group (Agah et al., 2014) • The purpose of this study was to evaluate the effects of N_2O on women in labor. These studies provided information based on maternal pain relief and satisfaction with N_2O and Apgar scoring outcomes (Sheylko et al., 2017). • Moreover, when evaluating the results of mothers' satisfaction rate, 57.6% of mothers in the N_2O group reported a high level of satisfaction rate versus 21.3% of mothers in comparison group. (Sheylko et al., 2017). • Participants evaluated the effectiveness of labor analgesia using the N_2O mixture via the completion of a questionnaire (Houser et al., 2018). Of these 55 women, 36 (65%) completed the satisfaction questionnaire. Items on the questionnaire included satisfaction with N_2O use, amount of pain relief, description of pain relief, and if N_2O would be a choice for future labor and delivery. The results of this study showed that 27 women (75%)

		"strongly agreed" or "agreed" that they were satisfied with the use of N_2O. • Of the 678 women who solely use nitrous oxide as labor analgesia, 264 clarifying comments were recorded. Two hundred thirty-eight women (90%) reported high satisfaction with a score >8/10 (Richardson et al., 2018)

Table 4

Summary of Instructional Videos

Title: Nitrous oxide use in the Laboring Mother: An Education Module
Purpose: The purpose of this PowerPoint with embedded video is designed to increase the knowledge for the labor and delivery team on Nitrous oxide (N_2O) for the laboring patient.

Learning Outcomes	**Content Outline**	**Methods of Instruction**	**Estimated time in minutes to complete section**
Define what N_2O is *Demonstrate understanding of N_2O background and mechanism of action*	• *Learning Outcomes* • *Overview* • *Background* • *Mechanism of Action*	*Narrated PPT*	3 minutes
Demonstrate understanding of benefits of N_2O *Demonstrates understanding of when N_2O is appropriate*	• Indications • Contraindications • Supporting Literature	*Narrated PPT*	4.7 minutes
Prepare the Nitronox device for safe patient use	• Equipment • Safety features of equipment	*Narrated PPT with embedded instructional video*	2 minutes
Demonstrate increased competence on N_2O administration for the laboring mother	• Step by step N_2O administration • Education	*PPT with embedded instructional video* *Teach back example instructional video*	3 minutes

Utilize appropriate decision-making skills regarding patient selection criteria	• FAQs • Conclusion	*Narrated PPT with embedded instructional video*	2 minutes

Table 5

Expert Content Analysis

Category validation for content analysis of preceptor training educational intervention development: Content Validity Check					
After answering two demographic questions, please read each item and answer the question. Comment sections have been provided to allow for any additional information you would like to provide. Your opinion on this topic is highly valued and appreciated. Thank you for participating in our survey and assisting us with our DNP project. Sincerely, Amanda Rota, SRNA and Jessica Stoffey, SRNA.					
					CVI score/Avg: 0.84
Provider experience In your clinical practice, have you ever provided nitrous oxide as an analgesic for the laboring patient?	1 = Yes	2 = No			**CVI= 0.85**
Education Have you ever received formal education (classroom lecture, mandatory educational module completion) related to nitrous oxide (Nitronix) administration?	1= Yes	2= No			**CVI= 0.8**

Administration Do you as a provider feel that nitrous oxide (Nitronix) administration should be offered as an analgesic option to the laboring patient?	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes	**CVI= 0.75**
Please read each item and rate its importance for inclusion in the educational module that will be created. Mechanism of Action of Nitrous Oxide Background of Nitrous Oxide Benefits of Nitrous Oxide Disadvantages of Nitrous Oxide Contraindications of Nitrous Oxide	Not relevant	Somewhat relevant	Quite relevant	High relevant		**CVI= 0.96**

Recent Literature on Nitrous Oxide in the Laboring Patient Administration of Nitrous Oxide Identifying parts of the Nitronox machine Patient monitoring Patient education Yearly training module						
Barriers What do you see as some of the barriers to implementing nitrous oxide administration in your clinical practice? Select all that apply.	None	Time constraints	Staff cooperation	Budgetary constraints	Administrative/managerial support	**N/A**

Figure 1

Q9 - Please read each item and rate its importance for inclusion in the educational module that will be created.