Educational Intervention on Preinduction Ondansetron as Prophylaxis for Subarachnoid Block-Induced Shivering

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Table of Contents

Dedication

To my beloved wife, Mary.

You are the heartbeat of our family, and your unwavering support fuels my journey. Your love and patience have been the cornerstone of my pursuit of growth. Without your constant encouragement and sacrifices, all this would be impossible. Thank you for believing in me, standing by me, and inspiring me to reach for the stars.

To my sons, Sawyer and Fitzgerald,

You are the reason I strive to improve each day. You fill my life with purpose and joy. As my academic journey ends, know that every late night and every sacrificed moment is dedicated to building a brighter future for you. Everything I do is for you, my greatest blessings.

This Doctor of Nursing Practice paper is not just a culmination of academic efforts but a testament to our family's love, strength, and unity. It symbolizes our journey and the unwavering bond that holds us together through every challenge and triumph.

With all my love,

Samuel LaRue Reddinger

Abstract

Background: Post-anesthesia shivering affects surgical patients who receive a subarachnoid block, which causes patient discomfort, increases the risk of cardiac complications, and interferes with standard monitors. Ondansetron can reduce the incidence of shivering when administered before the block. However, anesthesia providers do not routinely administer ondansetron before subarachnoid block. **Purpose**: This project aimed to increase provider recognition of post-anesthesia shivering as a clinical problem, decrease the incidence of post-anesthesia shivering, and increase the administration of ondansetron before subarachnoid block using an educational intervention. **Methods**: The eight-week project used an educational intervention to change anesthesia providers' perceptions of the incidence and severity of post-anesthesia shivering and the safety and efficacy of ondansetron in preventing it. The providers' perceptions were assessed using a pre- and post-educational intervention survey and retrospective chart review data. **Results**: The results showed a significant change in provider perceptions of ondansetron's efficacy and benefits. However, significant limitations and biases affected the project's results. Pre-subarachnoid block ondansetron administrations decreased after the intervention. It was not possible to quantitatively measure the incidence of shivering. Non-responses skewed data on barriers to practice. **Conclusions**: The limitations and biases must be addressed to produce significant results if the project is to be repeated.

Keywords: educational intervention, Health Beliefs Model, healthcare, neuraxial anesthesia, ondansetron, practice changes, shivering, spinal anesthesia, Zofran

Background and Significance

Spinal anesthesia, or subarachnoid block (SAB), is a common anesthetic technique. It is the preferred technique for both obstetric (e.g., cesarean section) and lower-limb orthopedic surgeries (e.g., total knee or total hip arthroplasty) due to its quick onset, fast recovery, dense sensory and analgesic blockade, reduced risk of adverse outcomes, and increased maternal and fetal well-being (Basques et al., 2015; Iddrisu & Khan, 2021). However, patients under SAB are prone to postanesthesia shivering (PAS), a common and unpleasant adverse effect that occurs in more than half of SABs (Crowley & Buggy, 2008). Moreover, not only is PAS a common occurrence, it is not always benign.

Although shivering is a crucial thermoregulatory response to hypothermia, it also induces psychological and physiological stress. It is uncomfortable and frightening for the patient (Ostheimer & Datta, 1981). It increases oxygen consumption by up to 500% and stimulates catecholamine release, increasing cardiac output and putting patients at risk for ischemia and cardiac compromise (Crowley & Buggy, 2008; Nnacheta et al., 2020). Shivering complicates blood pressure, oxygen saturation, and electrocardiogram measurement by interfering with standard monitors (Tie et al., 2014).

Interventions to treat or prevent shivering include pharmaceutical and nonmedication strategies. Active warming techniques include warmed blankets and gowns, forced air warmers, warmed intravenous (IV) fluids, and conduction mattresses. However, when used alone or in combination, these techniques can be costly and cumbersome and show only modest results in preventing shivering (Chen et al., 2019; Nnacheta et al., 2020). Standard medicinal treatments to treat shivering include clonidine, meperidine, or tramadol after shivering is observed (Crowley & Buggy, 2008). However, these drugs are likely to be given only after delivery in cesarean

procedures due to their potentially harmful effects on the mother and child (Mattingly et al., 2003). Waiting for delivery exposes the patient to the detrimental effects and discomfort of shivering for roughly 10-15 minutes (the difference between the average time of delivery in elective cesarean [25.7 ± 5.6 min] and the average onset of PAS [15-20 mins after SAB]; Esmat et al., 2021; Hassanin et al., 2022).

Administering ondansetron before the induction of spinal anesthesia is an anti-shivering prophylactic strategy (Alfonsi, 2001). Ondansetron, a 5-HT_3 receptor antagonist, has been shown to reduce both the occurrence and severity of PAS (He et al., 2016; Li et al., 2016; Tie et al., 2014; Tubog & Bramble, 2022). As an added benefit, prophylactic ondansetron reduces the incidence and severity of postoperative nausea and vomiting and postspinal hypotension (Griddine & Bush, 2022; Hou et al., 2022; Nallam et al., 2017). Furthermore, its broad therapeutic index, limited drug interactions, and lack of adverse fetal effects make it safe for patients, including parturients (Pasternak et al., 2013; Smith, 1989).

Despite the existing evidence, however, anesthesia providers (APs) do not routinely administer ondansetron before SAB (Santana et al., 2020). The APs' perceptions and feelings may explain this disparity. For instance, healthcare providers report being uncomfortable administering unfamiliar treatments (Bates, 2022; DuBose & Mayo, 2020). Additionally, they consider shivering an unimportant event (Macario et al., 1999). Moreover, providers resist new practices because they are unaware of available evidence and distrust new therapy efficacy (Johnson, 2014). Through education, this project seeks to change APs' perceptions of PAS and ondansetron and encourage them to administer it consistently before SAB.

Purpose

This project aimed to increase provider recognition of PAS as a clinical problem, decrease the incidence of PAS, and increase the administration of pre-SAB ondansetron (PSO) using an educational intervention. The primary investigator (PI) provided an evidence-based educational intervention to APs addressing the current evidence on the incidence and severity of PAS and ondansetron's safety and efficacy in preventing it. Primarily, this project intended to 1) increase AP utilization of the current evidence for the prevention of PAS with PSO, 2) increase AP awareness of PAS incidence and severity, and 3) identify AP perceived barriers to PSO administration. Secondarily, it is intended to 1) improve patient outcomes and experience by reducing the incidence of PAS and 2) support the importance of perception in healthcare provider behavior choices.

Review of Current Evidence

The PI completed an extensive literature review using PubMed and CINAHL Complete. The following search terms were entered individually and in combination using Boolean operators: Cognitive Theory, healthcare, practice changes, educational intervention, shivering, spinal anesthesia, neuraxial anesthesia, ondansetron, and Zofran. The PI reviewed articles for relevance and adherence to the inclusion criteria: peer-reviewed randomized controlled trials (RCTs), systematic reviews, or meta-analyses with full text available in English. The PI then reviewed reference lists from the relevant articles for additional sources. The UpToDate evidence-based clinical resource did not provide primary source material but provided additional sources for this review. Seventy-one articles met the criteria and were included in this review. The main themes for this review were the anatomy and physiology of SAB and PAS, shivering treatments, ondansetron's pharmacodynamics, and its efficacy in preventing PAS.

Subarachnoid Block

Subarachnoid block (SAB), also called spinal anesthesia, is a neuraxial anesthesia technique. It involves passing a needle between vertebrae and injecting a local anesthetic into the cerebrospinal fluid surrounding the spinal cord, resulting in a complete loss of sensation caudal to the injection site (Greene, 1993; Olawin & Das, 2022). Spinal anesthesia blocks motor and sensory nerve transduction, producing ideal operating conditions for obstetric, gynecologic, and urologic surgeries, orthopedic or vascular surgeries in the lower limbs, and general surgeries in the lower abdomen or perineum (Greene, 1993; Mulroy, 1998). However, SAB also interrupts sympathetic nerve transduction, leading to increased parasympathetic tone and reflexive compensatory responses, which can cause adverse effects (including PAS; Caruselli, 2018; Jadon, 2010; Lopez, 2018).

Shivering

Shivering is an involuntary, repetitive movement of one or more skeletal muscle groups commonly occurring during anesthesia. It is an expected physiological response to cold exposure, frequently caused by core hypothermia, and after vasoconstriction, it is the body's secondary heat retention tactic (Park et al., 2015). High-magnitude shivering can increase heat production six-fold (Giesbrecht et al., 1994). During the perioperative period, shivering can also occur in euthermic patients (Lopez, 2018). It occurs in 20% to 70% of general anesthetics and 40% to 64% of SABs (Crowley & Buggy, 2008; Eberhart et al., 2005). General anesthetic and SAB likely share some shivering mechanisms, but a few are specific to SAB.

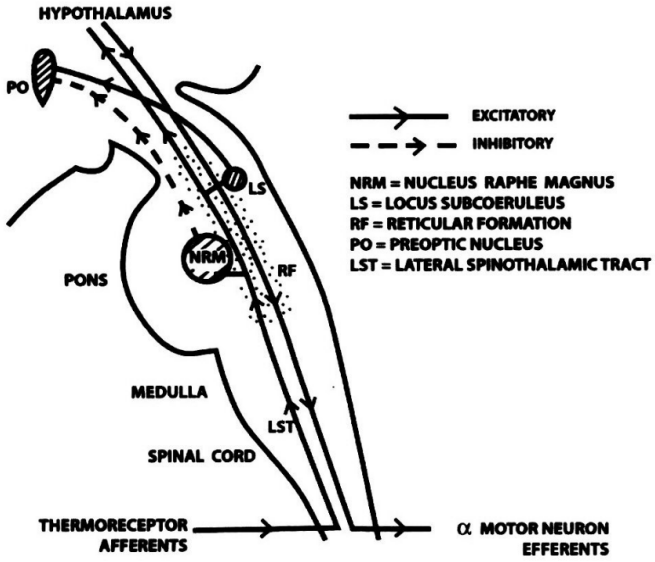
Mechanism

The neurologic pathway of shivering, illustrated in Figure 1, consists of sensation and afferent pathways, an integration center, and effector pathways (De Witte & Sessler, 2002).

Afferent nerves in the spinothalamic tract transmit thermosensory signals from the periphery to the pons in the brainstem. Here, the signal is divided and passes through a shiver-excitation pathway, the locus subcoeruleus (LS), and a shiver-inhibition pathway, the nucleus raphe magnus (NRM; Hinckel, 1991). The modulation of excitatory and inhibitory signals transmitted from the LS and NRM is responsible for the shivering threshold, the core temperature at which shivering begins (Crowley & Buggy, 2008; De Witte & Sessler, 2002; Wada et al., 2019).

Figure 1

Schematic Drawing of the Shivering Pathway



Note: From "Shivering and Neuraxial Anesthesia," by L.J. Crowley and D.J. Buggy, 2008, *Regional Anesthesia and Pain Medicine*, *33*(3), p. 242, © 2008 by the American Society of Regional Anesthesia and Pain Medicine. Reprinted with permission (see Figure A1).

The hypothalamus's preoptic nucleus (PO) is the afferent destination for thermosensory signals. Georg A. Petroianu (2022) refers to it as the "brain thermostat" because it is the central integrator for the signal. The PO integrates thermosensory signals with the combined LS and

NRM signals. This integration propagates variable-intensity inhibitory signals, which are then presented to the anterior hypothalamus (AH).

Under normal circumstances, the AH continuously emits pro-shivering signals whose intensity varies based on the strength of the inhibitory signals it receives from the PO (Crowley & Buggy, 2008; De Witte & Sessler, 2002). The effector motor neurons, responsible for heat production and protection (i.e., vasoconstriction, shivering, and others), respond to the intensity of the signal emitted by the AH.

Traditional Treatment Methods

Nonpharmacological Methods. Nonpharmacologic options for the prevention of PAS focus on preventing perioperative hypothermia and include forced air warmers, warmed IV fluids, ambient temperature control, and warming intrathecal medications to body temperature before administration (Alfonsi, 2001; Kim et al., 2014). Active cutaneous warming (e.g., forced air warmers) significantly benefits shivering prevention in perioperative settings (80.7% positive effect; Park et al., 2015). Passive cutaneous warming (e.g., ambient temperature control) and body core warming (e.g., warmed IV fluids, warmed intrathecal medications) have only marginal benefits (< 50% positive effect; B. Park et al., 2015). Regardless of their efficacy, these methods are cumbersome, costly, and can risk burns to the patient (Bayazit & Sparrow, 2010; Gendron, 1980; Shukla et al., 2011). These barriers can make it challenging to use non-pharmacological methods in certain situations (e.g., with an awake parturient during cesarean delivery).

Pharmacological Methods. Pharmacological options for the prevention and treatment of PAS include amine reuptake inhibitors, alpha-2 adrenergic receptor antagonists, anticholinergics, and others (Alfonsi, 2001; Crowley & Buggy, 2008; De Witte & Sessler, 2002; Lopez, 2018; S. M. Park et al., 2012). Amine reuptake inhibitors (e.g., tramadol, nefopam) block norepinephrine

and serotonin reuptake in the spinal cord, activating descending, anti-shivering pathways (Bilotta et al., 2002; de Witte et al., 1997; Shukla et al., 2011; T. & Kaparti, 2014). Alpha-2 adrenergic receptor antagonists (e.g., clonidine and dexmedetomidine) lower the shivering threshold, which reduces the core temperature necessary to initiate the shivering response (Talke et al., 1997). Physostigmine, an anticholinergic and parasympathomimetic, decreases sympathetic tone, which blunts shivering (Horn et al., 1998). Meperidine reduces the shivering threshold but spares other thermoregulatory responses (e.g., vasoconstriction; Ikeda et al., 1997; Kurz et al., 1997). Because of this, APs frequently select meperidine as a rescue medication to alleviate severe PAS.

Although these medications can effectively treat or prevent shivering, they can cause discomfort or harm and slow recovery times. Tramadol and nefopam can cause nausea, vomiting, dizziness, increase intracranial pressures, and reduce the seizure threshold (Rosa et al., 1995). Alpha-2 adrenergic receptor antagonists (e.g., clonidine and dexmedetomidine) cause bradycardia, hypotension, and sedation (Giovannitti et al., 2015). Physostigmine can potentially cause a life-threatening cholinergic crisis (i.e., muscular weakness, paralysis, gastrointestinal distress, bronchoconstriction, and initial tachycardia followed by precipitous bradycardia; Adeyinka & Kondamudi, 2022; Andrade & Zafar Gondal, 2022). Even meperidine can cause nausea, vomiting, and respiratory depression (Powell & Buggy, 2000).

Ondansetron

Ondansetron, a 5-HT_3 receptor antagonist, can significantly reduce PAS by 67-71% (He et al., 2016; Li et al., 2016; Tubog & Bramble, 2022). Ondansetron's anti-shivering mechanism of action has yet to be fully understood (Liu et al., 2020; Powell & Buggy, 2000). Alfonsi (2001) described the commonly accepted theory that 5-HT_3 receptors in the AH initiate the descending thermoregulation responses (part of which is shivering) in reaction to hypothermia. Ondansetron

lowers the body's shivering response by antagonizing serotonin (5-HT_3) binding at these receptor sites (Li et al., 2016).

Safety

Ondansetron's safety is well established. Current evidence has not yet discovered any safety issues related to fetal well-being and supports its use in pregnant patients (Fejzo et al., 2016; Pasternak et al., 2013; Picot et al., 2020). Because of its safety, it is the first-line "gold standard" medication for PONV prevention in almost all surgeries, even for the pregnant population (Gan et al., 2020; Siminerio et al., 2016; Tateosian et al., 2018)

Ondansetron has limited side effects, and they are generally well tolerated. The most common complaint is a mild headache that resolves spontaneously within minutes, occurring in 15-20% of people (Khan, 2002; Ruff et al., 1994). Weakness, constipation, and dizziness occur in roughly 10% of patients (Nnacheta et al., 2020; Perez et al., 1998). Of most significant concern, 5-HT_3 antagonists can cause electrocardiogram interval changes (i.e., QT interval prolongation), though this returns to baseline within a day and is often clinically negligible (Navari & Koeller, 2003). However, APs must use caution when treating patients taking multiple medications that prolong the QT interval, as this can lead to fatal cardiac arrhythmias from the R-on-T phenomenon (Anyfantakis & Makrakis, 2019; Freedman et al., 2014; Patel et al., 2019).

Efficacy

Multiple meta-analyses and randomized controlled trials (RCTs) have demonstrated that ondansetron significantly reduces the incidence of PAS by 67% on average (46%-88%; He et al., 2016; Kelsaka et al., 2006; Li et al., 2016; Nnacheta et al., 2020; Teoh et al., 2021; Tubog & Bramble, 2022). Some studies have failed to demonstrate a reduction in PAS with ondansetron

administration (Browning et al., 2013; Liu et al., 2020). Browning et al. (2013) showed a 5% greater reduction in PAS incidence with ondansetron compared to placebo; however, this difference was statistically insignificant ($P = 0.54$). Liu et al. (2020) concluded that ondansetron did not significantly affect PAS incidence compared to placebo. Interestingly, in both studies, subjects received a room temperature (22-26 °C, ambient room temperature) 500-1000 mL IV fluid bolus during induction (Browning et al., 2013; Liu et al., 2020). Studies that supported using ondansetron either did not provide IV boluses before induction or provided fluid boluses warmed to body temperature (37 ℃; Kelsaka et al., 2006; Nnacheta et al., 2020; Teoh et al., 2021). This difference in methodology could potentially explain the disparity in findings.

Ondansetron Dosing for PAS Prophylaxis

Early research has shown that patients who received higher doses (8 mg) of ondansetron had a significantly lower incidence of shivering (15%) than those who received lower doses (4mg, 33%) or placebo (57%; Powell & Buggy, 2000). More recent research by Gicheru et al. (2019) found that a weight-based ondansetron dose of 0.1 mg/kg actual body weight (ABW) reduced the incidence of PAS by half compared to a 4 mg dose (11.3% [0.1 mg/kg ABW], 22.6% [4 mg]). A meta-analysis by Tubog and Bramble (2022) showed a significant reduction in PAS with 8 mg doses (R2R, 0.59; 95% CI, 0.37 to 0.92; P = 0.02) but not with 4 mg doses (RR, 0.37; 95% CI, 0.12 to 1.10; P = 0.07) compared to placebo.

It is essential to note that administering larger IV doses of ondansetron should be done with caution as the incidence and severity of side effects such as headache, gastrointestinal upset, and arrhythmias correlate with and are proportional to administration speed and dose size (Bryson, 1992; Freedman et al., 2014). Furthermore, most studies in this review have supported using a 4 mg dose (He et al., 2016; Li et al., 2016; Nnacheta et al., 2020; Teoh et al., 2021).

Theoretical Framework

Cognitive Theory

Cognitive theory (CT) is a psychological framework that emphasizes the role of mental processes in shaping behavior. CT focuses on understanding how people think, learn, and process information. It asserts that behavior change occurs by influencing expectations rather than influencing behaviors directly (Skinner et al., 2015). Cognitive theorists suggest that change happens when individuals weigh the *value* of a result against their *expectations* that the result will occur (Lewin, 1942).

Health Belief Model

Irwin M. Rosenstock's Health Belief Model (HBM) provides the theoretical framework for this project. The model was developed from CT in the 1950s to explain why people were not participating in easily accessible preventative health practices (Rosenstock, 1966). This Doctor of Nursing Practice (DNP) project uses the HBM to explain AP behaviors as they make therapy choices for patients who cannot make choices of their own (e.g., under anesthesia). In this sense, the *value* for the provider rests in keeping their patients free from undesirable symptoms. The *expectation* is the likelihood that these symptoms will occur.

HBM proposes that people are more likely to partake in new health behaviors if they believe the following to be true (Rosenstock, 1966). Modifications, represented in brackets, depict AP beliefs.

- They are [their patient is] at risk for a condition.
- The condition presents deleterious consequences.
- A behavior [treatment] could reduce their [the patient's] vulnerability to or the severity of a condition.

- The behavior [treatment] is beneficial.
- Its barriers do not overshadow the benefits of a given behavior [treatment], nor are those barriers capable of blocking the behavior [treatment].

Behavior change occurs if these feelings shift (Rosenstock, 1966). Interventions to influence change should target six constructs: *perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action,* and *self-efficacy*.

Rosenstock's Six Constructs

Perceived Susceptibility. *Perceived susceptibility* is the feeling of the likelihood that the person will contract a disease or manifest a symptom (Rosenstock, 1966). This DNP project's pre/post survey gauged APs' perceived patient susceptibility. The educational intervention addressed this construct by discussing at-risk populations and incidence rates for PAS.

Perceived Severity. *Perceived severity* describes feelings about a symptom or disease's seriousness (Rosenstock, 1966). The project's pre/post survey gauged APs' perceived severity of shivering. In addition, the educational intervention discussed patient discomfort and deleterious sequelae for PAS.

Perceived Benefits. *Perceived benefits* are feelings about the positive aspects of a given therapy or treatment (Rosenstock, 1966). The pre/post survey gauged APs' perceived benefit of preinduction ondansetron. The educational intervention also discussed ondansetron's efficacy and mechanism in preventing PAS and suggested an effective dosage.

Perceived Barriers. *Perceived barriers* are feelings about the difficulties or negative aspects of the given therapy or treatment (Rosenstock, 1966). The pre/post survey for this DNP project asked APs what barriers they perceive to preinduction ondansetron. In addition, the

educational intervention discussed the incidence of ondansetron's common and severe side effects and their prevention or treatment.

Cues to Action. *Cues to action* are triggers that spark the use of a treatment or therapy (Rosenstock, 1966). This project intended to bring awareness to PAS prevention and encourage APs to attempt to prevent it.

Self-Efficacy. *Self-efficacy* is the belief that the therapy or treatment is feasible (Rosenstock, 1966). Anesthesia providers already commonly administer ondansetron, and its efficacy and safety are well documented. The PI believed that once APs began implementing the strategies suggested by this project, the positive results would encourage them to continue utilizing the practice.

Methods

Design

This mixed quantitative and qualitative evidence-based practice project followed a pretest/posttest design. Participants submitted a preintervention survey (Appendix B) before participating in an educational presentation (Appendix C). Participants then completed a postintervention survey (Appendix D) four weeks after the educational intervention. A retrospective medical record review (Appendix E) before and after the educational intervention compared the timing and dosage of ondansetron administration and shivering treatments in the postanesthesia care unit (PACU).

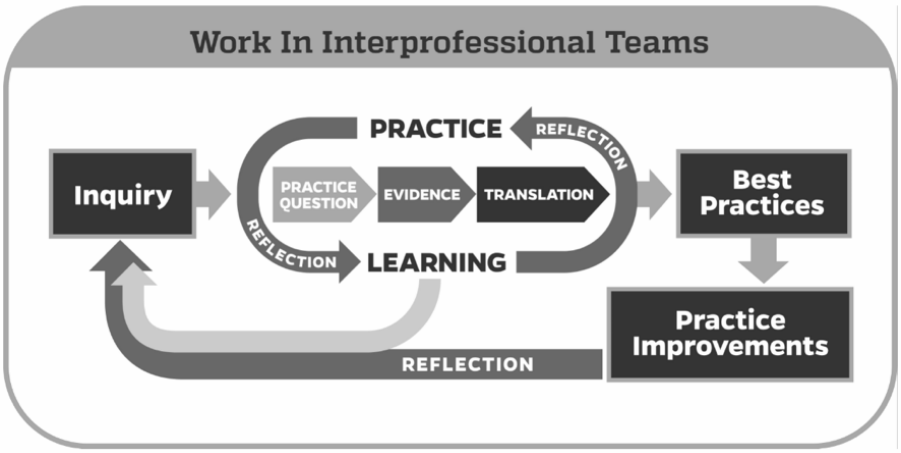
Evidence-Based Practice Model

The Johns Hopkins Hospital/The Johns Hopkins University allowed permission to use The Johns Hopkins Evidence-Based Practice Model and Tools (JHEBPM; Figure A2) as the evidence-based practice model for this project. The JHEBPM is built upon three foundations:

inquiry, *practice*, and *learning*, illustrated in Figure 2 (Dang et al., 2022). *Inquiry*, the first step in the model, is the strive to seek new knowledge, question current practices, and investigate issues and concerns. *Practice* is "the who, what, when, where, why, and how that addresses the range of nursing activities that define the care a patient receives" (Dang et al., 2022, p. 37). Finally, *learning* is any influence that results in a relatively permanent behavior change (Braungart & Braungart, R.G., 2003). These two foundations, *learning* and *practice*, form a revolving loop of implementing new processes, reflecting upon their success, and modifying them to suit specific needs. Then, the loop begins anew.

Figure 2

Johns Hopkins Evidence-Based Practice Model



Note: From *Johns Hopkins Evidence-Based Practice for Nurses and Healthcare Professionals: Model and Guidelines* (4th ed.) by D. Dang, S. Dearholt, K. Bissett, J. Ascenzi, and M. Whalen, 2022, Sigma Theta Tau International. © 2023 by The Johns Hopkins University, The Johns Hopkins Hospital, and The Johns Hopkins Health System Corporation. Reprinted with permission (Figure A2).

This learning/practice loop is guided stepwise through three stages: *practice question, evidence,* and *translation* (Dang et al., 2022). The first stage, *practice question*, focuses on creating an answerable question, gathering a team, and identifying potential stakeholders. In this stage, the PI developed the project question: Will an educational intervention increase the administration of preinduction ondansetron by APs and reduce the incidence of PAS? The project team included the PI, the DNP project advisor, a University of North Carolina at Greensboro (UNCG) statistician, and anesthesia leadership at the project site. Potential stakeholders included perioperative patients and staff at the project site (e.g., APs, peri anesthesia nurses, unit leadership, and surgical team members) and the UNCG School of Nursing: Nurse Anesthesia community. The second stage, *evidence*, gathers, analyzes, and synthesizes the evidence. During this stage, the PI conducted an extensive literature review to identify evidence-based strategies to decrease PAS. The final stage, *translation*, takes action to answer the posed question, including intervention, gathering data, evaluating the results, translating them, and spreading them to the stakeholders. During this stage, the PI recruited participants, provided the educational intervention, presented participants with surveys, completed chart reviews, analyzed the data, and disseminated the results to the stakeholders.

Setting

The PI implemented the project at a North Carolina hospital. The hospital conducts both inpatient and outpatient surgical procedures daily. The anesthesia department at the project site administers four to six SABs daily, divided between obstetric, orthopedic, and urological procedures.

Sample

A convenience sample of APs attending a regularly scheduled department meeting provided participants for the PAS educational intervention. Emails sent to APs by anesthesia leadership aided participant recruitment. Inclusion criteria included physician anesthesiologists, certified registered nurse anesthetists (CRNAs), anesthesiologist assistants (AAs), and student registered nurse anesthetists (SRNAs) who deliver anesthesia care to patients under SAB anesthesia at the project site. Exclusion criteria include APs that did not provide anesthesia care to patients under SAB anesthesia and APs that declined to participate.

Intervention

The participants attended a 20-minute educational PowerPoint presentation by the PI (Appendix C). The presentation covered the purpose of the DNP project, its background and significance, and the current evidence-based strategies to reduce PAS, including the preinduction administration of ondansetron. In keeping with the HBM, the presentation included information on PAS incidence and its harmful effects, the mechanism of action, efficiency, and safety of ondansetron, as well as ondansetron's side effects incidence and mitigation.

Data Collection

Before the educational intervention, participants completed the preintervention survey (Appendix B). The first item in the survey informed participants that they consented to participate in the project by completing the survey. A participant-generated cipher, "mother's birthday," written as MM/DD, linked the postintervention survey to the preintervention surveys. The data collected in the survey included AP demographics (age, gender, anesthesia credentials, educational degree, years of anesthesia practice, and the frequency of caring for patients under SAB). APs who reported providing care to patients under SAB or administering SABs answered

additional Likert-scale questions. These questions targeted Rosenstock constructs (*perceived susceptibility, severity, and benefit)*. The survey also had an open-ended qualitative section for input on *perceived barriers*.

The PI used Microsoft Forms to create the postintervention survey (Appendix D). The PI shared the survey link with the anesthesia department leadership, who then sent the link to the anesthesia department members through email 28 days after the educational intervention. To access the survey, participants had to provide the linking cipher, "mother's birthday," written in the MM/DD format.

The postintervention survey included Likert-scale questions and an open-ended qualitative section, identical to the preintervention survey. This data compared the baseline and postintervention data on the Rosenstock constructs. Additionally, the postintervention survey asked participants to report how frequently they cared for SAB patients, how often those patients shivered, and how often they administered ondansetron before SAB induction. They also rated the effectiveness of ondansetron in preventing PAS.

Retrospective chart reviews were conducted. Inclusion criteria for chart review included patients who received SAB anesthesia as their primary form of anesthetic for nonemergency surgical procedures at the project site during the project timeline. Exclusion criteria excluded patients less than 18 years of age or deceased at the time of the review, as well as charts with restricted access. The following data was collected and recorded using Microsoft Excel: the time ondansetron was administered, the time of SAB induction, the ondansetron dosage administered, shivering rescue medication use in the PACU, and subjective notes mentioning shivering during or after the procedure (Appendix E).

Participation in the project was voluntary, and participants confirmed their consent through the first item in the pre-intervention survey. Several precautions were implemented to protect the participants and the data provided. All primary presurvey documents were secured in the PI's home office, and a password-protected laptop computer was used to store all pre and post-intervention survey results and chart review data. Additionally, data backups were stored on two password-protected websites, Microsoft 365 and Google Drive. The surveys were linked pre-to-post using a participant-generated cipher ("mother's birthday") to ensure anonymity by not collecting any identifying information. The data collected during chart reviews was de-identified. Per the university policy at UNCG, the PI will retain the data for at least five years after the project's completion (The University of North Carolina at Greensboro, 2024).

Data Analysis

The PI reviewed the surveys completed by APs and retrospective chart review data collected, reviewed them for completion, and analyzed them with the assistance of a statistician from UNCG. Quantitative data was analyzed using descriptive statistics via Microsoft Excel's data analysis tool. Paired-sample t-tests were used to compare pre and postintervention survey data. Chi-squared analysis was used to compare pre and postintervention chart review data. The PI reviewed the qualitative data to identify common themes.

Timeframe and Budget

The project's design and literature analysis started in the summer of 2022. Site approval was obtained, and the Institutional Review Boards of UNCG and the project site deemed that the project did not involve human research and was thus exempt from further approval in January 2024. Implementation, which included the pre-survey, educational intervention, post-survey, and chart review, was carried out in February 2024, and data analysis took place in March 2024.

This DNP project incurred minimal costs. However, some expenses, including transportation and office supplies, were anticipated. The PI personally funded the budget, an estimated maximum of $200. Therefore, there was no need for external financial support.

Results

Twenty APs participated in the intervention; the preintervention survey sample size was 16 anesthesia providers. After the educational intervention, 14 postintervention survey responses were received. All 14 postintervention surveys were successfully linked to their corresponding preintervention surveys. The two unlinked preintervention surveys were omitted, and the final sample had 14 comparable responses.

Sample Demographics

Anesthesia provider participants provided demographic information, including age, gender, credentials, degree level, years of anesthesia practice, and frequency of administering care to patients under SAB (Table F1). The participants were 57% female (*n*=8) and 43% male (*n*=6). Fifty percent were between 36-45 years of age (*n*=7), while the remainder were in the 46-55 (*n*=4; 29%;) and 26-35 (*n*=3; 21%) age groups. The sample included twelve CRNAs (86%) and two SRNAs (14%), with no physician or AA participants. Most participants held a master's degree (*n*=9; 64%), while five others had a doctorate (36%). Years of practice among the APs were evenly distributed; four with 1-5 years (29%), the groups 6-10 years, 11-15 years, and 16-20 years each had three responses (21% each), and one participant (7%) had more than 20 years of experience. As per the inclusion criteria, all participants regularly provided anesthesia care to patients under SAB. Responses were split between “2-3 times a month” (*n*=8; 57%) and “2-3 times a week” (*n*=6; 43%). None of the participants reported providing this care daily.

Anesthesia Provider Perceptions

Participants completed surveys both before and after the intervention. The pre and postintervention surveys comprised fifteen five-point Likert scale items and one open-ended response. These surveys aimed to gauge the intervention's impact on participants' perceptions of the subject matter. Specifically, they assessed constructs aligned with Rosenstock's Health Belief Model: *perceived susceptibility, perceived severity, perceived benefits, perceived barriers, self-efficacy, and cues to action*.

Several statistical methods were employed to analyze the data. Initially, the fifteen survey items were categorized based on the Likert scale utilized in each item: frequency, effectiveness, or agreement (Table F2). These scales were then dichotomized into two options for comparison (e.g., high vs. low occurrence, effective vs. not effective, and agree vs. disagree), and total, percentage, and mean Likert scores were computed. Subsequently, the survey items were organized according to the Rosenstock constructs they assessed (Table F3). The mean Likert scores before and after the intervention across all survey items within each construct were compared for significance. The PI used an alpha level of 0.05 for all statistical analyses.

Susceptibility

Item 1 asked participants to rank the frequency their patients shivered under SAB using a five-option Likert “frequency scale” (0-never, 1-rarely, 2-sometimes, 3-often, and 4-always). This measured the APs' perceived patient susceptibility to PAS. For comparison, options “never” and “rarely” were grouped as *low occurrence*, while the options “sometimes,” “often,” and “always” were designated *high occurrence*. Before the intervention (Pre), 12 participants (86%) reported a high occurrence of PAS; after the intervention (Post), this reduced to 10 (71%).

A paired samples t-test was performed to compare mean Pre and Post Likert scores. There was not a significant difference between Pre (M = 2.428, SD = 0.756) and Post (M = 1.786, SD = 0.975); $t(13)=1.662$, p = 0.120. This would suggest that the intervention did not significantly impact the APs' perceived patient susceptibility to PAS

Severity

Items 7 and 11 of the survey gauged the perceived severity of PAS among the APs, using a five-point Likert "agreement scale" ranging from 0 (strongly disagree) to 4 (strongly agree). For comparison, responses were categorized into two groups: agree (agree and strongly agree) and disagree (strongly disagree, disagree, and neither agree nor disagree).

Before the intervention, only one AP (7%) agreed that shivering was benign (item 7). Postintervention, no APs (0%) agreed with this statement. Before the intervention, five APs (36%) agreed that shivering is dangerous (item 11), whereas after the intervention, this number increased to nine (64%).

Analysis by a paired samples t-test revealed no significant difference between the pre-intervention (M = 1.643, SD = 0.457) and post-intervention (M = 1.571, SD = 0.514) samples; $t(13)=0.342$, p = .738.

Benefits

Items 5, 9, 14, and 16 assessed the perceived benefits of PSO administration using the "agreement scale." Before and after the intervention, twelve participants (86%) agreed that ondansetron before spinal anesthesia was safe (item 5). Similarly, twelve participants (86%) agreed their shivering prevention techniques were safe (item 9), increasing to 13 (93%) after the intervention. Interestingly, none of the participants (0%) initially agreed that treating shivering after it had begun was easy (item 14); however, after the intervention, one participant (7%)

agreed. Additionally, before the intervention, seven participants (50%) believed that administering ondansetron before spinal anesthesia could prevent shivering (item 16); this number increased to 10 participants (71%) after the intervention.

A paired samples t-test on the combined mean Likert scores for items 5, 9, 14, and 16 compared the data. The results revealed a highly significant change between the Pre (M = 2.536, SD = 0.587) and Post (M = 3.286, SD = 0.914) samples; $t(13) = -4.469$, $p = .001$.

Barriers

The survey's open-ended question (item 4) asked participants to identify barriers to administering PSO as a prophylactic measure for PAS. Analysis revealed common themes among the responses. The most frequently cited preintervention themes were "limited time for administration" and "lack of awareness regarding ondansetron's use as a prophylactic measure." The "limited time for administration" theme persisted in the postintervention survey. Notably, following the intervention, no participants mentioned a “lack of awareness regarding ondansetron's use as a prophylactic measure.”

Items 6 and 13 utilized the "agreement scale" to further gauge perceived barriers to practice. Before the intervention, none of the participants (N=0, 0%) agreed that PSO has consequences (item 6). However, one person (7%) agreed afterward. Similarly, before the intervention, none of the participants (N=0, 0%) agreed that their methods to prevent shivering have consequences (item 13). However, after the intervention, one individual (7%) agreed. Unsurprisingly, a paired sample t-test revealed non-significant differences between the Pre and Post combined Likert means(Pre: M = 0.821, SD = 0.372; Post: M = 0.408, SD = 0.684; $t(13) = -1.632$, $p = 0.127$).

Cues to Action

The intervention's ability to motivate APs to take action was assessed by items 2 and 15. Item 2 gauged the frequency of PSO usage for PAS prevention using the "frequency scale." Before the intervention, seven participants (50%) reported a high frequency, while after the intervention, this increased to 12 participants (86%). Item 15 used the "agreement scale" to evaluate the participants' willingness to prevent shivering more consistently if given the necessary tools. In the presurvey, 13 participants (93%) agreed, slightly decreasing to 10 (71%) postintervention.

The combined average Likert score for items 6 and 13 in the Pre and Post samples did not show a significant difference (Pre: $M = 2.571$, $SD = 1.016$; Post: $M = 2.893$, $SD = 0.881$; $t(13) = -1.505$, $p = .156$).

Self-Efficacy

Item 3 asked participants to rate how effectively ondansetron prevents PAS. This 5-point Likert "effectiveness scale" included options ranging from "no effect" to "very strong effect." The options "no effect" and "minor effect" were categorized as ineffective, while "moderate effect," "strong effect," and "very strong effect" were considered effective. None of the participants (0%) initially rated PSO as effective. However, 11 participants (79%) rated PSO as effective after the intervention. A paired samples t-test comparing the mean Likert scores Pre ($M = 1.308$, $SD = 0.751$) and Post ($M = 2.923$, $SD = 1.256$) showed a highly significant difference; $t(12) = -4.029$, $p = .002$.

The remaining items (8, 10, & 12) evaluated the AP's perception of the efficacy of administering ondansetron for preventing PAS. Before the intervention, 11 participants (79%) agreed that it was possible to prevent PAS (item 8), which decreased to nine (64%) after the

intervention. The number of participants who agreed that preventing shivering is easy (item 10) increased from three participants (21%) before the intervention to six (43%) after. Before the intervention, 11 participants (79%) agreed they could treat shivering more effectively with the right tools (item 12), which decreased to nine (64%) after the intervention. The combined average Likert score for items 8, 10, and 12 in the Pre and Post samples did not show a significant difference (Pre: $M = 3.143$, $SD = 0.502$; Post: $M = 3.095$, $SD = 0.561$; $t(13)=0.268$, $p = .793$).

Chart Review

In addition to participant surveys, retrospective chart reviews provided a quantitative comparison of PSO administration frequency and the ondansetron dosages administered before and after the intervention (Table F4). Chi-square analyses assessed the significance of pre versus post-educational intervention PSO utilization and pre- versus post-intervention ondansetron dosages. A total of 181 charts were included in the analysis, 107 meeting the criteria for the Pre group and 74 for the Post group.

The data revealed that PSO was administered 44 times (41%) before the intervention and 26 times (35%) afterward. A chi-square test yielded a non-significant association between the intervention and the use of PSO; $\chi^2(1, N = 181) = 0.661$, $p = .416$. The mean ondansetron dosage slightly increased from 4.26 mg Pre to 4.59 mg Post, a 7.8% change. Similarly, the chi-square test indicated no significant association between the intervention and the dosage of ondansetron administered; $\chi^2(1, N = 181) = 3.384$, p = .066.

No subjective notes were found in the chart review referencing shivering within the project timeline. Additionally, the reviews revealed that tramadol, meperidine, and clonidine were not administered to any cases in the PACU before or after the educational intervention.

However, in two pre-educational intervention cases, an AP administered eight micrograms (mcg) of IV dexmedetomidine after leaving the operating room (OR) but before concluding anesthesia care (n = 2, 2%). Furthermore, after the educational intervention, one patient received 24 mcg of dexmedetomidine (n = 1, 1%) in the same setting.

Discussion

This quality improvement project aimed to achieve three key objectives. Firstly, to increase the use of PSO by APs. Secondly, to raise awareness among APs about the incidence and severity of PAS. Thirdly, to identify the barriers APs face in administering PSO. Additionally, the project aimed to reduce the incidence of PAS and emphasize the importance of perception in healthcare provider behavior choices. Despite facing some challenges, the project came close to achieving its goals. Although it did not succeed in the end, it provided valuable insights and opportunities for learning that can be applied to future projects.

Encourage Behavior Change

To determine if an educational intervention had increased the use of PSO, the PI compared survey results and medical records. The survey responses from the participants showed a 41% increase in the frequency of PSO administration. However, the data from medical records indicated a 15% decrease in the use of PSO. Moreover, no statistical differences were found in pre- and post-educational intervention chart reviews. Based on the chi-squared analyses presented in Table F4, it cannot be suggested that the educational intervention affected the frequency or dosage of PSO administration. Although the survey results initially indicated that an educational intervention could be an effective tool to increase the use of PSO, the evidence gathered from medical records did not support this assumption. As such, it cannot be concluded that the educational intervention had any impact on the healthcare behaviors of the participants.

The survey participants likely experienced response bias. Specifically, *demand characteristics* may have influenced them: subtle cues hinting at the project's goals, potentially leading participants to alter their responses accordingly (Orne, 1962, p.779). This project aimed for transparency and thoroughly explained its purpose and background during the educational intervention. In doing so, it may have inadvertently encouraged participants to align their responses with the project's objectives, a phenomenon Orne referred to as "playing the role of the good subject (1962, p. 776)." Simply stated, the participants may have attempted to say what they believed the PI wanted to hear.

Raise Awareness and Alter Perceptions

The participants' survey responses provided further insight into their healthcare behaviors and helped determine whether the educational intervention modified their perceptions. Survey item 7 asked participants how much they agreed that "shivering is benign." There was a significant 41% drop ($p = .048$) in the average Likert score in this survey item, indicating that post-educational intervention participants were less likely to agree that shivering is benign.

Another significant change occurred in survey item 3: "How effective is Zofran at preventing shivering when given before spinal anesthesia?" The average Likert score increased by 123% ($p = .002$), suggesting that the post-educational intervention participants find PSO effective for shivering prevention.

Survey items five, nine, fourteen, and sixteen were grouped to gauge the participants' beliefs concerning PSO's benefits (see Table F2 for each item's description). The average Likert score for all four items significantly increased by 30% ($p = .001$), signifying that post-educational intervention participants now agree that PSO benefits their patients. These findings suggest that the educational intervention effectively altered the APs' perceptions of PAS and

ondansetron's efficacy in preventing it. However, these assumptions are limited as they represent only a tiny fraction of the analyses conducted.

The PI conducted several additional statistical analyses, but they all showed insignificant results. The survey items used to measure the remaining Rosenstock constructs (perceived susceptibility, severity, barriers, cues to action, and self-efficacy) did not exhibit statistically significant changes between the pre- and post-educational intervention groups (Table F3). These results cannot suggest that the educational intervention substantially impacted the participants' health beliefs and perceptions. Still, the small portion of significant results does support its future potential.

Identify Barriers

The survey responses provided valuable information on barriers experienced by APs to administering PSO. The open-ended reports offered insight into the limitations they experienced. Before the educational intervention, two APs reported being unaware of ondansetron's potential in preventing PAS (*n*=2, 14%). After the educational intervention, no one mentioned this (*n*=0, 0%), indicating that the educational intervention successfully introduced ondansetron as a tool for PAS prophylaxis. Nevertheless, some APs still find it challenging to consistently use ondansetron, citing time constraints during the busy induction period, both before (*n*=1, 7%) and after the educational intervention (*n*=2, 14%).

Most of the participants in the survey, however, either did not answer or reported no barriers to administering PSO before and after the educational intervention (Pre: *n*=11, 79%; Post: *n*=12, 86%). This suggests that, beyond the minority previously mentioned, the APs do not face any barriers to PSO administration. However, this seems unlikely as, before the educational intervention, none of the survey respondents (0%) rated ondansetron as an effective tool for PAS

prevention (Item 3), as shown in Table F3. This alone could be considered a barrier to the administration of PSO and could be included as a response.

This survey item displayed significant response bias, particularly *non-response bias*, where non-responders to a survey differ systematically from those who do respond (Wolf et al., 2016). The non-responses skew the results of the survey item analysis by suggesting that, for the majority, there are no barriers to the use of PSO.

Reduce Shivering

The project was also unable to determine if the educational intervention reduced the incidence of PAS. The PI attempted to measure the incidence of PAS before and after the educational intervention by comparing the frequency of shivering rescue medication use in the PACU, which included meperidine, tramadol, dexmedetomidine, and clonidine. However, there were not enough shivering rescue medication administrations for comparison. None of the cases reviewed (N=181) received meperidine, tramadol, or clonidine. An AP administered dexmedetomidine in the immediate postoperative period after leaving the OR but before ending anesthesia care in two pre-educational intervention cases (2%) and only one post-educational intervention case (1%). Unfortunately, this sample size was too small for comparison, and it was unclear if these doses were explicitly administered for shivering.

The PI also struggled to compare the frequency of medical records mentioning "shivering" and related terms. To do so, the PI used the Epic electronic medical record system's built-in search engine to search the reviewed medical records for "shivering." The search results returned any portion of the patient's medical record that mentioned "shivering" or related terms (e.g., "shiver," "shivers," "tremble," "fever," "hypothermia," etc.). Although several records indicated the absence of shivering and fever, these records were dated outside the project

timeline, four weeks before and four weeks after the educational intervention—no medical records referenced shivering or related terms within the project timeline. Therefore, as there was no evidence of shivering rescue medication administration or notes mentioning shivering, the PI could not determine if the project influenced the incidence of PAS.

Bias and Limitations

The project site faced a significant challenge due to the recent change in anesthesia provider groups. This resulted in low morale and high employee turnover, which made it difficult to gather an appropriate sample size. The anesthesia group's instability and the employees' heightened focus on their new roles and responsibilities left little room for quality improvement projects. Therefore, it is recommended that future attempts be planned once the anesthesia provider turnover has stabilized.

It is also important to acknowledge that the sample used in the project did not include any physician anesthesiologists. These professionals play a critical role in the anesthesia care team at the project site, where part of their responsibilities involve providing physician orders for PACU nurses and serving as the primary medical provider in the post-anesthesia care unit (PACU). Notably, nearly none of the patients who received spinal anesthesia required shivering rescue medication when research indicates that shivering occurs in a significant proportion of spinal anesthesia cases (approximately 40% to 64%; Crowley & Buggy, 2008; Eberhart et al., 2005). Given the evidence, it is improbable that none of the 181 patients who received spinal anesthesia experienced shivering. The absence of physician orders to address shivering in the PACU reflects the historical attitudes of APs, who may not prioritize shivering as a significant concern (Macario et al., 1999), highlighting the importance of physician involvement in the project.

The project also encountered response biases, including non-response bias. According to Massey and Tourangeau (2013), increasing the response rate is the best way to address non-response bias. To do so, they recommend enhancing the project's design and methods. One possible strategy is mandating a response to the open-ended item before participants can complete the survey. This is only feasible with digital survey platforms, not pen-and-paper methods. This approach will guarantee responses, but not necessarily substantive ones. Alternatively, Massey and Tourangeau (2013) propose establishing direct contact with participants or reduce any survey burdens the participants can experience. Interviewing participants instead of relying solely on pen-and-paper surveys enables standardized clarification of unclear or biased responses, ensuring substantive answers. Substituting open-ended questions with multiple-choice options reduces non-responses. However, it is a less optimal option as it limits responses to those predefined by the survey designer, potentially introducing further bias.

Conclusion

This project aimed to determine if educating anesthesia providers would increase the administration of ondansetron before subarachnoid block anesthesia and decrease the incidence of post-subarachnoid block anesthesia shivering. The PI believed that providing educational material would effectively change the anesthesia providers' perceptions, which would, in turn, alter their practices for the benefit of their patients. This supposition was based on cognitive psychology theories, specifically Rosenstock's Health Beliefs Model (1966).

The project encountered some unexpected limitations and biases that affected the results. Consequently, the project could not find any significant evidence to support the idea that an educational intervention could modify perceptions and behaviors in a statistically significant

way. However, this situation provides an opportunity for further research and suggestions for quality improvement measures.

The available evidence supports administering ondansetron before initiating subarachnoid blocks as an effective anti-shivering prophylactic strategy. This evidence-based approach markedly diminishes the incidence and severity of post-subarachnoid block anesthesia shivering and offers additional advantages, such as mitigating postoperative nausea and vomiting and postspinal hypotension. This practice alleviates patient discomfort by reducing shivering, minimizes the risk of associated adverse reactions, and decreases interference with vital sign monitoring. As a result, it enhances the overall experience for the patient and the anesthesia provider.

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Appendix A

Permissions for Use

Figure A1

Permission to Use Schematic Drawing of the Shivering Pathway

BMJ

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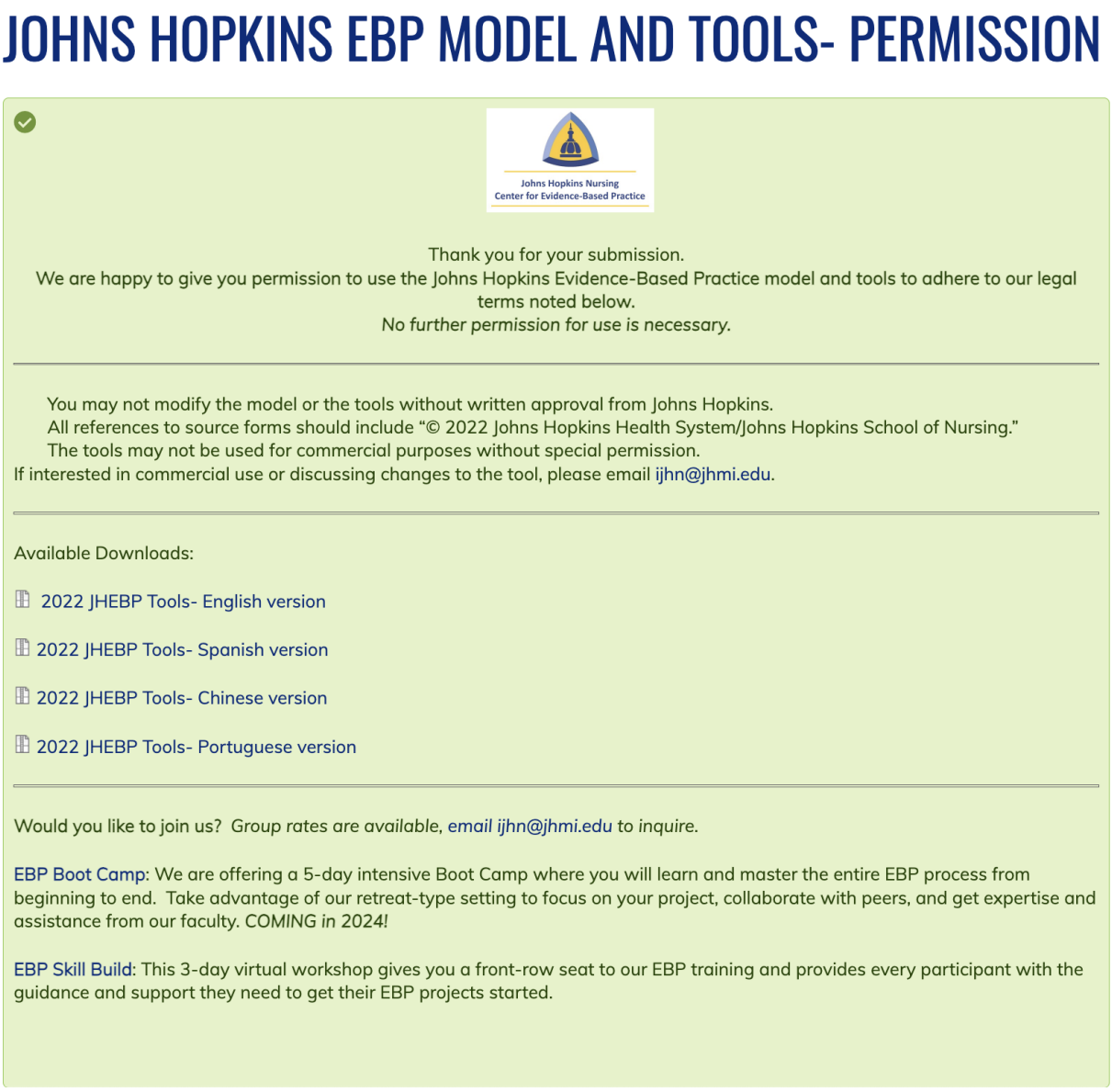
Figure A2

Permission to Use the Johns Hopkins EBP Model and Tools



Appendix B

Preintervention Survey

Pre-Intervention Survey

Consent: By completing this survey, you confirm that you agree to participate in this project.

Please enter the month and date (MM/DD) of your mother's birthday. *Please, take note of the date you enter for this item. You will be asked for it in the future. This will link your pre- and post-surveys.*	____/____

Demographics: The following questions are for demographic purposes only. Your answers are voluntary and will not affect your ability to participate in the study or the study's results.

Age	< 25	26-35	26-35	46-55	56-65	> 65
Gender	Male		Female		Self-identify _____	
What are your anesthesia credentials? (e.g., MDA, CRNA, AA, …)	*(fill in your response)*					
Anesthesia Degree	Certificate		Masters		Doctorate	
Years of anesthesia practice, including education and training.	< 1	1-5	6-10	11-15	16-20	> 20
On average, how often do you provide care for patients under spinal anesthesia?	Never	2-3 times a month	2-3 times a week	Daily		

Screening: The following questions will determine your eligibility to participate in the project.

Are you an anesthesia provider?	Yes	No
Do you provide anesthesia care to patients receiving subarachnoid blocks (i.e., spinal anesthesia) or administer subarachnoid blocks?	Yes	No

If you answered "YES" to **BOTH** questions in the previous section (Screening), please proceed to the reverse side to complete the survey.

If you answered "No" to **ANY** of the questions in the previous section (Screening), thank you for participating. Your survey is now complete.

Pre-Intervention Survey

How frequently do the following situations occur in your practice? *Please consider only your own experiences while practicing anesthesia.*	Never	Rarely	Some of the time	Often	Always
Patients under spinal anesthesia shiver.					
I administer Zofran to my patients prior to spinal anesthesia to prevent shivering.					
How effective is Zofran at preventing shivering when given prior to spinal anesthesia?	No effect	Minor Effect	Moderate Effect	Strong Effect	Very Strong Effect
What barriers prevent you from administering pre-spinal Zofran to prevent shivering?	*(fill in your response)*				
Please select the level to which you agree or disagree with the following statements. *Please consider only your own experiences while practicing anesthesia.*	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Administering pre-spinal Zofran to prevent shivering is safe.					
Administering pre-spinal Zofran to prevent shivering has negative consequences.					
Shivering is benign.					
It is possible to prevent post-spinal shivering.					
The techniques I use to prevent post-spinal shivering are safe.					
It is easy to prevent post-spinal shivering.					
Shivering is dangerous.					
If given the tools necessary, I could prevent post-spinal shivering more effectively.					
The techniques I use to prevent post-spinal shivering have negative consequences.					
It is easy to treat post-spinal shivering after it has started.					
If given the tools necessary, I would try to prevent shivering more consistently.					
Pre-spinal Zofran can prevent shivering.					

Appendix C

Educational Intervention PowerPoint

Pre-Spinal Zofran: Preventing Post-Spinal Shivers

A DNP Project presented by
Samuel Reddinger, SRNA
University of North Carolina at Greensboro, 2023

Purpose

Share current evidence	Post-anesthetic shivering (PAS) Current practices Ondansetron (Zofran)
Influence positive change	Patient outcomes Patient experience Provider experience

Background and Significance

Subarachnoid Block (SAB)
"Spinal Anesthesia"

- Preferred anesthetic in
  - *Cesarean section* (Iddrisu & Khan, 2021)
  - *Lower limb ortho* (Basques et al., 2015)
- Dense nerve blockade (Greene, 1993; Mulroy, 1998)
  - *Sensory*
  - *Motor*
  - *Sympathetic → vasodilation* (Caruselli, 2018; Jadon, 2010; Lopez, 2018)
    - Hypotension
    - Hypothermia
    - Nausea/vomiting
    - Bradycardia

Background and Significance

Postanesthetic shivering (PAS)

- Vital thermoregulatory response to hypothermia (Tan & Knight, 2018)
- Causes psychological and physical stress

Current interventions

- Active warming (forced air warmer, warmed IV fluid, ...)
- Medicinal therapies (clonidine, meperidine, tramadol)

Ondansetron

- Gold standard antiemetic (Gan et al., 2020; Griddine & Bush, 2022; Tateosian et al., 2018)
- Reduces occurrence rate and severity of PAS (He et al., 2016; Li et al., 2016; Tie et al., 2014; Tubog & Bramble, 2022)
- Reduces spinal-induced hypotension (55-64%) (Hu et al., 2020; Mendonça et al., 2021; Tatikonda et al., 2019; Vashishth et al., 2022)

Thermoregulation

The neurophysiological pathways

Afferent Input

(Crowley & Buggy, 2008; De Witte & Sessler, 2002)

Cutaneous thermoreceptors

- *Warm sensations initiate noradrenergic excitatory signals*
  (Darian-Smith et al., 1979)
- *Cold sensations initiate serotonergic inhibitory signals*
  (McKemy, 2012)

Spinal Cord

- *Cutaneous cold receptors can be activated by cooling their axons within the spinal cord*
  (Brock & McAllen, 2016; Cabanac, 1975; Simon & Iriki, 1971)

Brainstem Locus

- *Subcoeruleus Area (LS)*
  - Noradrenergic, excitatory pathway
  - Sends warm signals
- *Nucleus Raphe Manus (NRM)*
  - Sends cold signals
  - Controls the shivering threshold
  - Serotonergic inhibitory pathway

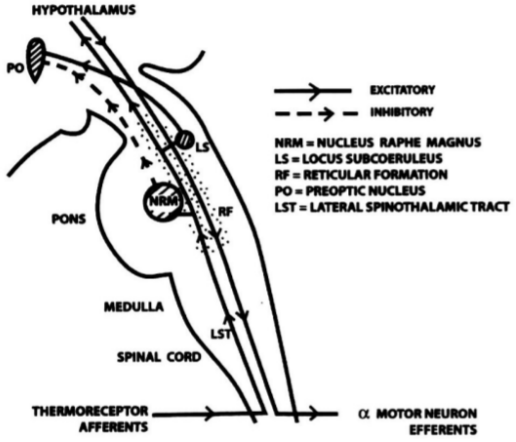


Figure 1. Schematic drawing of the shivering pathway. Adapted from "Shivering and Neuraxial Anesthesia", by L.J. Crowley and D.J. Buggy, 2008, *Regional Anesthesia and Pain Medicine, 33,* p. 242, ©2008 by the American Society of Regional Anesthesia and Pain Medicine

Integration center:

Preoptic anterior hypothalamus (PO)

(Crowley & Buggy, 2008; De Witte & Sessler, 2002)

Continuously initiates a common central command

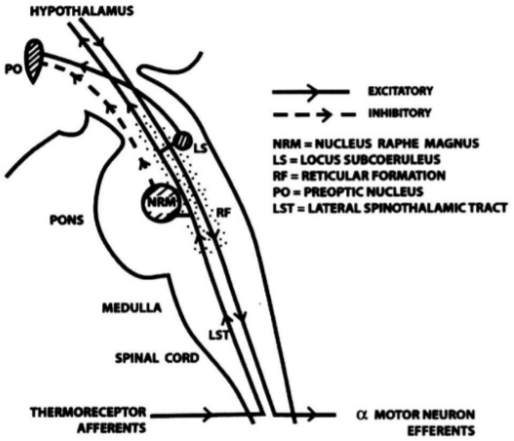
- *One common efferent signal to the periphery*

The signal is modulated based on the temp

- *PO "compares" core temp with signals received from LS and NR*

PO neurons also respond to non-temp. signals

- *Reproductive hormones* (Silva & Boulant, 1986)
- *Plasma osmolality* (Koga et al., 1987; Nakashima et al., 1985; Silva & Boulant, 1984)
- *Glucose concentration* (Boulant & Silva, 1987; Silva & Boulant, 1984)
- *Blood pressure* (Koga et al., 1987)
- *Noxious stimuli* (Kanosue et al., 1984)
- *Carbon dioxide* (Tamaki et al., 1986)
- *Emotional stimuli* (Hori et al., 1986)



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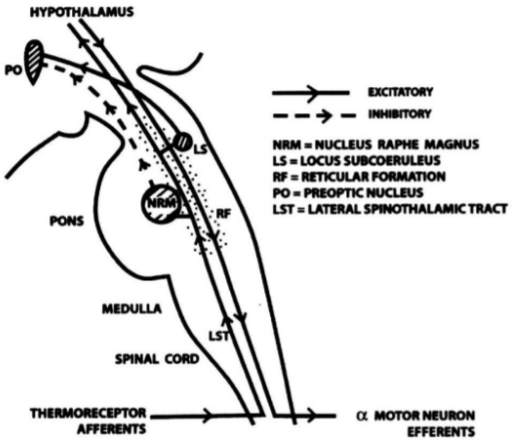
Effector Pathway

(Crowley & Buggy, 2008; De Witte & Sessler, 2002)

Mechanisms are initiated in order of efficiency.

- *Cutaneous vasoconstriction*
  - Firstline defense
  - Usually prevents core temps from dropping below the shivering thresholds (Sessler et al., 1990, 1992)
- *Non-shivering thermogenesis* (Dawkins & Scopes, 1965)
  - "Burning brown fat"
  - Only seen in neonates
- *Shivering*
  - Last-ditch effort
  - Is metabolically inefficient and physiologically deleterious



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Shivering

What it is and what it is not

Shivering

- Crossley and Mahajan classification (Crossley & Mahajan, 1994)
- Involuntary movement affecting one or several muscle groups (Crowley & Buggy, 2008)
- Can increase heat production 600% (Giesbrecht et al., 1994)
- Occurs in 55% of spinal anesthetics (interquartile range 40-64%) (Crowley & Buggy, 2008)

Grade	Description
0	No shivering.
1	No visible muscle activity, but one or more of piloerection, peripheral vasoconstriction or peripheral cyanosis (other causes excluded).
2	Muscular activity in only one muscle group.
3	Moderate muscular activity in more than one muscle group, but not generalised shaking.
4	Violent muscular activity that involves the entire body.

Table 1. Crossley and Mahajan shivering classification. Adapted from "The intensity of postoperative shivering is unrelated to axillary temperature", by A.W.A Crossley and R.P. Mahajan, 1994, *Anaesthesia, 49,* p. 205, @1994 The Association of Anaesthetists of Great Britain and Ireland

> Shivering is the only symptom the parturients mention as disconcerting during their labor, delivery, and postpartum recovery. The other symptoms are accepted as part of the physiologic changes that accompany the birth process.
>
> *-Ostheimer and Datta, 1981*

Adverse Effects

- It is NOT harmless
- Postoperative complications (Choi et al., 2017)
  - *Pain*
  - *Bleeding*
- Increased cardiovascular strain (Ralley et al., 1988)
  - ↑ *HR and* ↓ SvO_2
  - ↑ *Myocardial work*
  - *Potential for MI in compromised patients*
- Interferes with standard ASA monitors (Barker & Shah, 1996; de Courcy, 1989; Kiekkas et al., 2005; Ostheimer & Datta, 1981)

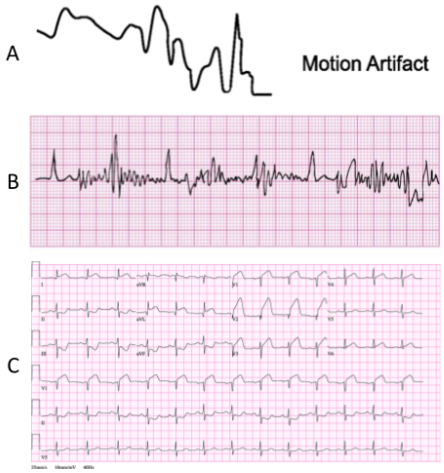
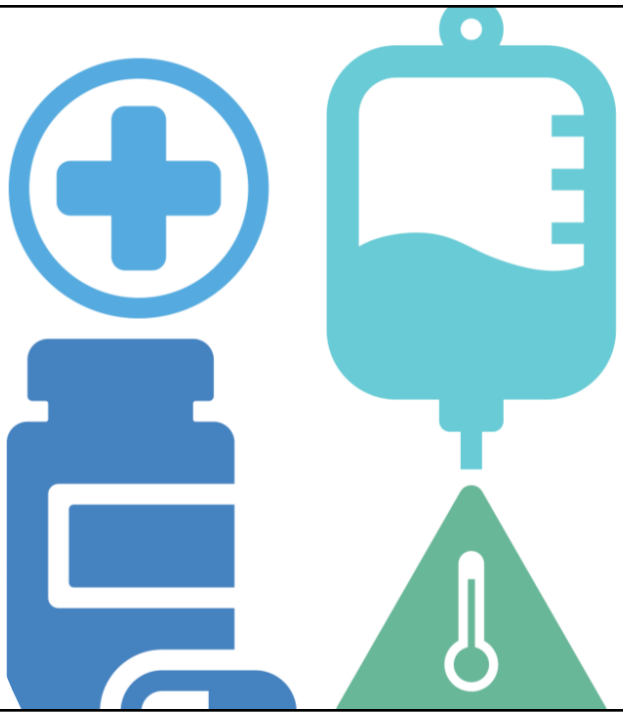


Figure 2. **A)** Pulse oximetry signal during motion artifact showing an erratic waveform. **B)** Somatic tremor ECG artifact. **C)** ECG showing an anterolateral STEMI

A) Adapted from "Pulse oximetry," by A. Jubran, 2015, *Critical Care, 19*, p. 272, © 2015 Jubran, B) Adapted from "EKG Plain and Simple," by K. Ellis, 2012, ©2012 Pearson, C) Adapted from "ST elevation: Differential diagnosis and caveats. A comprehensive review to help distinguish ST elevation myocardial infarction from nonischemic etiologies of ST elevation," by E.C. de Bliek, 2018, *Turkish Journal of Emergency Medicine*, *18*, p. 4, ©2018 The Emergency Medicine Association of Turkey.

Current Treatments

What are we doing?



Nonpharmacologic Therapies

- Forced air warmers
  - Long-lasting benefits if initiated preop (Camus et al., 1995)
- Warmed IV fluids
  - Helpful in multi-therapy models (e.g., forced air warmers + warmed IV fluids) (Cobb et al., 2016)
  - Less effective as sole therapy (Sessler et al., 1991)
- Increased ambient temperature (i.e., OR temperature)
  - Limited effect on core temperature (Pei et al., 2018)

Pharmacologic Therapies

Amine reuptake inhibitors (tramadol, nefopam) (Bilotta et al., 2002; de Witte et al., 1997; Shukla et al., 2011; T. & Kaparti, 2014)	• Block norepinephrine and serotonin reuptake in the spinal cord • Activate descending, anti-shivering pathways
α2 Agonists (clonidine, dexmedetomidine) (Talke et al., 1997)	• Decrease shivering threshold
Anticholinergics (physostigmine) (Horn et al., 1998)	• Decrease sympathetic tone
κ-Opioid agonists (meperidine) (Ikeda et al., 1997; Kurz et al., 1997)	• Decreases shivering threshold • Spares vasoconstriction

Pharmacologic Therapies

Amine reuptake inhibitors (tramadol, nefopam) (Rosa et al., 1995)	• Nausea/Vomiting • Dizziness • Increased ICP • Reduced seizure threshold
α2 Agonists (clonidine, dexmedetomidine) (Giovannitti et al., 2015)	• Bradycardia • Hypotension • Sedation
Anticholinergics (physostigmine) (Adeyinka & Kondamudi, 2022; Andrade & Zafar Gondal, 2022)	• Muscular weakness ⇒ paralysis • GI distress • Bronchoconstriction • Tachycardia ⇒ precipitous bradycardia
κ-Opioid agonists (meperidine) (Powell & Buggy, 2000)	• Nausea/Vomiting • Sedation • Respiratory Depression

Ondansetron

4 mg IV push

Before spinal induction

"Push before your call"

Ondansetron (Zofran)

- Targeted
- Safe
- Effective
- Easy

Ondansetron (Zofran)

Targeted

- Mechanism: 5-HT_3 (type 3 serotonin) antagonist (Liu et al., 2020; Powell & Buggy, 2000)
- 5-HT_3 antagonism in the afferent thermosensors, spinal cord, NRM, and PO (Alfonsi, 2001; Li et al., 2016)

Safe

- No adverse effects on fetal well-being (Fejzo et al., 2016; Pasternak et al., 2013; Picot et al., 2020)
- Limited side effects
  - *Mild, transient headache (15%)* (Khan, 2002; Ruff et al., 1994)
  - *Weakness, constipation, or dizziness (10%)* (Nnacheta et al., 2020; Perez et al., 1998)
  - *QT interval prolongation* (Navari & Koeller, 2003)
    - *Take care when treating patients on multiple QT-prolonging medications* (Anyfantakis & Makrakis, 2019; Freedman et al., 2014; Patel et al., 2019)

Ondansetron (Zofran)

Effective

- Significant reduction in PAS incidence
  - 46-88% in individual studies (Kelsaka et al., 2006; Nnacheta et al., 2020; Teoh et al., 2021)
  - 67-71% across meta-analyses (He et al., 2016; Li et al., 2016; Tubog & Bramble, 2022)
- Research does not always agree…
  e.g., Browning et al., (2013) and Liu et al., (2020)
  - No significant differences in incidence or severity compared to placebo
  - Possible confounding variable: Subjects received 500-1000 mL, room temp. (“cold”) co-loaded bolus

Ondansetron (Zofran)

Easy

- Standard doses are appropriate
  - 0.1 mg/kg > 8 mg > 4 mg > placebo
  - Doses ≥ 8 mg have significantly better results
    - 15% (8mg), 33% (4 mg), and 57% (P) (Powell & Buggy, 2000)
    - 11.3% (0.1 mg/kg) vs. 22.6% (4mg) (Gicheru et al., 2019)

Ondansetron (Zofran)

- Evidence supports a 4 mg dose
  - *Studies found significant results with 4 mg* (He et al., 2016; Li et al., 2016; Nnacheta et al., 2020; Teoh et al., 2021)
  - *Side effects ∝ dosage* (Bryson, 1992; Freedman et al., 2014)

Ondansetron (Zofran)

- 4 mg IV push
- Before spinal induction
- "Push before your call"

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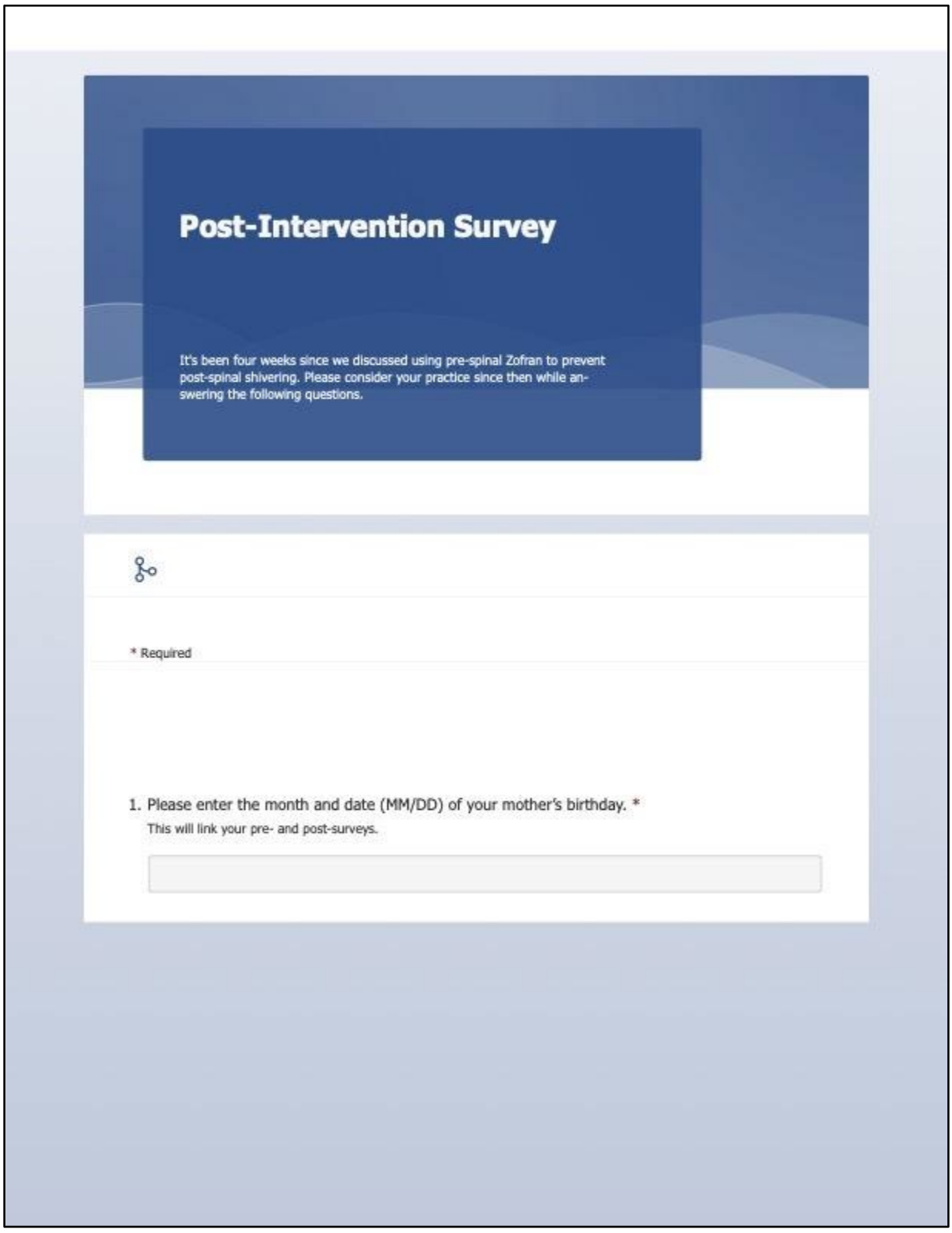
Appendix D

Postintervention Survey



2. In the past four weeks, how many times have you provided anesthesia care to patients under spinal anesthesia? *

- ◯ Never
- ◯ 2-3 times per month
- ◯ 2-3 times per week
- ◯ Daily

3. In your practice, how often did the following situations occur?

Please only consider your own experiences in anesthesia within the last four (4) weeks.

	Never	Rarely	Sometimes	Often	Always
Patients under spinal anesthesia shivered.	◯	◯	◯	◯	◯
I gave my patient Zofran prior to spinal anesthesia.	◯	◯	◯	◯	◯

4. How effective is Zofran at preventing shivering when given prior to spinal anesthesia?

- ◯ Very effective
- ◯ Somewhat effective
- ◯ Neither effective nor ineffective
- ◯ Somewhat ineffective
- ◯ Very ineffective

5. What barriers prevented you from administering pre-spinal Zofran to prevent post-spinal shivering?

6. Please select how much you agree or disagree with the following statements.

Please only consider your experiences in anesthesia within the last four (4) weeks.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Zofran for post-spinal shivering prevention is safe.	◯	◯	◯	◯	◯
Zofran for post-spinal shivering prevention has negative effects.	◯	◯	◯	◯	◯
Shivering is benign.	◯	◯	◯	◯	◯
It is possible to prevent post-spinal shivering.	◯	◯	◯	◯	◯
Techniques I use to prevent post-spinal shivering are safe.	◯	◯	◯	◯	◯
It is easy to prevent post-spinal shivering.	◯	◯	◯	◯	◯
Shivering is dangerous.	◯	◯	◯	◯	◯
I could prevent post-spinal shivering more effectively, if I had the tools I need.	◯	◯	◯	◯	◯
Techniques I use to prevent post-spinal shivering have negative effects.	◯	◯	◯	◯	◯
It is easy to treat post-spinal shivering after it has started.	◯	◯	◯	◯	◯
I would try to prevent shivering	◯	◯	◯	◯	◯

more consistently, if I had the tools I need.	◯	◯	◯	◯	◯
Pre-spinal Zofran can prevent shivering.	◯	◯	◯	◯	◯

Appendix E

Chart Review Tool

	A	B	C	D	E	F	G	H	I
1	Chart Review								
2	Case Number	Time Ondansetron Given (HH:MM)	Time of Induction (HH:MM)	Ondansetron Dosage (mg)	Meperidine Dosage in PACU (mg)	Tramadol Dosage in PACU (mg)	Dexmedetomidine Dosage in PACU (mcg)	Clonidine Dosage in PACU (mcg)	Subjective Remarks Regarding Shivering
3	1								
4	2								
5	3								
6	4								
7	5								
8	6								
9	7								
10	8								
11	9								
12	10								
13	11								
14	12								
15	13								
16	14								
17	15								
18	16								
19	17								
20	18								
21	19								
22	20								
23	21								
24	22								
25	23								
26	24								
27	25								

Appendix F

Tables of Results

Table F1

Sample Demographics

Characteristics	*n*	%
Age		
< 26	0	0.0
26-35	3	21.4
36-45	7	50.0
46-55	4	28.6
56-65	0	0
> 65	0	0
Gender		
Female	8	57.1
Male	6	42.9
Self-identify	0	0
Anesthesia Credentials		
SRNA	2	14.3
CRNA	12	85.7
Anesthesia Degree Level		
Masters	9	64.3
Doctorate	5	35.7
Years of Anesthesia Practice		
< 1	0	0
1-5	4	28.6
6-10	3	21.4
11-15	3	21.4
16-20	3	21.4
> 20	1	7.1
Frequency of SAB Care		
Never	0	0
2-3 times a month	8	57.1
2-3 times a week	6	42.9
Daily	0	0

Note: $N = 14$; SAB = subarachnoid block

Table F2

Pre and Postintervention Survey Responses

Survey Items Grouped by Likert Scale	Preintervention					Postintervention				
	n	*%*	*n*	*%*	*M*	*n*	*%*	*n*	*%*	*M*
Frequency Scale	Low Occurrence		High Occurrence			Low Occurrence		High Occurrence		
Item 1) Patients under spinal anesthesia shiver	2	14.3	12	85.7	2.429	4	28.6	10	71.4	1.786
Item 2) I administer Zofran to my patients prior to spinal anesthesia to prevent shivering	7	50.0	7	50.0	1.714	2	14.3	12	85.7	2.786
Effectiveness Scale	Effective		Not Effective			Effective		Not Effective		
Item 3) How effective is Zofran at preventing shivering when given prior to spinal anesthesia?	0	0	14	100	1.308	3	21.4	11	78.6	2.929
Agreement Scale	Agree		Disagree			Agree		Disagree		
Item 5) Administering pre-spinal Zofran to prevent shivering is safe.	12	85.7	2	14.3	3.429	12	85.7	2	14.3	3.429
Item 6) Administering pre-spinal Zofran to prevent shivering has negative consequences.	0	0	14	100	0.714	1	7.1	13	92.9	1.143
Item 7) Shivering is benign.	1	7.1	13	92.9	1.214	0	0	14	100	0.714
Item 8) It is possible to prevent post-spinal shivering.	11	78.6	3	21.4	2.786	9	64.3	5	35.7	2.786
Item 9) The techniques I use to prevent post-spinal shivering are safe.	12	85.7	2	14.3	2.786	13	92.9	1	7.1	3.214
Item 10) It is easy to prevent post-spinal shivering.	3	21.4	11	78.6	2.000	6	42.9	8	57.1	2.000
Item 11) Shivering is dangerous.	5	35.7	9	64.3	2.071	9	64.3	5	35.7	2.429
Item 12) If given the tools necessary, I could prevent post-spinal shivering more effectively.	11	78.6	3	21.4	3.071	9	64.3	5	35.7	2.786

Survey Items Grouped by Likert Scale	Preintervention					Postintervention				
	n	%	*n*	%	*M*	*n*	%	*n*	%	*M*
Agreement Scale	Agree		Disagree			Agree		Disagree		
Item 13) The techniques I use to prevent post-spinal shivering have negative consequences.	0	0	14	100	2.786	1	7.1	13	92.9	1.214
Item 14) It is easy to treat post-spinal shivering after it has started.	0	0	14	100	1.286	1	7.1	13	92.9	0.786
Item 15) If given the tools necessary, I would try to prevent shivering more consistently.	13	92.9	1	7.1	0.786	10	71.4	4	28.6	3.000
Item 16) Pre-spinal Zofran can prevent shivering	7	50.0	7	50.0	2.500	10	71.4	4	28.6	2.857

Note: $N = 14$; The survey utilized a five-point Likert scale with responses ranging from zero to four. Each survey item used one of the three Likert scales: Frequency, Effectiveness, and Agreement. Frequency scale: low occurrence = response zero or one, high occurrence = two, three, or four. Effectiveness scale: not effective = zero or one, effective = two, three, or four. Agreement scale: disagree = zero, one, or two, agree = three or four. The average response score was calculated for the preintervention group ($n = 14$) and the postintervention group ($n = 14$).

Table F3

Pre and Postintervention Survey Responses Grouped by Rosenstock Constructs

Survey Items Grouped by Rosenstock Constructs	Preintervention		Postintervention		*t*-Test		
	M	*SD*	*M*	*SD*	*t*	*df*	Sig.
Perceived Susceptibility							
Item 1	2.428	0.756	1.786	0.975	1.662	13	.120
Perceived Severity							
Items 7 & 11	1.643	0.457	1.571	0.514	0.342	13	.738
Perceived Benefits							
Items 5, 9, 14, & 16	2.536	0.587	3.286	0.914	-4.469	13	.001**
Perceived Barriers							
Items 6 & 13	0.821	0.372	0.408	0.684	-1.632	13	.127
Cues to Action							
Items 2 & 15	2.571	1.016	2.893	0.881	-1.505	13	.156
Self-Efficacy							
Item 3	1.308	0.751	2.923	1.256	-4.029	12	.002**
Items 8, 10, & 12	3.143	0.502	3.095	0.561	0.268	13	.793

Note: $N = 14$; Sig. = 2-tailed significance; Values considered significant if $p < .05$; Each of the 16 survey items measured one the participants health perceptions (Rosenstock Constructs) which were defined by I. M. Rosenstock in "Why people use health services", 1966, *The Milbank Memorial Fund Quarterly*, 44(3), 94–127. https://doi.org/10.2307/3348967. The mean Likert score was calculated across all survey items within each Rosenstock construct. The mean Likert scores from the preintervention group ($n = 14$) was compared to that of the postintervention group ($n = 14$) using paired-sample *t*-tests

**$p < 0.01$

Table F4

Chi-squared Data Analysis of Chart Review

Variables	Preintervention		Postintervention		Chi-squared Test		
	n	%	*n*	%	*χ2*	*Df*	*p*
PSO Administered							
Yes	44	41.1	26	35.1	0.661	1	.416
No	63	58.9	48	64.9			
Ondansetron Dosage							
Low dose (4 mg)	100	93.5	63	85.1	3.384	1	.066
High dose (8 mg)	7	6.6	11	14.9			

Note: $N = 14$; PSO = pre-subarachnoid block ondansetron; Values considered significant if $p < .05$