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Nitrous Oxide for Pain Management in the Emergency Department

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Walden University
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Abstract

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Project Submitted in Partial Fulfillment

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Abstract

The clinical practice problem addressed was pain control in emergency department (ED) patients. The purpose of this project was to establish situations when inhaled nitrous oxide (N_2O) could be used to manage pain in the ED. Specifically, a systematic review provided answers to questions related to appropriate uses of N_2O in acute pain management, the effectiveness of inhaled N_2O in managing acute pain, and the benefits of and barriers to N_2O use in the ED. The middle range nursing theory of acute pain management published by the Agency for Health Care Policy and Research served as the theoretical support for the project. A systematic literature review using the PRISMA checklist yielded 5 studies that were incorporated into the synthesis of evidence. Inhaled N_2O was found to be safe and effective for managing pain in some ED patients and in women undergoing labor. N_2O can be used in pediatric and adult patients for minor procedural pain relief and pain associated with burns and cancer. N_2O was associated with improved outcomes and increased patient and family satisfaction. However, extensive adoption was hindered by the scarcity of the delivery equipment, untrained medical staff, and the increasing use of N_2O as a recreational drug with addictive properties. Although integrating the use of inhaled N_2O to mitigate pain may improve patient outcomes, more research is indicated before widespread use of the drug can be encouraged. The findings were communicated to the ED staff for consideration of limited adoption of N_2O in the ED. Use of this alternative evidence-based and effective pain control agent may result in positive social change by lessening acute or procedural pain experienced by patients in specific ED situations.

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Section 1: Nature of the Project

Introduction

According to Liu et al. (2017), the occurrence of pain is a challenge for care providers because it negatively affects patients' quality of life. Acute pain is associated with a complex interaction of the psychological, physical, and social components of an individual. The occurrence of pain triggers individuals to self-protect from impending injury. However, persistent pain resulting from underlying medical conditions such as surgical procedures or illness could result in destructive adverse events. Pain not only causes discomfort but also causes a delay in healing and recovery (Good, 1998). Timely treatment of pain is necessary because research shows that pain stimulates a sympathoadrenal stress response that causes muscle tension, urinary retention, infection, and sensitivity to nociceptors (Good, 1998). According to The American Pain Society president in a 1990 editorial, pain is a fifth vital sign and the most common reason for visiting the emergency department (ED). Often the emergency room physician does not provide adequate pain relief, which causes patient dissatisfaction. Undertreatment of pain is also known as *oligoanalgesia* (Motov & Khan, 2008).

Brennan, Carr, and Cousins (2007) reported that there is a significant gap in understanding of the pathophysiology of pain as well as inadequate pain treatment. Undertreatment of pain has many side effects and is a sign of poor medical practice (Brennan, Carr, & Cousins 2007). If acute pain is not relieved, it can cause the occurrence of pathophysiological neural problems such as peripheral and central neuronal sensitization that may result in chronic pain syndrome (Brennan et al., 2007). So, it is

important to treat acute pain to prevent adverse effects. In the ED, many procedures are performed, and pain induced during procedures can be very high (Petrack, Christopher, & Kriwinsky, 1997). Therefore, several practices have been identified to help mitigate pain in hospitalized individuals. For example, current practices in the ED where I work include the administration of various medications such as opioids and nonsteroidal anti-inflammatory (NSAID) medications orally, intravenously, intramuscularly, or rectally.

Nitrous oxide (N_2O) has been used in United States. hospital settings since 1970 (Oglesbee & Selde, 2014). N_2O is a colorless gas with a pleasant odor and taste (Drug Bank, 2019). The gas is commonly known as "laughing gas" because it has a euphoric effect on users. N_2O gas administration has anesthetic and analgesic properties, making it useful not only to control acute pain, but also to manage procedural and postprocedural pain (Rosen, 2002). Because N_2O is inexpensive, fast acting, rapid clearing, and relatively safe to use, the providers have suggested it as an alternative to currently used acute pain control medications (Rosen, 2002). N_2O is absorbed quickly with the onset of effects occurring within four to six breaths (Rosen, 2002). The cessation of N_2O effects is also fast because the gas is eliminated through the lungs. The patient can be trained to use a mask, which can give the patient control in administering the medication (Rosen, 2002). The use of N_2O in labor began in the late 1800s and was introduced in England by Minnitt in 1934 for self-administration using mask or mouthpiece (Likis et al., 2014).Between 50% and 75% of women in England and 60% of women in Finland use N_2O during labor, but in the United States, only five centers nationally provide the option to use N_2O during labor (Likis et al., 2014).

N_2O is widely used internationally in EDs; it is used in France, Australia, Canada, and the United Kingdom, for instance. Inhalation of N_2O is fast-acting, which is beneficial in situations where time is of the essence in the ED when patients suffer from injuries related to trauma, burns, and acute myocardial infarction; acute pain from childbirth; or iatrogenic pain such as intravenous catheter insertion in pediatric patients (Oglesbee & Selde, 2014). As an analgesic, N_2O is suited for use in emergencies such as myocardial infarctions, moderate pain, severe burns, and musculoskeletal injuries (Oglesbee & Selde, 2014). N_2O functions by stimulating the release of the opioid peptide in the brain stem to activate the noradrenergic neurons resulting in the modulation of the sensation of pain in the spinal cord (Drug Bank, 2019). Like other drugs, N_2O is associated with various side effects including nausea and vomiting. In addition, prolonged use of N_2O for recreational purposes can result in addiction and inactivate vitamin B_{12} causing megaloblastic anemia and degeneration of the spinal cord (Ferner, Mackenzie, & Aronson, 2014).

Problem Statement

The clinical practice problem is the lack of safe, effective, and nonaddictive pain control for use in the ED setting. I analyzed the effectiveness of inhaled N_2O in managing pain in patients in the ED and the linked benefits and barriers using a systematic literature review approach. As a health care provider, I am legally and ethically mandated to use evidence-based practice and clinical practice guidelines to ensure best practices in the management of patients I treat. Although N_2O is used internationally to relieve acute pain in the acute care setting (Oglesbee & Selde, 2014).

The hospital where I am going to implement the recommendation of project finding does not offer N_2O as an anesthetic and analgesic option yet.

The ED patient satisfaction survey reports for the project site are showing patient dissatisfaction due to undertreatment of pain, and the scores are decreasing. Brennan et al. (2007) reported that there is a major gap in understanding the pathophysiology of pain resulting in inadequate pain treatment. Undertreatment of pain has many side effects and is a sign of poor medical practice. The underestimation of pain is a reason for the undertreatment of pain (Kappesser & Williams, 2010) and could be due to health care providers' poor pain assessment knowledge, fear of causing addiction, and fear of medication side effects, or lack of patient pain education (Sugarman et al., 2010).

In Europe, Asia, the Middle East, and Australia, N_2O is often administered during childbirth. Between 1930 and 1950, N_2O was also administered extensively in the United States during childbirth. The usage of N_2O in childbirth decreased in the United States when, in the 1970s, epidural analgesia was introduced (Illuzzi, Telfer, & Rubin, 2018). However, in the recent past, the use of N_2O in childbirth has again gained popularity in the United States because research showed that it does not affect cord blood gases, neonatal behavior, or Apgar scores (Illuzzi, Telfer, & Rubin, 2018). N_2O reduces sensitivity to pain through dopamine, norepinephrine, and endogenous opioid release (Illuzzi et al., 2018). Currently, providers are using N_2O in acute care settings such as the ED for conscious sedation in procedures such as laceration repairs. The use of N_2O may eventually be considered a suitable general anesthetic for hospitalized patients (Galeotti

et al., 2016). I studied the appropriateness and effectiveness of pain control with N_2O in the ED setting.

Procedure-related pain in the pediatric population is a pressing concern for providers and parents. A study done by Gail et al. (2001) using 50% N_2O mixed with oxygen as analgesia in the pediatric population during procedures such as bone marrow aspiration, laceration repair, fracture reduction, bone-marrow aspiration, flexible bronchoscopy, gastroscopy, lumbar puncture, surgical dressing change, venous cannulation, bladder catheter insertion, and cast remodeling. The results of the study were encouraging; the N_2O and oxygen had a rapid onset with no major side effects, were easy to administer, could be reversed quickly, and worked well for children 4 years of age and older (Gail et al., 2001). Study done by Hee, Goy, and Ng (2003) showed that using EMLA cream with N_2O during venous cannulation works better to relieves procedural pain.

Forty percent of the Canadian population does not obtain dental care due to fear of pain and anxiety. N_2O/oxygen can be used to relieve pain and anxiety during dental procedures (Ryding & Murphy, 2007). The combination uses of N_2O with EMLA numbing cream for venous cannulation has been shown to provide better pain relief than using EMLA cream alone (Hee et al., 2003). A study done by Kanagasundaram, Lane, Cavalletto, Keneally, and Cooper (2001) to evaluate the efficacy and safety of N_2O during painful procedures in children demonstrated that N_2O inhalation is effective in alleviating distress with short recovery time and minimal side effects.

Purpose

The purpose of this project was to conduct a systematic review of the literature to establish incidences where N_2O could be used for managing patients' acute pain as well identify the linked benefits and barriers to its administration. The practice-focused questions used to guide the generation of evidence were the following:

1. Among ED patients, in what situations can N_2O be recommended for acute pain control?
2. Among ED patients, what is the effectiveness of inhaled N_2O in managing pain? and
3. Among ED patients, what are the benefits of and barriers to N_2O use?

I generated the evidence to establish the applications, effectiveness, and benefits of N_2O to manage acute pain as well as the barriers to its use in U.S. acute care settings through a search of online databases; I did so use predetermined search terms and inclusion and exclusion criteria. The use of N_2O for pain management in the ED may help to relieve pain; in addition, patients can have control over its use. The effect of N_2O is very fast, which may help to increase patient satisfaction with ED pain control and address the gap in practice.

Nature of the Doctoral Project

The purpose of the project was to conduct a systematic review of the literature to determine whether N_2O can be used in the management of ED acute pain. A thorough search of literature databases included EBSCOhost, MEDLINE, CINAHL Plus, the Database of Abstracts of Effectiveness, and the Cochrane Database of Systematic

Reviews. I used the practice-focused questions addressing the use of N_2O in the management of pain to guide the literature search. The project design followed the Walden University *Manual for Systematic Review*. Prior to conducting the systematic review for this project, I completed the Walden University Institutional Review Board (IRB) Form A to obtain IRB approval of the project. Because no human subjects were involved in the data collection or data reporting for the project, no ethical issues were expected. The procedures of the systematic review helped to guard against my biases in evaluating the literature.

Significance

A review of literature on the effectiveness of N_2O in managing pain in ED patients helped to establish the instances when it is appropriate to administer N_2O. I planned to disseminate the findings of this project to the physicians, triage nurses, primary nurses, and patients at the project site because these stakeholders will be affected if N_2O is implemented in the ED. The use of N_2O may be adopted at the project site to provide a fast-acting and fast-clearing pain management option. This intervention could have a positive impact on patients and their families by decreasing anxiety, fear, and behaviors associated with poor pain management. The social change related to this project is provision of evidence-based and effective pain control in the ED.

Summary

The occurrence of pain in patients receiving acute care is inevitable. Pain serves as a trigger for individuals to protect themselves from impending injury by alleviating the discomfort. Various medications have been manufactured for mitigating pain in patients.

Among them are opioids, NSAIDs, and N_2O. These drugs are effective in relieving pain in patients hospitalized in acute care settings (Galeotti et al., 2016; Illuzzi et al., 2018). However, opioids, and NSAIDs to a lesser extent, have been associated with adverse events, including death (Galeotti et al., 2016; Illuzzi et al., 2018).

Therefore, there is a need to identify other medications that can function as effectively as opioids and NSAIDs. I undertook this project to establish the effectiveness of using N_2O to manage pain among patients hospitalized in the ED. The supporting evidence was generated through a systematic review of the literature. In Section 2, I will provide an overview of the concepts, models, and theories that I used in support of the project and the PRISMA steps that I followed for the systematic literature review.

Section 2: Concepts, Models, and Theories

Introduction

The practice problem is pain control in the acute care setting. The purpose of this project was to conduct a systematic review of the literature to establish instances where N_2O could be used effectively in the ED and the associated benefits and barriers of its use. There were no participants in this project; however, the target populations for the findings of this systematic review project were health care professionals and patients who may be able to use N_2O in managing pain in the ED. I focused the systematic review on articles addressing the pain control of ED patients in acute care. The setting was appropriate because patients in the ED are prone to experiencing pain due to medical procedures they have already undergone or will receive for developing pain. Failure to address the pain within a limited period can result in destructive adverse events (Serdarevic et al., 2017). In addition, patients are likely to develop other complications if the approaches for mitigating pain are not effective and safe, resulting in addiction or adverse side effects (Serdarevic et al., 2017). Therefore, establishing effective and safe alternate approaches for mitigating pain among hospitalized patients in the ED may result in the adoption of evidence-based practices that will improve patient outcomes in the project setting. The results of this systematic review project may be helpful to researchers and providers in developing and initiating new guidelines to treat pain in the clinical setting if the literature review supports the use of N_2O in managing pain.

Concepts, Models, and Theories

PRISMA Framework

According to Nilsen (2015), using developed theories to guide the generation and reporting of research evidence is crucial to ensure the identification and adoption of safe practices to improve patient outcomes. I developed this project to generate and synthesize the evidence related to the use of N_2O in managing pain in ED patients. Adhering to the framework of the PRISMA checklist (Nilsen, 2015) will ensure that credible evidence is generated to address the practice-focused questions. The findings from the project can then be incorporated into practice by nurses and other providers in the ED as supported by the literature (Nilsen, 2015). Adherence to the framework in identifying and evaluating evidence to address the identified health issue should thus enable accurate translation into practice.

The PRISMA framework is suitable for reporting systematic reviews of various types of research involving evaluation to assess for the benefits and harms of a health care intervention (Tam, Tang, Woo, & Goh, 2019). The PRISMA statement contains a checklist that researchers use to guide their selection of studies to include in a systematic review and reporting of findings. The PRISMA statement was developed by a group of 29 review methodologists, authors, medical editors, clinicians, and consumers who approved a 27-item checklist, a four-face flow diagram, and an explanatory paper that outlined the 27 items users should consider when conducting and reporting reviews of the literature (Liberati et al., 2009). The 27 items can be organized into four phases: introduction, methods, results, and discussion (Liberati et al., 2009). The items on the

PRISMA checklist are included in a specific, multistep order when conducting a systematic literature search report (see Appendix A).

Acute Pain Management Theory

The middle range nursing theory of acute pain management is based on pain management guidelines published by the Agency for Health Care Policy and Research in 1992 (Good, 1998). According to the theory, there should be a balance between the effectiveness of the analgesia and its side effects when treating patients with moderate to severe pain (Good, 1998). The middle-range theory of pain management includes three propositions that predict the patient outcome: multimodal intervention, attentive pain management, and patient participation to maintain the balance between analgesia and its side effects (Good, 1998). The goal is to achieve pain control with pharmacological and nonpharmacological approaches to maintain a balanced approach to pain management. Patient-attentive care can be provided by conducting pain assessment and regular pain reassessments to check the effect and side effects of the intervention (Good, 1998). Patient education and feedback helps to achieve a balance between the analgesic effects and side effects of pain medications (Good, 1998).

Relevance to Nursing Practice

According to the study done by Zier, Drake, McCormick, Clinch, and Cornfield (2007), safe and effective conscious sedation for procedures can be achieved in the pediatric population by nursing staff with multidisciplinary oversight. In the randomized clinical trial they conducted, Luhmann, Kennedy, Porter, Miller, and Jaffe (2001) compared the use of oral midazolam with 50% continuous N_2O to relieve the anxiety of

2- to 6-year-old patients for laceration repair. The group that received midazolam and N_2O 50% continuous flow during the procedure had fewer adverse effects and a shorter recovery time, and the N_2O was more effective in reducing distress than midazolam alone (Luhmann et al., 2001). Because the ED is a busy department, having a shorter recovery time, fewer side effects, and less distress will increase patient satisfaction and decrease the length of stay, the researchers concluded (Luhmann et al., 2001). In another study, Burnweit et al. (2004) administered N_2O to 145 subjects, 1 year of age to 20 years of age, for minor procedures such as cyst removal, incision, and drainage of abscesses, and foreign body removal. They concluded that N_2O is an effective analgesia alternative for minor surgical procedures in place of conscious sedation or general anesthesia (Burnweit et al., 2004). Other benefits included high staff, patient, and parent satisfaction and cost-effective N_2O administration that required no postprocedural monitoring (Burnweit et al., 2004).

Local Background and Context

The ED site for the project has 30 beds and a daily census of more than 200 patients. The patients seen in the ED on a daily basis present with abdominal pain, flank pain, orthopedic injuries, falls, sports injuries, stroke, acute myocardial infraction, gunshot wounds, and burns, etc. The procedures performed in the ED are laceration repairs, joint reductions, cast applications, foreign body removal, incision and drainage of abscesses, dilation and curettage, ingrown toenail removal, central line placements, and lumbar punctures. The hospital pharmacy sends every provider's opioid use list every month and is asking providers to reduce the use of opioids. A pregnancy test is

mandatory before prescribing NSAIDs for every childbearing age female and providers have to be very careful when prescribing NSAIDs to patients who are 60 years of age and older can be used for any age group and gender and has been used elsewhere for pain relieve in the common patient presentations seen in the ED and the frequently performed procedures. High concentration N_2O for children age 1 year or older for minor procedures in the ED can be administered by trained nurses (Frampton, Browne, Lam, Cooper, & Lane, 2003).

Role of the DNP Student

In developing the project, I have been involved as the project leader. I performed the following project activities: the systematic review of the literature to generate evidence for using N_2O in managing pain in ED patients, synthesized the collected information, and developing a report containing conclusions from my analysis of the literature search findings. I am excited to present the findings of my review to the ED committee who will decide whether to pilot a program of N_2O use in the ED.

Role of the Project Team

The project findings will be discussed with the ED interdisciplinary team, which included physicians, nurses, the administrator, the manager, and pharmacists. The findings of the project will be discussed during the ED provider monthly meeting first and then in the ED staff meeting. The project findings also will be discussed in the pharmacy/anesthesia meeting if there is ED provider and ED staff support.

Summary

Untreated pain can cause patient and family stress and dissatisfaction and can delay healing. This project will be an opportunity for me and my colleagues in the ED to consider use of an alternative method of pain control, which has been tested for many decades and is used commonly in European countries. Studies have shown N_2O is an effective pain control alternative that is also cost effective. The effect of N_2O is fast and patients can control the use themselves. Additionally, nurses can be trained to administer N_2O, which will have a direct effect on the affordability of N_2O use in the ED.

Section 3 provides an overview of the collection and analysis of evidence used in support of the project and the PRISMA steps for the systematic literature review.

Section 3: Collection and Analysis of Evidence

Introduction

The project approach was a systematic review of the literature related to N_2O and its use in pain management in the ED setting. I reviewed existing literature to generate evidence of the applicability and effectiveness of using N_2O in managing pain among patients in the ED. I report the findings (see Section 4) using the format of the PRISMA checklist (Liberati et al., 2009).

Practice-Focused Questions

I developed three practice-focused questions to guide the process of generating evidence for the project. The questions were the following:

1. Among ED patients, in what situations can N_2O be recommended for acute pain management?
2. Among ED patients, what is the effectiveness of inhaled N_2O in managing pain?
3. Among ED patients, what are the benefits of and barriers to N_2O use?

Sources of Evidence

The project was a systematic review of the literature related to use of N_2O in the ED to reduce pain. No human subjects were involved in the data collection. I obtained Walden University IRB approval prior to initiation of the project (IRB approval number 10-30-19-0469906). The selected five studies were evaluated critically for processes and procedures relating to the use of N_2O for managing pain, as well as the known benefits and the potential barriers of its use. I also assessed the quality of the studies for

establishing the appropriateness and effectiveness of the interventions of N_2O use. The information extracted from the studies was used to achieve the purpose of the project.

I derived the evidence in support of the project from a systematic review of the literature published between 2000 and 2019. The search strategy is reflected in the PRISMA flowchart (see Appendix B). The evidence is presented in an evidence table (see Appendix C). The findings from the analysis of the evidence are presented in Section 4.

Published Outcomes and Research

I performed an extensive literature search in different databases to generate information relating to N_2O and its use in pain management in the ED. The search was customized to focus on the benefits, barriers, and positive or negative effects of using N_2O in managing pain in patients. The information was sourced from the following databases: EBSCOhost, MEDLINE, CINAHL Plus, the Database of Abstracts of Effectiveness, and the Cochrane Database of Systematic Reviews. The terms used during the search were *N_2O*, *pain management*, *ED*, *acute care*, *benefits*, and *barriers*. Different terms were combined using Boolean operators to refine the search results. The combined terms included *N_2O* AND *pain management*, *N_2O* AND *ED*, *N_2O* AND *benefits*, and *N_2O* AND *barriers*. The total number of studies identified in the literature across all the databases was 252 (see Appendix B). No studies were obtained from sources other than the listed databases. After sorting the returned studies to remove duplicates, only 83 articles were left. Screening the identified studies for eligibility resulted in the exclusion

of 47 articles. Of the remaining 36 studies, only five attained the threshold for being included in the qualitative synthesis.

Inclusion and exclusion criteria. I assessed the studies obtained from the literature search for eligibility using preset inclusion criteria. The inclusion criteria were that the articles had to have been (a) published in English, (b) available in full text, (c) peer reviewed, and (d) published between 2000 and 2019. Articles that did not address the use of N_2O for managing pain in the ED or acute care or the benefits or barriers to use were excluded from the review.

Analysis and Synthesis

Instances of patients in acute care experiencing excruciating pain are inevitable. The evidence from the literature search identified acute care settings including labor units and the ED in hospitals as places where N_2O can be used (Collins et al., 2012; Frampton et al., 2003; Herres et al., 2016,). The patients in these units are prone to experiencing intense pain that, if left to persist for long, can result in adverse events (Collins et al., 2012). Therefore, numerous strategies for mitigating pain have been developed by providers such as use of various medications (NSAIDS, opioids,). Inhaled N_2O is among the strategies used to relieve pain in these patients. The medication is administered by placing a gas mask on the face of the patient and having the N_2O released either constantly or intermittently (Collins et al., 2012). The effects of the medication can be felt within 30 to 50 seconds of administration (Collins et al., 2012).

For women experiencing labor, inhaled N_2O has been found effective for relieving pain to aid in treating delivery-related injuries such as laceration repair, uterine

curettage, and manual removal of the placenta (Collins et al., 2012; Dammer et al., 2014; Frampton et al., 2003). Both patients and care providers have endorsed the medication because it is less invasive than other pain relief medications and it is effective. Studies by Frampton et al. (2003), Herres et al. (2016), and Liu et al. (2018) have also shown that N_2O is an efficacious analgesic for relieving pain in patients in the hospital such as the cancer unit or the ED in trauma relating to intense injury such as extreme burns.

The barriers associated with the use of N_2O comprise limited availability of delivery equipment and lack of skills and knowledge by some care providers to monitor and regulate the administration of the medication (Collins et al., 2012; Dammer et al., 2014). Worthy of consideration are the growing reports of N_2O use as a recreational drug (Garakani et al., 2016. Its popularity is a result of its induction of euphoria, widespread availability, and its low cost (Garakani et al., 2016). Increasingly, rehabilitation centers are seeing admissions for N_2O drug use (Garakani et al., 2016).

The findings from the selected sources of evidence on the use of N_2O in relieving pain and related benefits and barriers indicated that the medication is an effective analgesic (Collins et al., 2012; Dammer et al., 2014; Frampton et al., 2003; Gao et al., 2018; Liu et al., 2017). Research reports indicating that inhaled N_2O as a labor analgesia is associated with improved outcomes for both the mother and the child can be used to facilitate the incorporation of the medication in actual practice. Inhaled N_2O has also been shown to be effective in managing pain in patients in the ED with burn injuries and chronic disease pain such as pain in advanced cancer (Gao et al., 2018; Liu et al., 2017). In addition, the general acceptance for the medication by women undergoing labor and

their care providers following the assessment for individual experience and satisfaction in the procedure forms a basis for integrating the use of inhaled N_2O in the delivery process (Dammer et al., 2014). Therefore, there is a possibility of increased adoption of the use of inhaled N_2O as an analgesic in some acute care hospital settings in place of the alternative approaches such as opioids, which have been shown to have addictive properties that can trigger other complications (Volkow & Collins, 2017). However, recent evidence describes drug abuse and addiction in N_2O use as well, thus provider need to have extensive knowledge N_2O use, its side effects, and potential abuse (Garakani et al., 2016).

Summary

I used a systematic review of the literature approach to generate evidence relating to the use of N_2O in pain management in ED settings. The evidence was generated and reported using the framework of the PRISMA checklist. The extensive literature search yielded a total of 252 studies, of which five were incorporated into the synthesis (see Appendix B).

Section 4: Findings and Recommendations

Introduction

In this section, I present the findings from the literature collection, analysis, and synthesis. I evaluate the resulting information in relation to the impact on actual practice. Recommendations for facilitating the implementation of the intervention are proposed. A discussion of the strengths and limitations linked to the project activities is also presented.

Findings and Implications

The critical evaluation of the selected articles led to the categorization of the information in the studies into three distinct situations where N_2O can be utilized for pain control. The situations comprise (a) pain control during labor, (b) pain control in the ED for cancer and trauma patients in excruciating pain, and (c) pain control for pediatric patients during painful procedures. The evidence from the five studies is presented in this subsection.

Nitrous Oxide for Pain Relief of Women in Labor

Collins, Starr, Bishop, and Baysinger (2012) discussed the use of N_2O in managing pain during labor. The authors indicated that the use of inhaled N_2O as an analgesic has not been implemented extensively in the United States. A review of existing literature indicated that N_2O could be used by women in during the first, second, and third stages of labor or to facilitate the administration of an epidural (Collins et al., 2012). In addition, the medication can be administered during postdelivery before performing procedures such as manual removal of the placenta, laceration repair, or

uterine curettage (Collins et al., 2012). Patients self-administered the medication by holding a gas mask against their noses and the gas was released intermittently. The medication has a rapid onset of between 30 and 50 seconds (Collins et al., 2012). Medical reports have noted that laboring women experience relief when they inhale N_2O approximately 30 seconds before the start of contractions (Collins et al., 2012). The use of the medication has been associated with safe outcomes for both the mother and child (Collins et al., 2012). The major barrier to the extensive use of N_2O in the United States is the scarcity of the required delivery equipment (Collins et al., 2012).

Dammer et al. (2014) conducted a study to investigate the acceptance of the inhaled N_2O analgesia among midwives and pregnant women during labor. Several women who went into labor were requested to use the inhaled N_2O for pain relief during the time study was being conducted (Dammer et al., 2014). After delivery, the women and the nurses who facilitated the process were assessed for their experience and satisfaction with the procedure through a face-to-face interview (Dammer et al., 2014). The findings from the assessment indicated that the use of N_2O in relieving pain during labor was accepted by both delivering mothers and their midwives (Dammer et al., 2014). One of the concerns raised during the study was investing in the training of care providers to equip them with skills for monitoring and controlling the self-administration of N_2O by patients during treatment (Dammer et al., 2014). Dammer et al. also recommended that the medication could be used in the treatment of birth-related injuries.

Nitrous Oxide for Pain Relief in the ED

Liu et al. (2018) conducted a study to assess the analgesic effect of using N_2O for mitigating breakthrough pain in adult patients with cancer. Patient satisfaction is very crucial in the ED, since pain is the very common compliant of the patients come to ED if not managed properly can cause dissatisfaction. Herres et al. (2016) conducted a nonblinded observational study to evaluate the analgesic effectiveness of a self-administered and self-contained N_2O device and to assess patient and staff satisfaction in patients of a busy ED. Frampton et al. (2003) conducted a prospective descriptive study over 12 months in the ED of the Children's Hospital at Westmead. The study was done on 224 subjects undergoing minor procedures such as intravenous catheter insertion, dressing change, wound repair, urinary catheter insertion, fracture manipulation, joint dislocations, in pediatric patient over 12 months of age (Frampton et al., 2003). A 70% high concentration nitrous oxide was administered by trained nursing staff (Frampton et al., 2003). Frampton et al. reported that nitrous oxide was a safe and effective analgesia for patients older than 1 year of age. They found that 73.2% of pediatric patients did not have any complications (Frampton et al., 2003). The other observational study done by Herres et al. included 85 patients 18 years and older who came to the ED with moderate to severe pain and who received self-administered 50% N_2O through a portable delivery device. The results showed significant pain score reduction from baseline (Herres et al., 2016). The subjects, nurses, and physicians were satisfied with the use of N_2O (Herres et al., 2016). The evaluation of total time for the gas administration, the pace with which patients attained relief from pain, the safety related to physiological parameters and

adverse events, and the satisfaction and acceptance of the procedure by both patients and health care professionals indicated that the medication was an effective analgesic for managing pain in cancer and trauma patients in EDs (Frampton et al., 2003; Herres et al., 2016; Liu et al., 2018).

Recommendations

In facilitating the implementation of inhaled N_2O as an analgesic in ED settings, several recommendations have been made to ensure accuracy in translating the intervention into practice. A major recommendation from this project is to have care providers adhere to a procedural analgesia and sedation nursing guideline for administering inhaled N_2O in the ED. For example, a guideline from the Royal Children's Hospital Melbourne provides information on the delivery method; contraindications to use (severe cardiac disease, severe psychiatric disorders, head and neck procedures with cautery, pneumothorax, first trimester pregnancy, and critically ill patients); and nursing actions related to monitoring effectiveness. Adhering to the guideline will ensure precision in administering inhaled N_2O and thus improve patient outcomes.

There are many appraisal tools available to ensure that clinical practice guidelines are systematically developed statements that help practitioners to improve health care processes and patient outcomes (Siering, Eikermann, Hausner, Hoffmann-Eßer, & Neugebauer, 2013). To implement the use of N_2O in the ED, I recommend using *The Appraisal of Guidelines for Research and Evaluation instruments (AGREE)* tools (Brouwers et al.,2010). The AGREE II tools are the most comprehensive, validated guideline appraisal tools available (Brouwers et al.,2010). It is critical when selecting or

developing a guideline for clinical practice to use appraisal tools to assess the methodological quality and the integrity of the guideline's development (Siering et al., 2013). AGREE II tools and support are available online and can facilitate developing and evaluating guidelines. The AGREE II assesses 23 items in six domains and is used by health care providers, guideline developers, policy makers, and educators (Brouwers et al., 2010). The AGREE II tools and training will be using in selecting a guideline or developing a new guideline for implementing N_2O pain control in the ED to adopt the recommendation based on results of this project.

Strengths and Limitations of the Project

The approach used in the implementation of the project was prone to both strengths and limitations. The strength of the project was that the evidence generated is credible and overcame the limitation of results from a single study examining the efficacy of N_2O in managing pain in patients. However, the evidence is limited and only one randomized controlled study was identified, and it related to cancer pain in adults and not pediatric or procedural pain presentations in the ED. According to Peterson et al. (2014), ranking evidence from research based on the quality of the design, applicability to patient care, and validity is useful for establishing interventions that can be replicated in practice. In addition to the limitation inherent in the low quantity of applicable articles identified, the level of evidence (one Level II study, two Level VI studies, and two-Level VII study) was low (Melnyk. Using the American Association of Critical Care ranking, the evidence is between a "B" and a "C" level, which means that the strength of the evidence is borderline for translation into practice. Additional limitations in the reviewed articles

were (a) no clarification of how publication bias was addressed and (b) no conflict of interest declared.

The N_2O should be used with caution due to its potential for abuse. The study done by Garakani et al. (2016) reported N_2O abuse case numbers are increasing especially in last decade and this is a significant public health concern. The recreational use of N2O is very dangerous and can cause neurotoxicity and death. There were 29 deaths reported due to N_2O abuse and in most cases a mask or plastic bag was used, which was connected to the tank. The author stated that N_2O abuse is underreported. The 2014 Global Drug Survey (GDS) results confirmed that N_2O is the eighth most common substance used as a recreational drug in clubs and festivals in United Kingdom and Unites States and the method of delivery is N_2O filled balloons. N_2O inhalation caused hallucination, confusion, and accidental injuries (Karr et al., 2016).

Summary

The generated evidence indicated the inhaled N_2O could be used in labor and in EDs to relieve pain in some patients. Two studies demonstrated the effectiveness of using N_2O to aid in treating the injuries resulting from delivery. Findings from the two other studies demonstrated the applicability and effectiveness of using N_2O to mitigate pain (both procedural and nonprocedural) in patients in the ED. In these applications N_2O has been associated with improved patient outcomes. Additionally, few recent articles have demonstrated how N_2O can be integrated into ED care for pediatric and adult patients presenting with pain or likely to be exposed to procedural pain. Therefore, evidence for the applicability and effectiveness of N_2O for mitigating pain in patients experiencing ED

pain is limited and N_2O should be implemented with caution following international administration guidelines such as those developed by The Royal Children's Hospital Melbourne (2019).

The answers to project questions project questions as synthesized from the systematic review of the literature are:

1. *Among ED patients, in what situations can N_2O be recommended for acute pain management?*

The systematic literature review answer to first project is nitrous oxide can be used for acute pain management in pediatric and adult patient populations for procedural pain, cancer pain, and labor pain. Nitrous oxide is safe and effective in controlling the pain but should be used with caution. N_2O can be used for pediatric and adult patients for minor procedures such as cyst removal, incision and drainage of abscesses, and foreign body removal. The conclusion was N_2O is an effective analgesia alternative for minor surgical procedures in place of conscious sedation or general anesthesia. Staff, patient, and parent satisfaction were high. N_2O administration was also cost effective and required no postprocedural monitoring.

The second project question:

2. Among ED patients, what is the effectiveness of inhaled N_2O in managing pain?

The answer to above question is N_2O is effective in relieving pain. Many studies have shown the use of N_2O is very safe and effective in controlling pain but should be used with caution because there are reports of abuse and deaths related to N_2O abuse.

Nursing staff and physicians should be well educated and should understand the pathophysiology of pain and N_2O pathways to fully understand the use of N_2O for pain control.

3. Among ED patients, what are the benefits of and barriers to N_2O use?

The benefit of N_2O use is that it is very fast acting, cost effective, can be administered by trained nurses, and patients can have control while using it. The review of literature showed that N_2O can be effective in managing pain but should be used with caution. However, extensive implementation of N_2O use in the ED has been barred by factors such as nursing staff and physician lack of knowledge of pain pathophysiology, lack of skills to use the technique, and scarcity of the delivery equipment. The abuse of N_2O can be another barrier in implementing the drug into daily ED practice.

Section 5: Dissemination Plan

Introduction

The implementation of the DNP project provided answers to the practice-focused questions. Inhaled N_2O is an effective analgesia for managing pain in patients in labor and those in the ED with excruciating pain. Inhaled N_2O has been associated with improved outcomes and acceptance by both patients and care providers because it is less invasive yet effective than other pain medications (Collins et al., 2012, Frampton et al., 2003).

Dissemination Plan

Results from research studies have to be shared with the relevant audience for effective and extensive translation into practice to ensure improved outcomes (World Health Organization, 2014). Numerous platforms have been designed to facilitate the sharing of research findings. For this project, the results can be disseminated by developing a policy brief--a short document, usually two to four pages long, containing the findings and recommendations of a research study to a non-specialized audience (World Health Organization, 2014). Also, the findings may be published in a peer-reviewed journal such as the *Journal of Emergency Medical Services* or *Reviews in Obstetrics and Gynecology* to ensure access by people from different parts of the world (World Health Organization, 2014).

Analysis of Self

N_2O use for acute pain management in the ED is a new concept in the United States. Before this project, I did not have any knowledge about N_2O and its use in ED

medicine. After a systematic review of the literature, I gained extensive knowledge about N_2O related to its use, side effects, pathophysiology, and so forth. If the recommendations and findings of the project are adopted by the ED staff at the project site, patients in acute pain may be helped tremendously. Nitrous Oxide is being abused, people use as recreational drug which is very dangerous and can cause death (Garakani et al. (2016) and before this project, I was unaware of the abuse of N_2O and the rehabilitation centers that have been established for patients who are abusing the drug.

The journey of the DNP program from start to finish was one of my life's significant achievements and will be a great boost, I anticipate, to my career and my life. I gained a depth of knowledge about research, how to evaluate the literature, and how to search databases for evidence. Obtaining the highest degree in nursing was my dream since the start of my nursing career. I was not sure if I made a right decision to pursue the DNP, but the knowledge I gained from the program and the DNP project helped me to become a better clinician, educator, and researcher. The program has been life changing by significantly increasing my confidence as a clinician, an educator, and as a nursing leader.

Summary

Managing pain in patients has become a crucial concern in health care because it affects the treatment outcomes of individuals. Various approaches have been developed to assist in relieving pain. The approaches comprise administration of opioids, NSAIDs, and inhaled N_2O (Frampton et al., 2003; Herres et al., 2016; Liu et al., 2018).

Although the medications all have been shown to be effective in relieving pain, they have been associated with adverse complications, including opioids due to their intrinsically self-reinforcing properties (Frampton et al., 2003; Herres et al., 2016; Liu et al., 2018). Therefore, I undertook this project to investigate the applicability and effectiveness of using inhaled N_2O to manage pain in patients in the ED. The findings from the project have shown N_2O to be an effective analgesic for managing pain in some the ED patient presentations. But there is risk of abuse associated with N_2O use. The findings will be communicated to the target audiences through a policy brief and possibly a peer-reviewed journal article. With proper use, N2O may lessen patient's pain, however, in a safe manner, resulting in improved outcomes for patients and their families and the United States health care system.

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Appendix A: PRISMA Checklist (Liberati et al., 2009)

Title

1. Establishing whether the report is a meta-analysis, systematic review, or both.

Abstract

2. Providing a structured summary of the issue being investigated.

Introduction

3. Providing a rationale for the review based on what is known.
4. Stating the objectives of conducting the review with reference to project participants, intervention, comparison, outcomes, and research design.

Methods

5. Indicating whether a review protocol exists and how it can be accessed.
6. Specifying the characteristics of the study and resulting reports.
7. Providing a description of the information sources used in conducting the search.
8. Presenting the electronic search strategy used in at least one major database.
9. State the process of isolating studies to be incorporated in the review.
10. Describe how data were extracted from the reports.
11. Identify the quality indicators and any assumptions and simplifications made.
12. Describe the approaches used to assess the risk of bias in individual studies.
13. State the outcomes of primary interest.
14. Outline the planned strategies for conducting data analysis.
15. Specify any potential risk of bias that can affect the cumulative evidence.
16. Specify other methods of additional analyses.

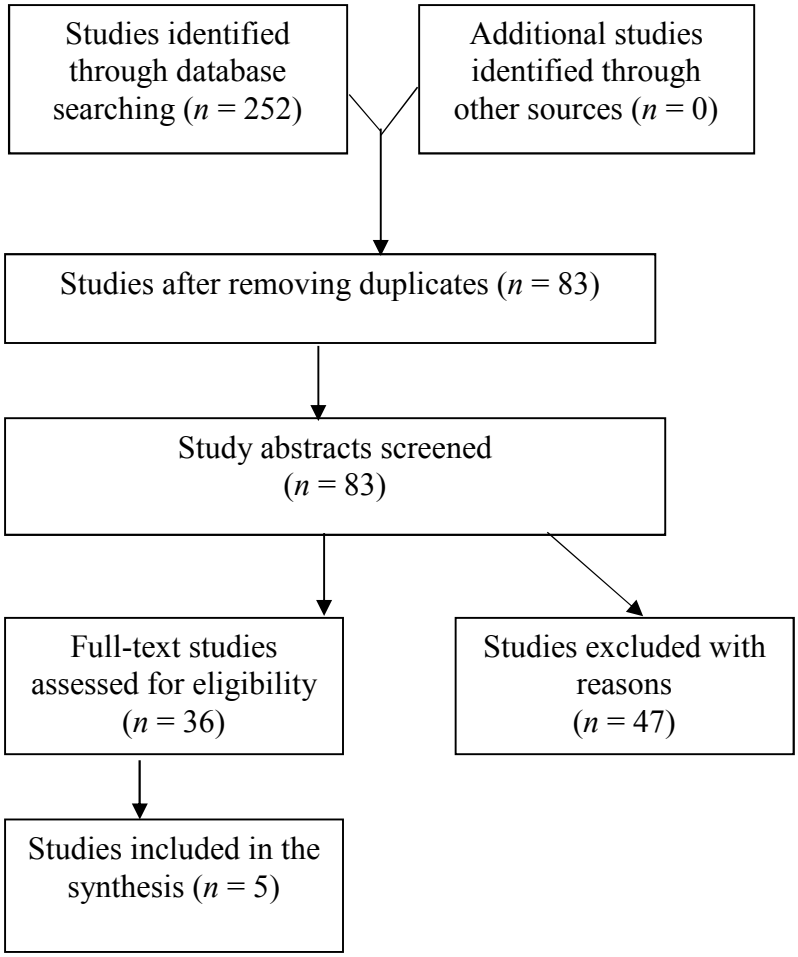
Results

17. Provide numbers of studies screened and assessed for eligibility.
18. Present the characteristics of data extracted from each study.
19. Provide data on the risk of bias for each of the selected studies.
20. Present a summary of the findings of individual studies.
21. Perform a synthesis of all the findings.
22. Specify potential risk of bias for the synthesized evidence.
23. Provide results of any additional analyses.

Discussion

24. Summarize the main findings.
25. Identify any limitations of the study and outcome level.
26. Provide a general interpretation of the results.
27. Identify any sources of funding or support for the project (Liberati et al., 2009).

Appendix B: PRISMA Flowchart Illustrating the Literature Search Process



Appendix C: Evidence Included in the Synthesis

Citation						
Purpose	Population/ Sample Size (*n*) /Setting	Design	Variable/ Instrument Used	Results	Nursing Implication	Level of Evidence (I–VII) and Intervention Effectiveness
Collins, M. R., Starr, S. A., Bishop, J. T., & Baysinger, C. L. (2012). Nitrous oxide for labor analgesia: Expanding analgesic options for women in the United States. *Reviews in Obstetrics and Gynecology, 5*(3-4), e126. Retrieved from https://www.ncbi.nlm.nih.gov/mc/articles/PMC3594866/'						
Study of protocol for use of N_2O for labor pain management		Hospital protocol study	Review of the literature and hospital protocol	N_2O is used in other countries but there is limited use in the US. There is a need for a protocol to increase use of N2O		Level VII Effective
Dammer, U., Weiss, C., Raabe, E., Heimrich, J., Koch, M. C., Winkler, M., ... & Kehl, S. (2014). Introduction of inhaled nitrous oxide and oxygen for pain management during labour–evaluation of patients' and midwives' satisfaction. *Geburtshilfe und Frauenheilkunde, 74*(07), 656-660. doi:10.1055/s-0034-1368606						
To investigate the acceptance of inhaled nitrous oxide /oxygen by midwives and women during labor	*n* = 66	Observational study		Nitrous oxide and oxygen is effective for pain management during labor and accepted by patients and mid-wives		Level VI Effective

(*table continues*)

Citation

Purpose	Population Sample Size (*n*) /Setting	Design	Variable/ Instrument Used	Results	Nursing Implication	Level of Evidence (I–VII) and Intervention Effectiveness
Liu, Q., Gao, L. L., Dai, Y. L., Li, Y. X., Wang, Y., Bai, C. F., ... & Zhang, Y. J. (2018). Nitrous oxide/oxygen mixture for analgesia in adult cancer patients with breakthrough pain: A randomized, double-blind controlled trial. *European Journal of Pain*, *22*(3), 492-500. doi:10.1002/ejp.1144						
To assess the analgesic efficacy of fixed inhaled N_2O/O_2 mixture for adult cancer patients with break-through pain.	*n* = 240 cancer patient 18 years and older	Double-blind, placebo-controlled, randomized clinical trial		Results showed self-administration decreased moderate to severe break-through pain in cancer patients with low incidence of side effects		Level II Effective
Herres, J., Chudnofsky, C. R., Manur, R., Damiron, K., & Deitch, K. (2016). The use of inhaled nitrous oxide for analgesia in adult ED patients: A pilot study. *The American Journal of Emergency Medicine*, *34*(2), 269-273. doi:10.1016/j.ajem.2015.10.038						
The study evaluated analgesic effects of self-administered N_2O in ED patients. Also assessed patient and staff satisfaction.	*n* = 85	Observational study		The study results show effectiveness of nitrous oxide use in managing pain in ED patients. The staff, patients, and physicians were satisfied with its use.	The device was easy to use	Level VI Effective

(*table continues*)

Citation						
Purpose	Population Sample Size (*n*) /Setting	Design	Variable/ Instrument Used	Results	Nursing Implication	Level of Evidence (I–VII) and Intervention Effectiveness
Frampton, A., Browne, G. J., Lam, L. T., Cooper, M. G., & Lane, L. G. (2003). Nurse administered relative analgesia using high concentration nitrous oxide to facilitate minor procedures in children in an emergency department. *Emergency Medicine Journal*, *20*(5), 410-413. doi:10.1136/emj.20.5.410						
To describe using high concentration of N_2O analgesia administered by trained nursing staff in pediatric patients under-going minor procedures in the ED and to demonstrate N_2O safety.	*n =224*	Prospective descriptive study		N_2O is safely administered by trained staff in patients 1 year or older for minor procedures in ED	Nurses can be trained to administer N_2O.	Level VI effective