Noise Pollution in the Operating Room

Chimene Mathurin, BSN, RN, CCRN

Jeremy Pastor, BSN, RN

Project Mentor: Danny Jijon, MSNA, CRNA: USAP-Florida

Project Chair: Alescia L. DeVasher Bethea, Ph.D., CRNA

MSNA Nurse Anesthesia Program, AdventHealth University

February 24, 2019

Abstract

Anesthesia providers have a responsibility of maintaining safe environments for both patients and themselves. This includes minimizing potential distractions that can result from noise pollution within the operating room. The literature review examined the different causes of noise pollution in the operating room and revealed multiple effects that it has on anesthesia providers. Potential solutions, including a behavior modification process to counteract the harmful effects of noise in the operating room, were heavily promoted throughout the literature. As noise levels in the operating room continue to increase, it is imperative that student registered nurse anesthetists (SRNAs) be educated on the definition of noise and its implications for work. The objective of this project was to enhance the knowledge base of 21 SRNAs for future clinical encounters. The AdventHealth University MSNA Nurse Anesthesia Program (AHU NAP) SRNA Cohort of 2019 was educated with a 30-minute PowerPoint presentation on the implications of noise for their clinical practice. A ten-item questionnaire was administered before and after the educational presentation to determine any increase in the participants' knowledge base. A correlation between scores utilizing statistical software determined that an increase in the knowledge base of the SRNAs was achieved. Noise pollution education was successfully implemented and resulted in an increase in SRNA knowledge base. Noise pollution in the operating room is relevant to the anesthesia profession. Therefore, a thorough understanding of noise pollution etiology, risk factors, incidence, prevalence, evidence-based prevention and treatment, may be advantageous in possibly reducing its occurrence.

Table of Contents

Noise Pollution in the Operating Room

Introduction

It is essential to define and examine operating room (OR) noise levels and its effects on all personnel in the operating room, especially anesthesia providers. Noise levels above federal standards can interfere with accurate communication, patient safety, and even the incidence of surgical site infections (Kurmann et al., 2011). As emphasized in the recent literature, noise pollution in the OR is a clinical problem locally and globally due to its negative impact on patient safety and surgical suite environments (Ginsberg et al., 2013; Hasfeldt, Laerkner, & Birkelund, 2010). Increased occurrence of patient harm occurred when noises surpassed recommended safe levels in the OR due to ineffective communication, impaired hearing capabilities, and decreased attentiveness (Way et al., 2013).

Anesthesia providers are required to perform visually oriented actions while attentively listening for changes in patients' vital signs through auditory monitoring. The effects of divided attention and volume of contending information on patient monitoring, such as distinguishing auditory changes from pulse oximetry in arterial oxygen saturation, are significant concerns in operating room environments. Audible noise concentration in the OR averages 77 dB(A), with incidences that can reach 100 dB(A) (Stevenson, Schlesinger, & Wallace, 2013). These high levels of noise concentrations have been shown to hinder anesthesia providers in their ability to perform cognitive tasks (Katz, 2014).

Student registered nurse anesthetists (SRNAs) entering different surgical areas of clinical anesthesia practice, such as cardiac, neurosurgery, organ transplantation, and orthopedics, are exposed to various OR noise levels. With this variety of experiences, they are tasked with providing anesthetic care in high-stress situations where critical thinking and clear communication are necessary. Adequate knowledge of how to effectively prevent excessive noise levels will be vital as SRNAs adapt to become contributing members of the intraoperative team.

Two questions in PICOT format directed the scholarly project. The first question addressed the clinical problem and guided the literature review: In operating room personnel participating in surgical procedures (P), how do routine surgical-related noises (I) influence critical thinking (O) during the performance of effective clinical care (T)? The second question addressed the project intervention: When quantified by a pre-test and post-test, how much does the knowledge of noise effects on operating room personnel increase (O) after a 30-minute PowerPoint presentation (I) for student registered nurse anesthetists at Adventist University of Health Sciences (P)?

Literature Review

Background

Noise can be defined as any unwanted sound that interferes with normal hearing, irritates or interrupts performance, and is stressful physiologically and psychologically (Kam, Kam, & Thompson, 1994). Noise can be categorized as fluctuating, random, unharmonious waveforms that interrupt desired signals. Sounds are measured on a decibel dB(A) scale, which is a frequency-weighted scale screening out frequencies below 1 kHz. Pitch is determined by the frequency and is measured by the number of cycles per second (Hz). While most sounds in everyday life are between 60 and 6000 Hz, the average person perceives sounds within a frequency range of 20 to 20,000 Hz (Kam et al., 1994). The different forms of noise include pure tones (e.g., siren), narrowly banded frequencies (e.g., steam hiss), broad-banded frequencies (e.g., static radio), impacts (e.g., hammer strike), or impulse (e.g., gunshot). They can also be continuous, intermittent, or fluctuating (Kam et al., 1994).

Duration, phase, and rate of repetition determine the characteristics of sound. Low-frequency sounds are physiologically less damaging than high-frequency sounds. Although the human ear adapts to constant noises, it may be disturbed by intermittent noises such as ringing telephones. Sounds in the frequency range of 2000-8000 Hz are perceived as being 10-20 dB(A) noisier than those outside the same range with similar intensity. Typical examples of noises and their decibel levels are summarized in Table 3 (Appendix A).

Along with water and air pollution, noise has been labeled as the "third pollution" which deserves equal focus for prevention (Shapiro & Berland, 1972). Possible noise pollutions during surgery come from healthcare provider communication, surgical tools, and elective music (Way et al., 2013). Noise pollution negatively impacts both working environment and patient safety in the OR (Ginsberg et al., 2013; Hasfeldt et al., 2010). Concerning morbidity and mortality, miscommunication was mentioned as the causative aspect of 43% of errors which gave rise to lasting disability or death (Gawande, Zinner, Studdert, & Brennan, 2003). According to Gawande et al. (2003), over 50% of surgery-related adverse events are avertable. Consequently, a reduction in noise levels may improve communication, potentially preventing patient mortality and morbidity in 43% of surgical cases (Gawande et al., 2003; Way et al., 2013). When noises exceed recommended safe levels in the OR, surgical staff may experience miscommunication, hearing loss, and decreased concentration, which result in patient harm (Way et al., 2013).

Occupational Regulations of Noise Limits

The following noise exposure regulations were organized with hearing protection and practicality in mind. As mandated by the Occupational Safety and Health Administration (OSHA), accepted noise levels span from 90 dB(A) for 8 hours to only 15 minutes of exposure at 115 dB(A) (Ginsberg et al., 2013). Similarly, the National Institute for Occupational Safety set guidelines for spontaneous noises so that peak levels should not be more than 140 dB(A) (Katz, 2014). The Environmental Protection Agency (EPA) set sound regulations between 35 to 45 dB(A) for ambient OR noises, although these are considered to be below the dB(A) level of regular conversations (Mazer, 2012). Even without the addition of music, current research shows that OR decibel levels exceed these limits set by various organizations (Shambo et al., 2015). For example, during a routine cholecystectomy, Shapiro and Berland (1972) reported noise levels of 85 dB(A) within the operating room and 108 dB(A) during non-specified major surgery. Although the cholecystectomy complied with OSHA guidelines, it exceeded the parameters set by the EPA (Mazer, 2012), and it would be considered as loud (refer to Table 1).

Although many articles cite noise level recommendations from the EPA, they are considered irrelevant due to their unenforceable nature and unpopularity. Also, noise levels were only measured by their sound pressure levels. According to Mazer (2012), the listener ultimately determined sound as noise, regardless of its decibel level. Therefore, noise is a subjective matter. For example, lowering the volume of an annoying sound does not eliminate the physiologic stress it causes on the healthcare provider. The context of the sound is more relevant than the actual volume that is heard (Mazer, 2012).

Causes of Noise Pollution

According to Way et al., (2013), noise pollution in the OR can be categorized into two groups: staff-related or equipment-related. Verbal and telephone conversations, music, opening and closing of doors are all associated with OR staff and may account for up to 78 decibels alone (Katz, 2014; Way et al., 2013). One significant contribution to staff noise is the need for precise communication. Conversing accurately requires staff to speak louder, sometimes even 10-15 dB(A) over the background noise source (Hogan & Harvey, 2015). The effect of team-related noises was measured by Hasfeldt et al. (2010), which found that 95% of noise in the OR is staff associated. Equipment related noises include surgical instruments, alarms, monitors, and suction.

Altogether, equipment can reach a peak noise level of 120 dB(A), with specific surgical instruments reaching 131 – 140 dB(A) (Way et al., 2013). However, even with the absence of staff or equipment noises, the OR itself has background noise that provides a baseline level of 13 dB(A) (Kam et al., 1994). High capacity air conditioners and other ambient sounds contribute to this baseline (Katz, 2014). Due to smaller room size and the consistency of materials used in the OR, noises take longer to dissipate and thus contribute to noise levels that sometimes reach 40 dB(A) over federal regulations (Katz, 2014; Shambo et al., 2015).

Music as a Potential Distractor

Even without the addition of music, average noise levels in ORs routinely exceed the industry acceptable standards of occupational noise levels (Katz, 2014). Although precise music levels in the OR have yet to be accurately measured, they can be inferred to be as high as 87 decibels (Katz, 2014). Unlike other types of inevitable forms of noise within the OR, music is a choice (Shambo et al., 2015). The incidence of music in the OR has been reported to be quite pervasive, with over 60 to 70 percent of personnel reporting they like to listen to music in the OR, and nearly 50 percent like music to be at medium to high levels (Way et al., 2013).

Several studies have set out to show the controversial role of music in the OR. According to Way et al. (2013), some types of music have been shown to decrease stress and improve the surgeon's efficiency. Music can have a soothing effect in stressful situations and provide some form of anxiolysis to patients before, during, and after surgery (Katz, 2014). However, another study found that auditory processing of communication containing critical information became more difficult in the presence of music (Hogan & Harvey, 2015).

The effect of music can also be seen in technical skills demonstrated by newer surgeons and resident anesthesiologists. Music was shown to have a detrimental effect on surgical performance with novice surgeons, while the more experienced surgeons were able to block out the distraction (Katz, 2014; Kurmann et al., 2011). In a study by Stevenson et al. (2013) on the abilities of anesthesia residents, no adverse effects of classical or self-selected music were seen on different psychomotor exams. This contrasts with an earlier study in which anesthesiologists reported an adverse effect on vigilance and communication with the presence of music (Hawksworth, Asbury, & Millar, 1997). Music seems to have varied effects in the operating room and on different personnel.

Implications for Anesthesia Providers

Anesthesia providers are entrusted with performing a multitude of critical tasks during surgery while optimizing patient safety and comfort (Hogan & Harvey, 2015). Anesthesiology is described as a discipline that demands strict attention to detail, vigilant awareness, and effective communication (Stevenson et al., 2013). Auditory cues, such as alarms from monitors and ventilators, alert the provider to potentially significant changes in the patient and require an immediate response. However, distractions such as background noise can impair or delay provider response to these changes (Katz, 2014). One experiment studied the effect of visual and auditory distraction on anesthesia residents while testing their ability to detect changes in a pulse oximeter. It showed that they were less able to detect changes as visual distractions compounded with increases in noise (Stevenson et al., 2013). If anesthesia providers are unable to hear an alarm or monitor, this can become a significant patient safety issue. With baseline noise levels in the OR reaching between 51 and 75 dB(A), this can be a significant challenge to anesthesia providers to provide safe care (Hasfeldt et al., 2010). The noisiest parts of most non-orthopedic surgeries occur during induction and emergence, which are the most critical moments for providers (Hasfeldt et al., 2010). Disruption during these essential points can diminish the full attention of anesthesia providers, which can lead to unfortunate effects for the patient (Katz, 2014). The majority of anesthesia-related errors do not result from a single disastrous accident, but instead, they are derived from numerous minor mistakes, such as failing to notice a decrease in oxygen saturation which can swell into a severe event (Stevenson et al., 2013).

Another component of safe anesthesia care requires the use of correct and effective communication with other members of the surgical team. Excessive noise can hinder effective communication and lead to situations that place patient safety in jeopardy, such as hearing the incorrect name or dose for a medication (Way et al., 2013). Beyea (2007) shares how a breakdown in communication between a surgeon and anesthesiologist due to the volume of music and conversations going on at the same time led to a delay in a patient intervention. Excessive noise in the OR has the potential of limiting the full attention of anesthesia providers during patient care and can lead to errors.

Impact on Practice

Anesthesia providers cannot effectively manage OR noises alone; therefore, the surgical team must collaborate in synchrony (Beyea, 2007). Educating healthcare providers will bring awareness to noise-reducing strategies. According to Hogan and Harvey (2015), it is essential to improve the attitude and behaviors of staff members regarding noise awareness. The amalgamation of team motivation and increased consciousness reduced noise stimulation during critical anesthesia phases such as induction and emergence (Ginsberg et al., 2013). Behavior modification programs educate staff members about the potential harm of noise pollution and its sources. This educational program offers solutions to easily remove unnecessary noises from ORs (Katz, 2014).

Collectively, the surgical team dramatically decreased noise levels if they were instructed to avoid unnecessary conversations, turn off music, limit telephone usage, minimize entrance and exit of the operating room, and be mindful of patient anxiety. Anesthesia providers contributed to decreased noise levels if they prepared medical equipment well in advance, carefully placed metallic instruments on hard surfaces, and minimized the opening of drawers. OR nurses assisted with mindful instrument preparation, counted instruments before patients entered the room and before emergence, supervised noise levels, and controlled the unnecessary entrance of staff members (Hogan & Harvey, 2015). Surgeons communicated with their staff which sounds annoyed them, and if it could not be eliminated, they discussed how to reduce its specific noise level, such as lowering oxygen saturation monitor alarm volume (Beyea, 2007).

Although mechanical equipment has a significant impact on noise levels, minor changes can dramatically reduce it: repairing door bumpers, changing wheels, applying insulation to sound-reflective flooring, and installing effective acoustic ceiling tiles to reduce reverberation of unavoidable noise (Mazer, 2012). Strategized placement of noisy equipment, such as speakers, can be applied by placing them further from anesthesia monitors. According to Katz (2014), replacing metallic trays with plastic bowls can minimize the clanging sounds. Implementing an alarm system configuration and testing acoustics in the OR may also decrease noise levels (Mazer, 2012). While small corrective measures could be used at little expense, additional research is required to identify effective strategies to further decrease mechanical equipment noise levels (Katz, 2014).

Contribution and Dissemination/Justification

The AHU NAP MSNA SRNA Cohort of 2019 was selected to be the target population for this proposed study. The cohort comprises of 24 students; however, a maximum total of 21 participated in the pre- and post-test results. Based on the most recent review of the literature, this scholarly project aimed to increase the awareness regarding noise effects on surgical personnel in the operating room. The goal was to increase the cohort's knowledge base on the definition of noise, technical regulations of noise limits, causes of noise pollution, how music is viewed as a potential distractor, implications of noise on anesthesia providers, and noise's impact on practice. Per the project timeline, this presentation was disseminated in the Fall trimester of 2018.

Project Aims

This scholarly project aimed to increase the knowledge base of a select group of SRNAs (AHU NAP MSNA Cohort of 2019) on the topic of noise and its potential for distraction in the operating room. By educating future anesthesia providers, it was hoped that patient safety may improve. The SRNAs were presented with information on the issue in the Fall of 2018 trimester during their Clinical Conference IV class. Immediately before and after a 30-minute PowerPoint presentation, their pre-existing understanding and potential knowledge increase were evaluated using a pre- and post-test (Appendix C & D). Statistical software was utilized to evaluate the scores and ascertain if the project met its aims.

Project Methods

The implementation process began once the Scientific Review Committee and the Institutional Review Board approved the scholarly project. An educational PowerPoint was presented to the AHU NAP MSNA SRNA Cohort of 2019 during the Fall 2018 trimester. Only SRNAs who signed the informed consent form (Appendix B) were utilized for data collection of pre- and post-test scores. If the students did not provide informed consent or failed to complete either the pre- or post-test, their data was excluded from collection and analysis. Professors and other personnel attended the presentation; however, they were not included in the statistical data collection. The PowerPoint presentation consisted of information gathered from the current body of research through the means of a literature review. Each set of tests was correlated with a specific numerical value placed at the top right-hand corner of the pre- and post-test. The numerical system ensured that the pre-test and post-tests being evaluated were completed by the same student. The tests were administered via envelopes with corresponding numbers written on the outside. No personal information from the SRNAs were requested in the tests. The number system functioned as a safeguard to the right to privacy and anonymity for SRNAs. The researchers collected and securely saved all the test results in a password-protected Excel spreadsheet on an encrypted external hard drive. After entering the results from the pre- and post-tests into an Excel spreadsheet, the scores were statistically evaluated by AHU's statistician, Dr. Roy Lukman. After the statistical analysis was complete, the researchers formulated a conclusion for the scholarly project. The goal of this project was to increase the awareness and knowledge about noise effects in the OR for SRNAs who participated in the pre- and post-test process. The data collected for this project was only accessible to the researchers, project mentor, project chair, and AHU statistician via the password-protected file on the encrypted external hard drive. The data will be kept for two years and then destroyed.

Timeline

The literature review and research for this project started in the Summer 2018 trimester. The scholarly project proposal was outlined as information was compiled. Requirements, as outlined in the syllabus, were achieved. After IRB and SRC approval, project implementation and data collection occurred within the Clinical Conference IV course during the Fall 2018 trimester on 11/29/18. Subsequently, the data was analyzed.

Data Collection Plan

On 11/29/18, the researchers implemented the project and collected data from AHU's NAP Cohort of 2019, a convenience sample of SRNAs (n = 21). After acquiring informed consent, a ten-question pre-test assessed their prior knowledge base before the PowerPoint presentation (Appendix F). The researchers ensured that each participant received only one set of questionnaires, in one envelope. A number system was utilized with the pre-and post-tests to protect participant anonymity. The questions assessed their knowledge of decibel sound level standards, OR noise incidences and prevalence, adverse effects of noises on the surgical team, types of OR noises, and evidence-based methods for minimizing noise levels in the OR. A post-test with the same ten questions was administered to the SRNAs immediately after the conclusion of the PowerPoint presentation. There was one exchange for the pre-test and one exchange for the post-test. To ensure accurate results, the post-test was proctored to prevent group collaboration and enforce individual efforts. Data analysis took place once the tests were collected and counted by the researchers. Surrounding the thirty-minute presentation, the SRNAs had ten minutes to complete the pre-test and ten minutes to complete the post-test, which totaled a 50 minutes process.

Evaluation Plan

Evaluation of this scholarly project included a ten-item pre- and post-test, before and after the PowerPoint presentation, respectively. The pre-and post-test for each participant was numbered and matched after collection into a correspondingly numbered envelope. This was to ensure that scores remain paired. Using Microsoft Excel, the paired scores were entered in table format with columns indicating the pre- and post-test scores, respectively, with rows indicating which scores belong to which numbered participant. The scores from the questionnaires for each SRNA were then statistically analyzed using SPSS software. This analysis included whether there is a difference in the pre-test and post-test scores, and if so, if this difference was statistically significant. A paired t-test was the best method to evaluate each matched pair of pre- and post-test scores. The significance level was designated as < 0.05. Data analysis included the mean and standard deviation of the test results. This analysis was then formulated into tables. If the post-test scores increased and were statistically significant from the pre-test scores, then this evidence would demonstrate that the PowerPoint presentation was successful in increasing the knowledge base of the SRNAs regarding noise.

Results

A paired samples t-test was conducted to analyze the data collected from the pre- and post-test scores (See Appendix E). The pre-test revealed a mean score of 24.76% with a standard deviation of 16.32 and a standard error mean of 3.56. The results of the post-test demonstrated a mean score of 73.81% with a standard deviation of 19.62 and a standard error mean of 4.28. The paired sample tests revealed a mean of -49.04, a standard deviation of 21.66, a standard error mean of 4.72, and a t value of -10.378, which is associated with a *p* value of < 0.001. Mean test scores increased by 49.05 overall between the pre- and post-tests.

Table 1. Paired Samples Test

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	.2476	21	.16315	.03560
	Post-Test	.7381	21	.19615	.04280

Table 2. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test – Post-Test	-.49048	.21658	.04726	-.58906	-.39189	-10.378	20	.000

Conclusions and Limitations

Pre- and post-test questionnaires (see Appendix C) were administered to the AHU SRNA MSNA Cohort of 2019. Twenty-one responses (n = 21) were evaluated. The data obtained from the pre-tests demonstrated that initial knowledge base of noise pollution in the operating room was limited, with a mean pre-test correct score percentage of 25.24%. The results of the pre-test scores showed that education was needed in regard to noise and its application in the clinical setting. Noise pollution in the operating room is relevant to the anesthesia profession and may have an immense impact on patient safety; therefore, this is a subject that requires anesthesia provider attention. Providing an evidenced-based PowerPoint presentation regarding noise pollution to the AHU SRNAs enhanced their knowledge base of noise pollution. The mean percentage pre-test score of 25.24% and the post-test mean percentage score of 73.81%, demonstrate a significant increase in test scores after the PowerPoint presentation was administered ($p < 0.001$). The outcome of this scholarly project was an increase in awareness and knowledge of current operating room noise pollution literature among SRNAs. Therefore, regarding the aim of the study to increase SRNA knowledge base of operating room noise pollution, the scholarly project was relevant and successful. The post-test indicated the effectiveness of the presentation as it relates to the students' ability to define noise, identify the different occupational regulations pertaining to noise limits, isolate different causes of noise pollution, as well as pinpoint specific implications for anesthesia providers and the impact of noise on clinical practice. AHU SRNAs from the Cohort of 2019 benefitted from this scholarly project as evidenced by the statistical analysis of the data.

Limitations to the scholarly project including potential biases and potentials for error were present. The scholarly project was conducted at a single site: AdventHealth University. Additionally, the inherent nature of a convenience sample already subjected the project to bias. The sample size was small ($n = 21$), decreasing validity of the scholarly project. Additionally, the sample was homogenous, consisting entirely of AHU SRNAs. Therefore, the data was not representative of the entire SRNA population and cannot be used to generalize results to other populations. A prominent limitation of this research project was that it only accommodated the evaluation of an immediate increase in knowledge. Retention of knowledge may be better assessed by administration of a post test at a later date instead of immediately after the educational PowerPoint presentation. Additional studies consisting of larger varied sample sizes may be beneficial for practice and knowledge expansion.

Concepts from this presentation may ultimately aid in the education of SRNAs in different programs, other students in healthcare programs, and licensed anesthesia providers. While the scholarly project demonstrated a statistically significant increase in SRNA knowledge base, ongoing education may be beneficial to continue to increase noise pollution awareness and maintain noise pollution knowledge base. A thorough understanding of operating room noise pollution etiology, risk factors, incidence, prevalence, evidence-based prevention, and treatment, may be advantageous in reducing its occurrence. A poster (Appendix G) of this scholarly project will be presented to AHU faculty and students upon completion in April 2019.

References

Beyea, S. C. (2007). Noise: A distraction, interruption, and safety hazard. *AORN Journal*, *86*(2), 281-285. https://doi.org/10.1016/j.aorn.2007.07.017

Gawande, A. A., Zinner, M. J., Studdert, D. M., & Brennan, T. A. (2003). Analysis of errors reported by surgeons at three teaching hospitals. *Surgery*, *133*, 614-621. https://doi.org/10:1067/msy.2003.169

Ginsberg, S. H., Pantin, E., Kraidin, J., Solina, A., Panjwani, S., & Yang, G. (2013). Noise levels in modern operating rooms during surgery. *Journal of Cardiothoracic and Vascular Anesthesia, 27*(3), 528-530. https://doi.org/10.1053/j.jvca.2012.09.001

Hasfeldt, D., Laerkner, E., & Birkelund, R. (2010). Noise in the operating room: What do we know? A review of the literature. *Journal of PeriAnesthesia Nursing*, *25*, 380-386. https://doi.org/10.1016/j.jopan.2010.10.001

Hawksworth, C., Asbury, A. J., & Millar, K. (1997). Music in theatre: Not so harmonious. *Anaesthesia*, *52*(1), 79-83. https://doi.org/10.1111/j.1365-2044.1997.t01-1-012-az012.x

Hogan, L. J., & Harvey, R. L. (2015). Creating a culture of safety by reducing noise levels in the OR. *AORN Journal, 102*(4), 410.e1-410.e7. https://doi.org/10.1016/j.aorn.2015.08.005

Kam, P. C., Kam, A. C., & Thompson, J. F. (1994). Noise pollution in the anaesthetic and intensive care environment. *Anaesthesia, 49*(11), 982-986. https://doi.org/10.1111/j.1365-2044.1994.tb04319.x

Katz, J. (2014). Noise in the operating room. *Anesthesiology, 121*(4), 894-898. https://doi.org/10.1097/ALN.0000000000000319

Kurmann, A., Peter, M., Tschan, F., Muhlemann, K., Candinas, D., & Beldi, G. (2011). Adverse effect of noise in the operating theatre on surgical-site infection. *British Journal of Surgery*, *98*, 1021-1025. https://doi.org/10.1002/bjs.7496

Mazer, S. E. (2012). Creating a culture of safety: Reducing hospital noise. *Biomedical Instrumentation & Technology*, *46*(5), 350-355. https://doi.org/10.2345/0899-8205-46.5.350

Shambo, L., Umadhay, T., & Pedoto, A. (2015). Music in the operating room: Is it a safety hazard? *AANA Journal, 83,* 43-48. Retrieved from http://www.aana.com/docs/default-source/aana-journal-web-documents-1/music-in-or-0215-pp43-48.pdf?sfvrsn=a7cd48b1_4

Shapiro, R. A., Berland, T. (1972). Noise in the operating room. *New England Journal of Medicine*, *287*, 1236-1238. https://doi.org/10.1056/NEJM197212142872407

Stevenson, R. A., Schlesinger, J. J., & Wallace, M. T. (2013). Effects of divided attention and operating room noise on perception of pulse oximeter pitch changes: A laboratory study. *Anesthesiology*, *118*, 376-381. https://doi.org/10.1097/ALN.0b013e31827d417b

Way, T. J., Long, A., Weihing, J., Ritchie, R., Jones, R., Bush, M., & Shinn, J. B. (2013). Effect of noise on auditory processing in the operating room. *Journal of the American College of Surgeons, 216*(5), 933-938. https://doi.org/10.1016/j.jamcollsurg.2012.12.048

Appendix A

Table 3

Sources and Effects of Noise

Intensity dB(A)	Quality	Example	Effect
10-39	Just audible, very quiet	Whisper	Desired for sleep
40-59	Quiet	Average home or light traffic	Desired for work
60	Moderately loud	Normal conversation	
70-89	Loud	Vacuum cleaner, heavy traffic, or telephone ringing	Annoyance
90-119	Very loud	Pneumatic drill, power mower	Hearing loss
120-170	Uncomfortably loud	Nightclub, a shotgun blast	Pain and distress

Note. Adapted from "Noise pollution in the anaesthetic and intensive care environment," by P. C. A. Kam, A. C. Kam, & J. F. Thompson, 1994, *Anaesthesia, 49*(11), p. 982-986.

Appendix B

AHU NAP CAPSTONE PROJECT – INFORMED CONSENT

We are two MSNA students in the Nurse Anesthesia Program (NAP) at AdventHealth University (AHU). We are doing a Capstone Project called *Noise Pollution in the Operating Room*. This project is being supervised by the Nurse Anesthesia Program. We would like to invite you to participate in this project. The main purpose of this form is to provide information about the project so you can make a decision about whether you want to participate.

WHAT IS THE PROJECT ABOUT?

The purpose of this project is to bring awareness to the influence of noises on operating room personnel, which may affect critical thinking during the performance of effective clinical care.

WHAT DOES PARTICIPATION IN THIS PROJECT INVOLVE?

If you decide to participate in this project, you will be asked to complete an anonymous pre-assessment, attend a classroom presentation, and then complete an anonymous post-assessment. The assessment will address your level of knowledge concerning noise pollution and its effects in the operating room. Your participation by attendance at the presentation and completion of the survey is anticipated to take approximately 45 minutes.

WHY ARE YOU BEING ASKED TO PARTICIPATE?

You have been invited to participate as part of a convenience sample of students currently enrolled in the AHU NAP. Your participation in this study is voluntary. You may choose to not to participate. The decision to participate or not participate in this research study is completely up to you. If you choose not to participate your refusal to participate in this research study will involve no penalty or loss of benefits to you. If you choose to participate, you can change your mind later and withdraw your consent and discontinue participation from this study at any time. If you chose to withdraw inform the Principal Investigator of your wishes.

WHAT ARE THE RISKS INVOLVED IN THIS PROJECT?

Although no project is completely risk-free, we don't anticipate that you will be harmed or distressed by participating in this project.

ARE THERE ANY BENEFITS TO PARTICIPATION?

We don't expect any direct benefits to you from participation in this project. The possible indirect benefit of participation in the project is the opportunity to gain additional knowledge about noise pollution and its effects in the operating room.

HOW WILL THE INVESTIGATORS PROTECT PARTICIPANTS' CONFIDENTIALITY?

The results of the project will be published, but your name or identity will not be revealed. To maintain confidentiality of assessments, the investigators will conduct this project in such a way to ensure that information is submitted without participants' identification. The tests will be administered via envelopes with correlating numbers written on the outside. No personal information from the SRNAs will be requested in the tests. The number system will safeguard the right to privacy and anonymity for SRNAs. The researchers will collect and securely save all the test results in a password-protected Excel spreadsheet on an encrypted external hard drive. After entering the results from the pre- and post-tests into an Excel spreadsheet, the scores will be statistically evaluated by AHU's statistician. After the statistical analysis is complete, researchers will formulate a conclusion for the scholarly project. The data collected for this project will only be accessible to the researchers, project mentor, project chair, and AHU statistician via the password-protected file on the encrypted external hard drive. The data will be kept for two years and then destroyed. Thus, the investigators will not have access to any participants' identities.

WILL IT COST ANYTHING OR WILL I GET PAID TO PARTICIPATE IN THE PROJECT?

Your participation will cost approximately 45 minutes of your time but will require no monetary cost on your part. You will not be paid to participate.

VOLUNTARY CONSENT

By signing this form, you are saying that you have read this form, you understand the risks and benefits of this project, and you know what you are being asked to do. You do not have to participate in this research study and choosing not to participate in this study will not involve any penalty or loss of benefit to you. The decision to participate or not participate in this research study is completely up to you. If you choose to participate, you can change your mind later and withdraw your consent and discontinue participation from this study at any time. If you chose to withdraw from the study inform the investigators of your wishes. The investigators will be happy to answer any questions you have about the project. If you have any questions or concerns about the project process or the investigators, please contact the Nurse Anesthesia Program at (407) 303-9331.

____ **Date** _______________
Participant Signature

____
Participant Name (Printed Legibly)

Appendix C

Pre-Test and Post-Test Questionnaire

1) As mandated by the Occupational Safety and Health Administration (OSHA), what are the accepted noise levels for the operating room?
   a. 10 dB(A) for 4 hours to 40 dB(A) for 30 minutes
   b. 70 dB(A) for 4 hours to 90 dB(A) for 30 minutes
   c. 90 dB(A) for 8 hours to 115 dB(A) for 15 minutes
   d. 120 dB(A) for 8 hours to 170 dB(A) for 15 minutes

2) When are the noisiest parts of some non-orthopedic surgeries? (Select all that apply)
   a. During pre-op
   b. During induction
   c. During intra-op
   d. During emergence
   e. During post-op

3) Noise pollution in the operating room can be categorized into what two groups? (Select one)
   a. Staff-related or equipment-related
   b. Patient-related or healthcare provider-related
   c. Music-related or vocal-related
   d. Machine-related or room-related

4) Which one of the following statements is TRUE?
   a. Even without the addition of music, average noise levels in ORs do not routinely go over the acceptable standards of occupational noise levels
   b. Music in the OR was shown to have more detrimental effects on surgical performances with experienced surgeons than novice surgeons
   c. National Institute for Occupational Safety set guidelines for spontaneous noises so that peak levels should not be more than 90 dB(A)
   d. The Environmental Protection Agency (EPA) set sound regulations between 35 to 45 dB(A) for ambient OR noises, which are below the dB(A) level of normal conversations

5) How can surgical teams dramatically decrease noise levels in the operating room? (Select all that apply)
   a. Avoid unnecessary conversations
   b. Turn off background music
   c. Prepare medical equipment after induction
   d. Minimize opening of drawers

6) Which one of the following statements is FALSE regarding noise pollution in the operating room?
    a. Noise pollution negatively impacts both working environment and patient safety in the O.R.
    b. Miscommunication was mentioned as the causative aspect of 43% of errors which gave rise to lasting disability or death.
    c. When noises exceed recommended safe levels in the operating room, surgical staff may experience miscommunication, hearing loss, and decreased concentration, which results in patient harm.
    d. Reduction in O.R. noise levels may improve communication, potentially preventing patient mortality and morbidity in 25% of surgical cases.

7) The average person perceives sound within a frequency range of?
    a. 10 to 10,000 Hz
    b. 20 to 20,000 Hz
    c. 30 to 30,000 Hz
    d. 40 to 40,000 Hz

8) Miscommunication was mentioned as the causative aspect in what percentage of errors that gave rise to disability or death?
    a. 18%
    b. 24%
    c. 36%
    d. 43%

9) Which of the following organizations set regulations for noise levels? (Select two answers)
    a. Environmental Protection Agency (EPA)
    b. Occupational Safety and Health Administration (OSHA)
    c. US Health and Human Services (HHS)
    d. The Joint Commission (TJC)

10) What percentage of noise is the OR can be attributed to staff?
    a. 85%
    b. 90%
    c. 95%
    d. 98%

Appendix D

Pre-Test and Post-Answer Key

1. C
2. B, D
3. A
4. D
5. A, B, D
6. D
7. B
8. D
9. A, B
10. C

Appendix E

Data Collection

Table 4. Pre-Test Scores

Pre-Test #	Correct	Incorrect	Grade (%)
1	3	7	30
2	2	8	20
3	2	8	20
4	2	8	20
5	2	8	20
6	2	8	20
7	3	7	30
8	6	4	60
9	1	9	10
10	2	8	20
11	3	7	30
12	2	8	20
13	1	9	10
14	1	9	10
15	3	7	30
16	4	6	40
17	7	3	70
18	3	7	30
19	0	10	0
20	2	8	20
21	2	8	20
Average % correct			25.238095238

Table 5. Post-Test Scores

Post-Test #	Correct	Incorrect	Grade (%)
1	8	2	80
2	9	1	90
3	9	1	90
4	9	1	90
5	8	2	80
6	8	2	80
7	8	2	80
8	9	1	90
9	9	1	90
10	7	3	70
11	5	5	50
12	5	5	50
13	2	8	20
14	8	2	80
15	8	2	80
16	10	0	100
17	8	2	80
18	7	3	70
19	8	2	80
20	4	6	40
21	6	4	60
Average % correct			73.809523809

Table 1. Paired Samples Test

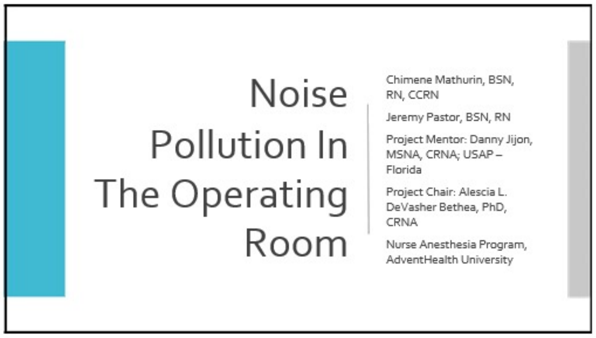
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test – Post-Test	-.49048	.21658	.04726	-.58906	-.39189	-10.378	20	.000

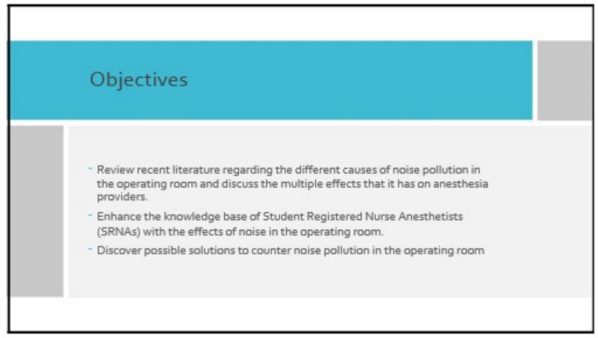
Table 2. Paired Samples Test

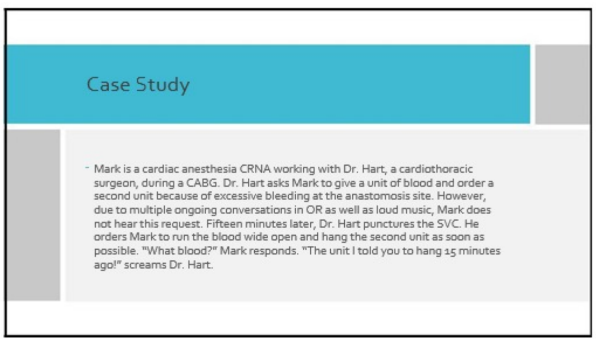
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	.2476	21	.16315	.03560
	Post-Test	.7381	21	.19615	.04280

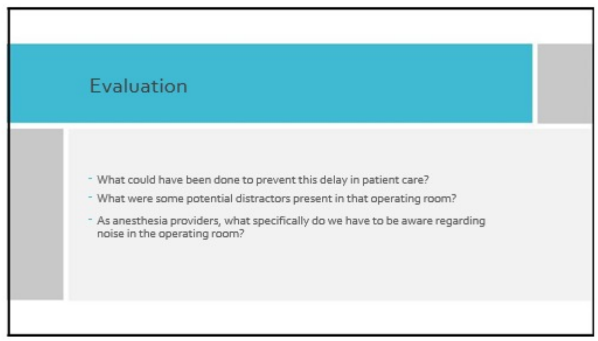
Appendix F

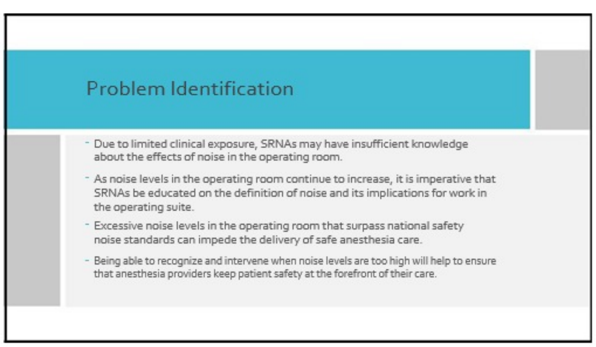
Educational Noise Pollution in the Operating Room PowerPoint Presentation

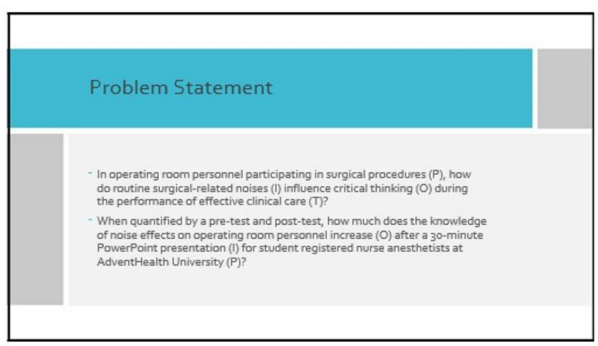












What is Noise?

- Noise can be defined as any unwanted sound that interferes with normal hearing, irritates or interrupts performance, and is stressful physiologically and psychologically (Kam, Kam, & Thompson, 1994)
- Can be categorized as fluctuating, random, unharmonious waveforms that interrupt desired signals (Kam, Kam, & Thompson, 1994)
- While most sounds in everyday life are between 60 and 6,000 Hz, the average person perceives sounds within a frequency range of **20 to 20,000 Hz** (Kam, Ka, & Thompson, 1994)

Sources and Effects of Noise

Intensity dB(A)	Quality	Example	Effect
10 - 39	Just audible, very quiet	Whisper	Desired for sleep
40 - 59	Quiet	Average home or light traffic	Desired for work
60	Moderately loud	Normal conversation	
70 - 89	Loud	Vacuum cleaner, heavy traffic, or telephone ringing	Annoyance
90 - 119	Very loud	Pneumatic drill, power mower	Hearing loss
120 - 170	Uncomfortably loud	Nightclub, a shotgun blast	Pain and distress

Note. Adapted from "Noise pollution in the anaesthetic and intensive care environment." by P. C. A. Kam, A. C. Kam, & J. F. Thompson, 1994, Anaesthesia, 49(11), p. 982–986.

Occupational Regulations

- Exposure limits are set to protect workers against the health effects of exposure to substances found in the workplace (Ginsberg et al., 2013)
- Noise is included as one of the substances that can be harmful to workers (Ginsberg et al., 2013)
- Noise exposure regulations were created to protect workers from noise induced hearing loss (Ginsberg et al., 2013)
- 3 different organizations enforce noise exposure limits in the operating room (Hasfelt, Laerkner, & Birkelund, 2010; Shambo et al., 2015)

Enforcement of Occupational Regulations

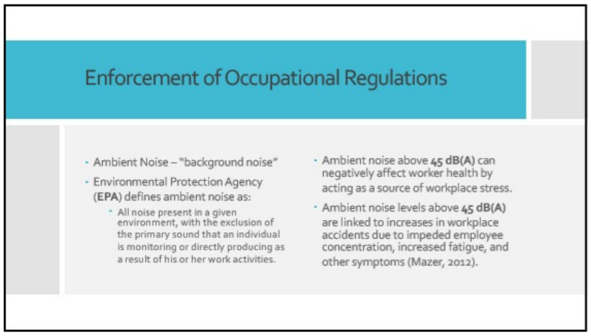
- Occupational Safety and Health Administration (OSHA)
  - Created in 1971 as a part of the U.S. Department of Labor in order to assure safe and healthy working environments
- Noise exposure limit: **90 dB(A) for 8 hours to only 15 minutes of exposure at 115 dB(A)** (Ginsberg et al., 2013)

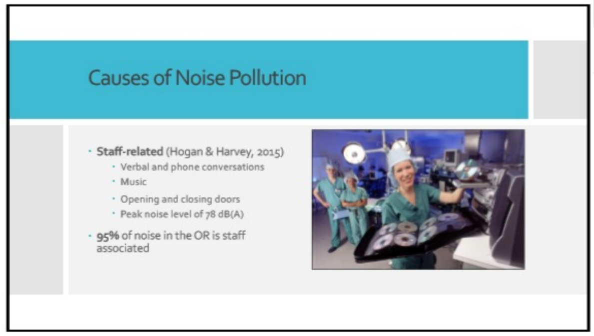
Enforcement of Occupational Regulations

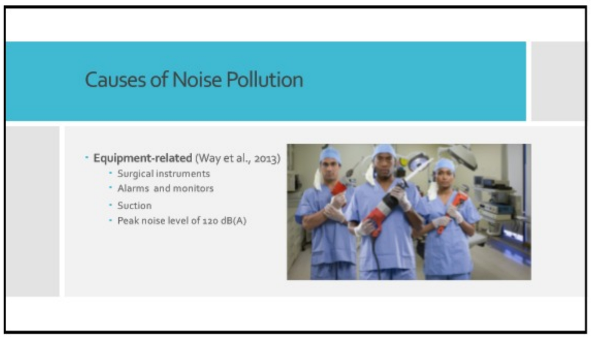
- National Institute for Occupational Safety (**NIOSH**)
  - Research agency focused on creating safe and healthy workplaces 1970
  - Noise exposure limit: **peak levels no more than 140 dB(A)** (Katz, 2014)

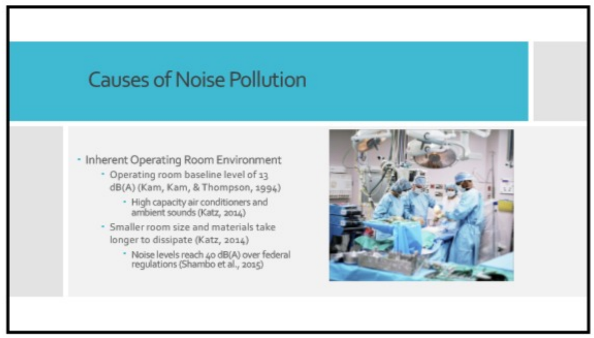
Enforcement of Occupational Regulations

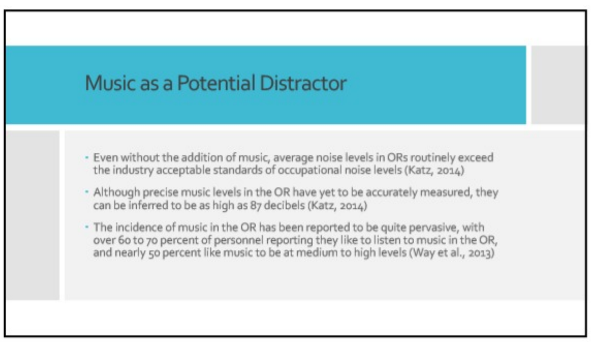
- Environmental Protection Agency (EPA)
  - Since 1970, Implements regulations when Congress writes environmental laws
- Noise exposure limit: 35 to 45 dB(A) for ambient OR noises (Mazer, 2012)

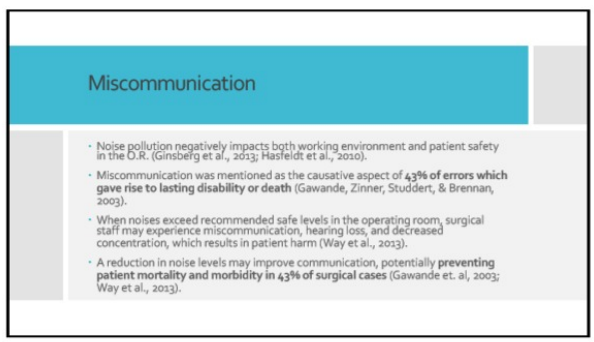

Enforcement of Occupational Regulations
Ambient Noise – "background noise"
Environmental Protection Agency (EPA) defines ambient noise as:
All noise present in a given environment, with the exclusion of the primary sound that an individual is monitoring or directly producing as a result of his or her work activities.
Ambient noise above 45 dB(A) can negatively affect worker health by acting as a source of workplace stress.
Ambient noise levels above 45 dB(A) are linked to increases in workplace accidents due to impeded employee concentration, increased fatigue, and other symptoms (Mazer, 2012).

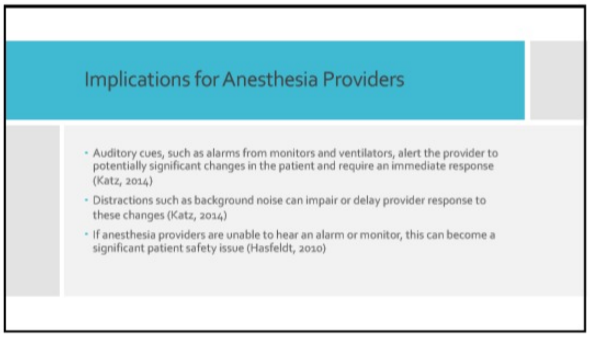

Causes of Noise Pollution
Staff-related (Hogan & Harvey, 2015)
Verbal and phone conversations
Music
Opening and closing doors
Peak noise level of 78 dB(A)
95% of noise in the OR is staff associated

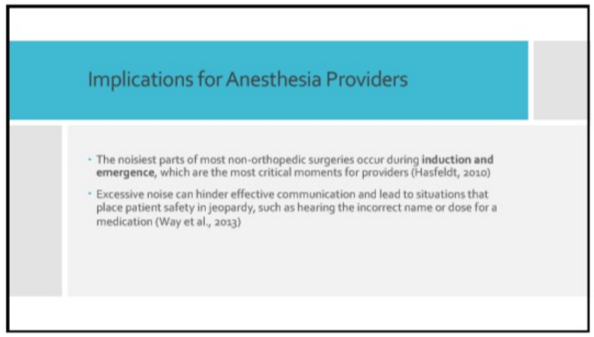

Causes of Noise Pollution
Equipment-related (Way et al., 2013)
Surgical instruments
Alarms and monitors
Suction
Peak noise level of 120 dB(A)

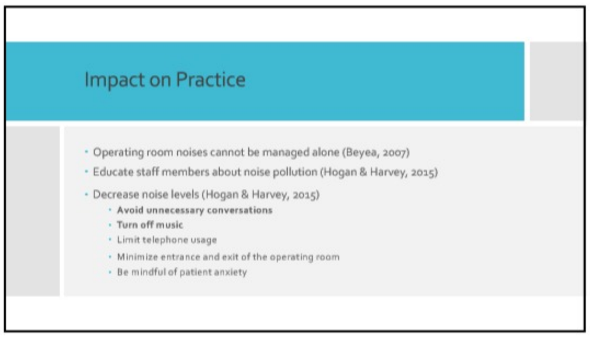

Causes of Noise Pollution
Inherent Operating Room Environment
Operating room baseline level of 13 dB(A) (Kam, Kam, & Thompson, 1994)
High capacity air conditioners and ambient sounds (Katz, 2014)
Smaller room size and materials take longer to dissipate (Katz, 2014)
Noise levels reach 40 dB(A) over federal regulations (Shambo et al., 2015)

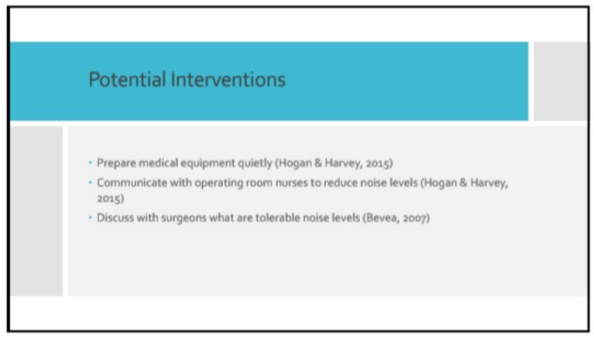

Music as a Potential Distractor
Even without the addition of music, average noise levels in ORs routinely exceed the industry acceptable standards of occupational noise levels (Katz, 2014)
Although precise music levels in the OR have yet to be accurately measured, they can be inferred to be as high as 87 decibels (Katz, 2014)
The incidence of music in the OR has been reported to be quite pervasive, with over 60 to 70 percent of personnel reporting they like to listen to music in the OR, and nearly 50 percent like music to be at medium to high levels (Way et al., 2013)

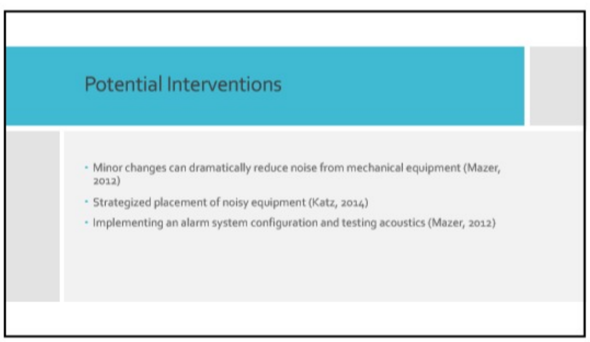

Miscommunication
Noise pollution negatively impacts both working environment and patient safety in the O.R. (Ginsberg et al., 2013; Hasfeldt et al., 2010).
Miscommunication was mentioned as the causative aspect of 43% of errors which gave rise to lasting disability or death (Gawande, Zinner, Studdert, & Brennan, 2003).
When noises exceed recommended safe levels in the operating room, surgical staff may experience miscommunication, hearing loss, and decreased concentration, which results in patient harm (Way et al., 2013).
A reduction in noise levels may improve communication, potentially preventing patient mortality and morbidity in 43% of surgical cases (Gawande et. al, 2003; Way et al., 2013).

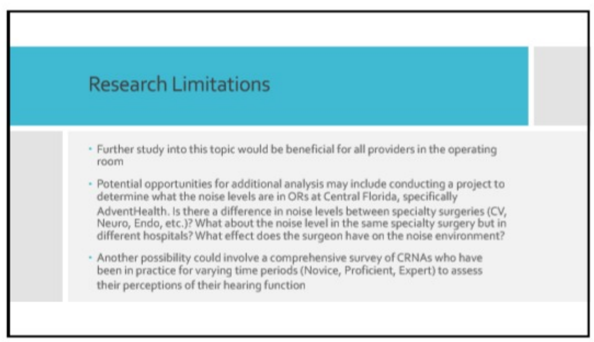

Implications for Anesthesia Providers
Auditory cues, such as alarms from monitors and ventilators, alert the provider to potentially significant changes in the patient and require an immediate response (Katz, 2014)
Distractions such as background noise can impair or delay provider response to these changes (Katz, 2014)
If anesthesia providers are unable to hear an alarm or monitor, this can become a significant patient safety issue (Hasfeldt, 2010)

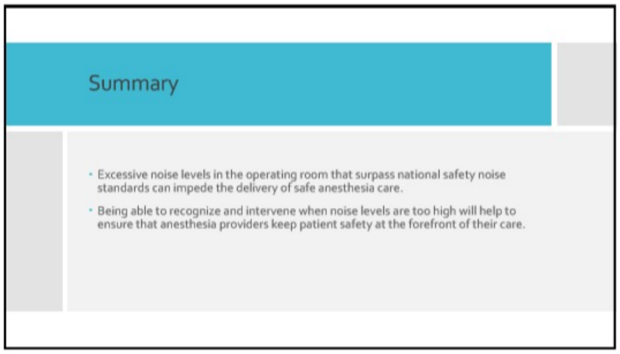

Implications for Anesthesia Providers
The noisiest parts of most non-orthopedic surgeries occur during induction and emergence, which are the most critical moments for providers (Hasfeldt, 2010)
Excessive noise can hinder effective communication and lead to situations that place patient safety in jeopardy, such as hearing the incorrect name or dose for a medication (Way et al., 2013)


Impact on Practice
Operating room noises cannot be managed alone (Beyea, 2007)
Educate staff members about noise pollution (Hogan & Harvey, 2015)
Decrease noise levels (Hogan & Harvey, 2015)
Avoid unnecessary conversations
Turn off music
Limit telephone usage
Minimize entrance and exit of the operating room
Be mindful of patient anxiety


Potential Interventions
Prepare medical equipment quietly (Hogan & Harvey, 2015)
Communicate with operating room nurses to reduce noise levels (Hogan & Harvey, 2015)
Discuss with surgeons what are tolerable noise levels (Bevea, 2007)

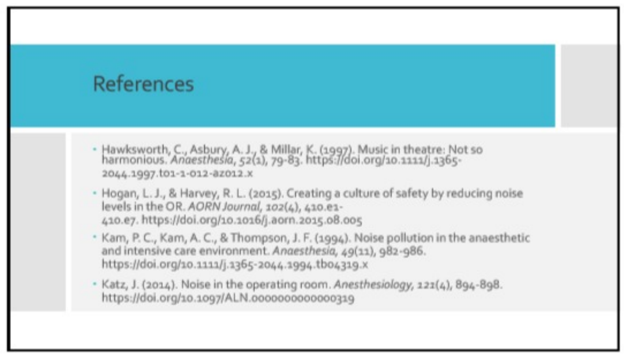

Potential Interventions
Minor changes can dramatically reduce noise from mechanical equipment (Mazer, 2012)
Strategized placement of noisy equipment (Katz, 2014)
Implementing an alarm system configuration and testing acoustics (Mazer, 2012)


Research Limitations
Further study into this topic would be beneficial for all providers in the operating room
Potential opportunities for additional analysis may include conducting a project to determine what the noise levels are in ORs at Central Florida, specifically AdventHealth. Is there a difference in noise levels between specialty surgeries (CV, Neuro, Endo, etc.)? What about the noise level in the same specialty surgery but in different hospitals? What effect does the surgeon have on the noise environment?
Another possibility could involve a comprehensive survey of CRNAs who have been in practice for varying time periods (Novice, Proficient, Expert) to assess their perceptions of their hearing function


Summary
Excessive noise levels in the operating room that surpass national safety noise standards can impede the delivery of safe anesthesia care.
Being able to recognize and intervene when noise levels are too high will help to ensure that anesthesia providers keep patient safety at the forefront of their care.


Questions?
?


References
Beyea, S. C. (2007). Noise: A distraction, interruption, and safety hazard. AORN Journal, 86(2), 281-285. https://doi.org/10.1016/j.aorn.2007.07.017
Gawande, A. A., Zinner, M. J., Studdert, D. M., & Brennan, T. A. (2003). Analysis of errors reported by surgeons at three teaching hospitals. Surgery, 133, 614-621. https://doi.org/10:1067/msy.2003.169
Ginsberg, S. H., Pantin, E., Kraidin, J., Solina, A., Panjwani, S., & Yang, G. (2013). Noise levels in modern operating rooms during surgery. Journal of Cardiothoracic and Vascular Anesthesia, 27(3), 528-530. https://doi.org/10.1053/j.jvca.2012.09.001
Hasfeldt, D., Laerkner, E., & Birkelund, R. (2010). Noise in the operating room: What do we know? A review of the literature. Journal of PeriAnesthesia Nursing, 25, 380-386. https://doi.org/10.1016/j.jopan.2010.10.001


References
Hawksworth, C., Asbury, A. J., & Millar, K. (1997). Music in theatre: Not so harmonious. Anaesthesia, 52(1), 79-83. https://doi.org/10.1111/j.1365-2044.1997.t01-1-012-az012.x
Hogan, L. J., & Harvey, R. L. (2015). Creating a culture of safety by reducing noise levels in the OR. AORN Journal, 102(4), 410.e1-410.e7. https://doi.org/10.1016/j.aorn.2015.08.005
Kam, P. C., Kam, A. C., & Thompson, J. F. (1994). Noise pollution in the anaesthetic and intensive care environment. Anaesthesia, 49(11), 982-986. https://doi.org/10.1111/j.1365-2044.1994.tb04319.x
Katz, J. (2014). Noise in the operating room. Anesthesiology, 121(4), 894-898. https://doi.org/10.1097/ALN.0000000000000319


References
Kurmann, A., Peter, M., Tschan, F., Muhlemann, K., Candinas, D., & Beldi, G. (2011). Adverse effect of noise in the operating theatre on surgical-site infection. British Journal of Surgery, 98, 1021-1025. https://doi.org/10.1002/bjs.7496
Mazer, S. E. (2012). Creating a culture of safety: Reducing hospital noise. Biomedical Instrumentation & Technology, 46(5), 350-355. https://doi.org/10.2345/0899-8205-46.5.350
Shambo, L., Umadhay, T., & Pedoto, A. (2015). Music in the operating room: Is it a safety hazard? AANA Journal, 83, 43-48. Retrieved from http://www.aana.com/docs/default-source/aana-journal-web-documents-1/music-in-or-0215-pp43-48.pdf?sfvrsn=a7cd48b1_4
Shapiro, R. A., Berland, T. (1972). Noise in the operating room. New England Journal of Medicine, 287, 1236-1238. https://doi.org/10.1056/NEJM197212142872407


References
Stevenson, R. A., Schlesinger, J. J., & Wallace, M. T. (2013). Effects of divided attention and operating room noise on perception of pulse oximeter pitch changes: A laboratory study. Anesthesiology, 118, 376-381. https://doi.org/10.1097/ALN.0b013e31827d417b
Way, T. J., Long, A., Weihing, J., Ritchie, R., Jones, R., Bush, M., & Shinn, J. B. (2013). Effect of noise on auditory processing in the operating room. Journal of the American College of Surgeons, 216(5), 933-938. https://doi.org/10.1016/j.jamcollsurg.2012.12.048